AMERICAN UNIVERSITY OF BEIRUT

# ERGONOMIC ABLUTION STATION DESIGN

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# ABSTRACT
# OF THE THESIS OF

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Ablution is an important aspect in the everyday lives of Muslims. It is a required process to attain purity in order to perform necessary prayers. As many prayers occur during the day, when people are at work, there was a need to create proper ablution stations. There are four ablution stations that are the most popular choice in most mosques. The current study is motivated by the few studies that examine the ergonomic aspects of ablution stations, one of which is Mokhtar (2005) which looks at these four stations. This study is also motivated by the fact that most studies done around the topic are not recent, and thus exclude modern methods of design. These stations are yet to be studied using proper ergonomic tools and techniques. 40 Muslim participants, aged between 18 and 75, were asked to fill a survey examining the selected ablution designs in light of their experiences. The questions focused on comfort level, wetness level, and overall thoughts about the designs. The results show that out of the existing designs, design A was seen as the most comfortable. Results also show that there is a significance between height, weight, and gender and the perceived comfort level per design, while there was no significance when it comes to the age of participants. Overall, the participants preferred the seated design and would rather use the two new designs that also have a seat. Additionally, another 5 Muslim participants, men only, were asked to use selected ablution stations at the mosque and fill an LMD scale questionnaire about its comfort. RULA was used to score the designs based on the participants' postures while performing ablution on one of the four station designs in question. Design A had the lowest RULA score amongst the four designs. Designs A and C were subjectively the most comfortable design for participant's 5 and 4. The results are situated in the ergonomics framework for analysis and are intended to be a steppingstone for future studies to build upon.

*Keywords:* ablution, station, designs, mosques, Islam, washing, ergonomics, upper body, lower body, comfort, slipping

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# CHAPTER I

# INTRODUCTION

To belong to society and follow different faiths, humans are required to perform various forms of physical activities for multiple reasons. In most cases, these physical activities become part of one's routine and are frequently repeated during the day, week, or month. First coined by Polish scientist Wojciech Jastrzebowski in 1857, *ergonomics* is a field of study that is dedicated to examining and evaluating the design and engineering of products and processes and how it would affect human comfort. The physical activities constantly done by humans are accomplished for different purposes, yet not ergonomically evaluated. For this reason, the field of ergonomics has become multidisciplinary, concerning itself with the interactions between humans and their physical activities.

Physical activities do not only include manual labor, but also small tasks done throughout the day. One of those daily tasks is fulfilling religious duties that require a specific set of movements to be repeated daily or weekly. All religions have their own sets of rules that their followers must abide by throughout their lives. Islam is practiced by 1.91 billion people worldwide, making up about 24.9% of the overall population of the world (Religion by Country, 2021). One of the pillars of Islam is the obligatory five daily prayers, referred to as 'Salah.' The timings of these prayers are at dawn (Fajr), noon (Duhur), late afternoon (Asr), sunset (Maghrib), and night (Isha). Before performing these prayers, the person must be in a state of 'purity' by performing ablution wudu' (wuḍuʔ) a ritual that involves washing the hands, face, arms, head, and feet with water. Ablution can be performed at home using a regular sink or at a mosque using an ablution station (Fig. 1). Hence, ablution is an indispensable part of the daily lives of Muslims. Since these activities tend to be frequent, an ergonomic analysis of the processes and an evaluation of the designs that accompany them are needed. While performing ablution, people are exposed to awkward postures such as bending the back, standing on one leg, and frequently reaching forward (Fig. 2).

These postures may cause inconvenience, discomfort, or even slip and fall injuries. Ablution stations in most mosques in the Arab world are still only designed with a simple faucet and drain, with no special ergonomic considerations. The faucets are either too high which increases the likelihood of splashing unwanted areas, or too low and require extreme back bending. Therefore, there is a need to study existing ablution station designs in order to identify the design deficiencies and systematically propose a design that accounts for human comfort, safety, and preferences. Given the ergonomic concerns present while performing ablution and the limited research on ablution station design, the objectives of this study are to:

1. Perform an ergonomic evaluation of common existing ablution station designs;
2. Conduct interviews to collect the public's perceptions on existing ablution station designs, in terms of comfort, safety, and preferences; and
3. Develop a recommended ablution station design that accounts for anthropometry, the findings of the ergonomic evaluations, and the public's feedback.

Chapter II reviews ergonomic studies done on ablution station designs in the Arab region and throughout the world. It summarizes and highlights the main methods and proposed suggestions offered by the researchers. It also reviews several ergonomic tools that can be used for the evaluation process. Chapter III discusses the main methods used in this study, as well as the limitations and gaps. Chapter IV details the results of the study which are interpreted in Chapter V which analyzes and evaluates the results and situates them in broader ergonomic discussions.

# CHAPTER II

# REVIEW OF THE LITERATURE

## A. Ergonomics

Ergonomics, also known as human factors, is a branch of science that aims at learning about human capabilities and limitations and then applying this knowledge to improve people's interactions with environments, products, and systems (ISO, 2016). The environment under study is multipart, consisting of the physical (products and equipment), social (human interaction and social norms), and organizational aspects (how tasks are organized and managed) (Dul et al., 2012). Hence, ergonomics focuses on people and their surrounding environments, design, performance, and human comfort and wellbeing (Dul et al., 2012). There are three main branches of ergonomics based on the different aspects under study. The first branch of ergonomics is organizational ergonomics which deals with complex organizational work (Middlesworth, 2019). Relevant topics of the branch include teamwork, quality management, and design of work hours (Middlesworth, 2019). The second branch is cognitive ergonomics that focuses on how mental processes affect human interactions and other aspects of the environment (Middlesworth, 2019). Relevant topics for this branch include mental workload, work stress, and human-computer interaction. The final branch is physical ergonomics which deals with human anthropometric, biomechanical, physiological, and anatomical characteristics in relation to physical tasks (Middlesworth, 2019). This section of ergonomics is most focused on workplace ergonomics. Workplace ergonomics, being a subsection of physical ergonomics, revolves around building a better workplace by decreasing costs and risks while also increasing productivity, quality, and engagement (Middlesworth, 2019). The proposed topic is closely related to physical ergonomics as the process of ablution involves performing a physical task that might lead to discomfort and/or slip and fall injuries.

Figure 1: Typical ablution station

Figure 2: Awkward postures while performing ablution

### B. Performing Ablution

Ablution is the process of washing specific body parts in a chronological order. By performing this task, the individual attains the ablution (or purification) status. This status allows a person to perform the obligatory prayers, to hold the Holy Quran, and to circumambulate the Kaaba (Sayeed & Prakash, 2013). There are four major steps of ablution as mentioned in the Quran. The process starts with having the intention of starting ablution. This can be done silently within oneself. What follows is part related to washing with water. The person must start off by washing the face, followed by washing the forearms to the elbows, then wiping the head with wet hands, and finally, washing the feet up to the ankles. This process is based on the following verse of the Holy Quran, “O you who believe! When you intend to offer As-Salat (the prayer), wash your faces and your hands (forearms) up to the elbows, rub (by passing the hands over) your heads, and (wash) your feet up to the ankles (Holy Quran; 5:6).”

Additional steps of ablution are present to whomever wants to follow the way or “Sunnah” of the Prophet Muhammad, peace be upon him (pbuh). These additional steps are mainly presented throughout different noble hadiths, which is a collection of sayings of the Prophet Muhammad (pbuh), which serves as an additional resource for Muslims besides the Quran. These additions are performed by many Muslims around the world who believe that doing those steps would perfect the process of ablution. The steps include washing the hands (Abu Dawood, n.d., no.118), rinsing the mouth (Abu Dawood, n.d., no.139), sniffing a small amount of water through the nostrils and then sniff it out (Abu Dawood, n.d., no.139), wiping the ears (Abu Dawood, n.d., no.108), and repeating all actions three times (Abu Dawood, n.d., no.134). Although some of the actions might vary, depending on the followed doctrine, the mentioned process is the most prevalent method among the Muslim population. This study will consider the full process in order to capture all the postures present when performing ablution.

## C. Existing Ablution Station Designs

Ablution stations have always been an essential part of the daily lives of Muslims. Muslims need to pray five times per day; three of those prayer times might coincide with working hours. Therefore, they would have to resort to praying outside their homes in mosques or ‘musallas’ (small praying areas). To obtain the state of ablution needed to perform a prayer, ablution stations are oftentimes present in those areas. In most Islamic countries, one may find musallas in malls, airports, and educational institutions.

The design of the ablution station has evolved over the years. Gamal (2018) discusses the evolution of ablution stations from clay holes in the ground where water can be filled to modern ceramic designs to advanced technological designs (Fig. 3). Early designs focused only on providing people with fresh water. Not much thought was put into how the design of such stations would risk injuries or discomfort. Later studies have shown the need of a proper ablution station that would minimize that risk (Kim & Omar, 2019; Kim & Bendak, 2021). Although station models have then evolved, many still had serious problems with regards to cleanliness, ease of access, and the specific needs of the elderly.

Figure 3: Preliminary ablution station

A study by Mokhtar (2005) provides information about the number of stations needed based on the size of the mosque. This study also included some designs that were deemed “safe for use.” These four designs are similar in that the floor is made of or covered with anti-slip material that allows water to sift through. Another similar aspect is the availability of a shelf which would allow people to place any carried or worn items, such as a watch or a cellphone. The designs mainly differ in the seat availability, faucet height, and sink availability. Design A (Fig. 4. a). Sitting with faucet (Si-F) is shown to have a round seat, a faucet a little above the seat level, and a small inclination in the wall which would allow users to place their feet when washing them (Gamal, 2018).

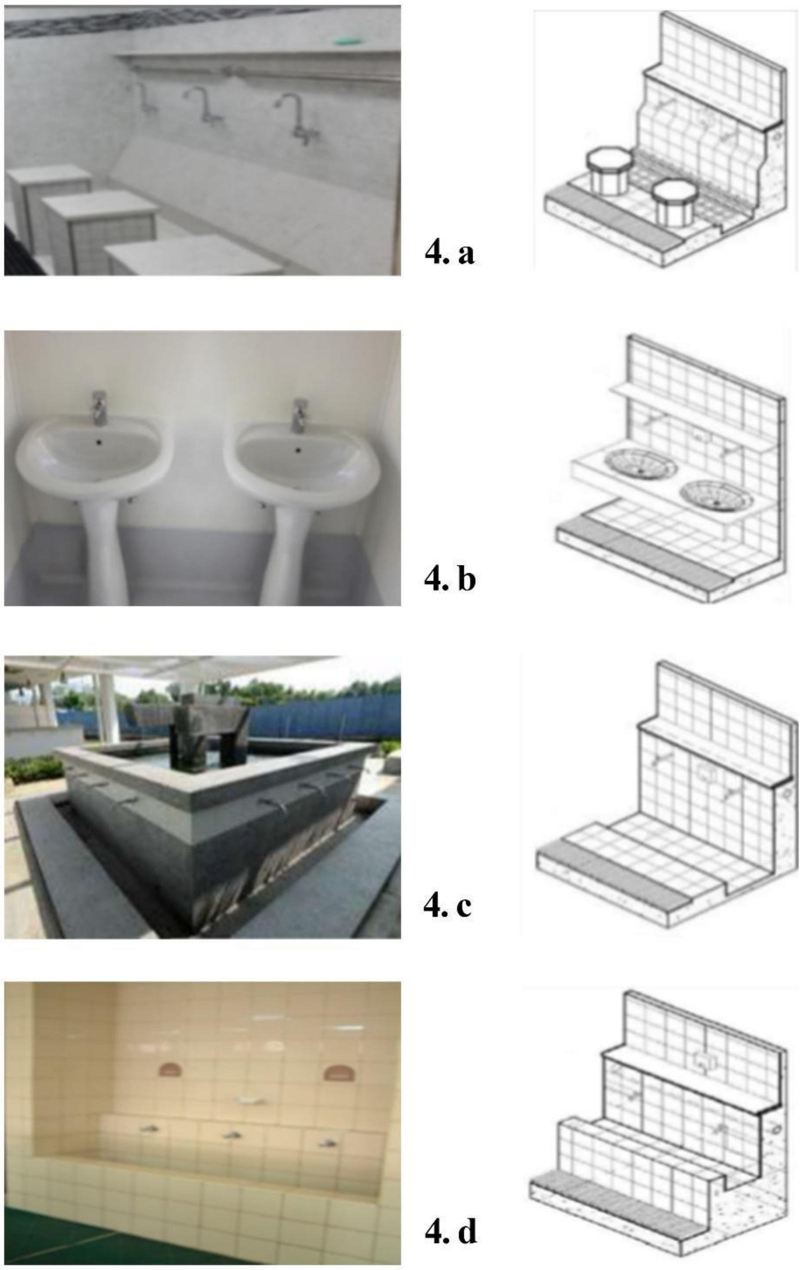



Figure 4: Prominent ablution station designs

Design B (Fig. 4. b) Standing with Sink (St-S) is similar to a common sink that is found at households. The user would have to raise their feet to the sink level to be able to wash them. This might cause a lot of discomfort to many people, and it also does not consider the needs of elderly or the disabled as they might prefer a station with a seat (Gamal, 2018). Design C (Fig. 4. c) Standing with Faucet (St-F) is another standing station wherein the only provided tool is a faucet (Gamal, 2018). This design is the simplest out of all the four designs. The floor in this design is lower to act as a drain for the water. Although this design is the cheapest, it has many problems of risk such as slipping and awkwardly bending to reach the faucet. Design D (Fig. 4. d) Standing with Faucet and Ledge (St-FL) is also a standing station. The main difference between this design and design C is the addition of a ledge. This ledge allows people to place their feet while washing them and it also provides less chances of splashing (Gamal, 2018). Although these designs are modern and are placed in mosques around the world, little analysis has been done to show the extent of which these models were ergonomically designed.

New advanced technologies have been integrated in the ablution station design. These advanced designs use technology such as sensors and timed water splashes in order to save the largest amount of money while doing this procedure (Fig. 5). These designs are often found in technologically advanced countries (e.g. Japan). Although these designs are effective in saving water and sometimes effort, they can be more costly and require more maintenance. Some of these advanced designs, however, make it difficult to rub the feet as they are being washed. Rubbing the feet with water is considered obligatory according to some Islamic schools of thought (Imam Malik) but only running water over the feet is required by other schools of thought (Al-Nawawi). Thus, a disadvantage in these advanced designs is that they only account to running water over the feet but rubbing the feet still requires standing in uncomfortable positions.

Figure 5: Advanced ablution stations

**D. Ergonomic Risk Factors & Awkward Postures**

While performing ablution, people might encounter discomfort and injury risk factors caused by awkward postures. These awkward postures are a result of the current designs of ablution stations, which do not account for human comfort. The postures include back bending, standing on one leg, and frequently reaching to water faucets.

When a person bends their back, the spine fully flexes. This causes a change in the line of action of the lumbar extensor muscles, which reduces their effectiveness in supporting shear forces. This bending position also renders the muscles inactive, leaving only the soft tissues responsible for keeping the body from falling (Pope et al., 2002). Hence, any frontal shear load on the lumbar spine will most likely cause discomfort and back injuries (Pope et al., 2002).

Standing, which is common when performing ablution, can also cause discomfort. If the person is standing upright with respect to the body's center of gravity, there would be minimal pressure on the person. Any movement that causes a shift in the body's center of gravity requires muscle activity to counterbalance that change (Pope et al., 2002). This effect increases when a person is standing on one leg. Standing on one leg (Fig. 6) will shift the center of gravity away or toward the raised leg's side (depending on whether it is stretched out), thus increasing the muscle activity needed to maintain balance. This extra muscle activity stems from spinal muscles which, if excessively exerted, may cause low back pain or musculoskeletal disorders such as ruptured or herniated discs (Pope et al., 2002; Middlesworth, 2019).

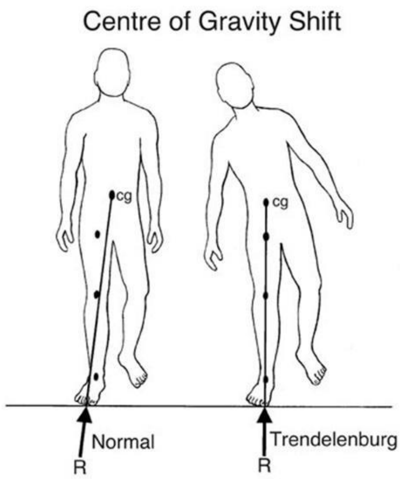



Figure 6: Center of gravity shift when standing on one leg

Twisting and lateral bending positions, oftentimes grouped as awkward positions, increase muscle and intradiscal pressure. This pressure would be increased in positions of asymmetry. This leads to unequal stress exerted on the spine. Studies done using electromyography (EMG) show higher intradiscal pressure when subjects were in an awkward position (Pope et al., 2002,). Another EMG study demonstrates that twisting increases the activity of deep trunk muscles which explains why twisting can lead to lower back pain (Shan et al., 2013). Approximately 36-70% of lower back pain injuries are a result of awkward postures caused from tripping, slipping, and falling (Pope et al., 2002,).

These risk factors and injuries may lead to severe cases of musculoskeletal disorders such as tendonitis, muscle or tendon strain, ligament sprain, and ruptured or herniated disc (Middlesworth, 2019). In order to avoid the mentioned risk factors and injuries, ergonomists have developed several assessment tools for studying posture and loading effects on the human body.

### E. Ergonomic Assessment Tools

Numerous analysis methods have been designed and developed to tackle the problem of ergonomic risk. These assessment tools are used to identify whether everyday tasks, if regularly practiced, might cause musculoskeletal disorders (MSD). Some assessment tools are directly related to the lifting of heavy objects; these tools will not be taken into consideration as ablution does not require any heavy lifting. That narrows down the search to a select few, namely: the Washington Industrial Safety and Health Act (WISHA) caution/hazard zone checklists (Dean, n.d.), the Ovako Working Posture Assessment (OWAS) (Karhu et al., 1977), the Rapid Upper Limb Assessment (RULA) (McAtamney et al., 1993), and the Rapid Entire Body Assessment (REBA) (Hignett et al., 2000).

The WISHA caution/hazard zone checklists were developed by the Washington State Department of Labor and Industries (Appendix A; Appendix B). These checklists are used to determine whether everyday activities might put people at risk of ergonomic stress. They mainly focus on awkward postures that are required to perform a job. The two checklists require that the action be performed more than once per week, for more than one week per year, and more than two hours per day to be considered significant for study (Appendix A; Appendix B). The advantage of using WISHA checklists is that they identify the difference between jobs that need caution or jobs that are hazardous and need corrective action. In addition to that, they incorporate vibration, lifting, and contact stress studying and by such, it would address a combination of risk factors (Dean, n.d.). Although WISHA allows the user to focus on many factors, some users who want to focus on one factor might need a different analysis tool. WISHA also does not separate the risk by body part as it studies the entire body altogether (Dean, n.d.).

The Ovako Working Posture Assessment (OWAS) is an ergonomic observation tool (Karhu et al., 1977). This method was created to solve the problems of postures in the workplace. It focuses on two key ideas; feasibility and accuracy of the analysis (Karhu et al., 1977). OWAS is also quantitative as it provides scores for the observed posture based on predetermined conditions. The four main aspects OWAS focuses on are: back posture, arm position, leg position, and load category, each given a separate score. A final score is found by combining the four scores using the table provided. Based on the final score, the user will know the action category needed for the specific task. There are four action categories with: 1 meaning that no action is needed; 2 meaning that the posture has some harmful effects, and a corrective action needs to be taken; 3 meaning that the posture has harmful effects and a corrective action should be taken very soon; and 4 meaning that the posture has very harmful effects and a corrective action must be taken immediately to avoid any risk of MSD (Karhu et al., 1977).

The Rapid Upper Limb Assessment (RULA) is a quantitative analysis tool to explore the risk factors that people are being exposed to which might lead to upper limb disorders (McAtamney et al., 1993). The assessment is performed by taking a snapshot of the activity in progress and then analyzing the posture. This analysis is performed by looking at specific angles of different body parts and then grading them based on predetermined tables. For ease of use, the body is split into segments which form two groups. Group A includes the wrist in addition to the upper and lower arm, while Group B includes the neck, trunk, and legs (Appendix C). Additional marks would be added if the posture includes twisting or lifting a heavy load which will lead to a more awkward position and a higher score. After recording all the scores, the final score is deduced from the table provided (McAtamney et al., 1993). The final score is compared to the given guidelines with 1 or 2 being acceptable, 3 or 4 needing further investigation, 5 or 6 needing further investigation and should probably be changed soon, and finally a score of 7 requiring immediate change to achieve optimal ergonomic conditions (McAtamney et al., 1993).

The Rapid Entire Body Assessment (REBA) is another quantitative analysis tool (Hignett et al., 2000). REBA was developed after the researchers found a need for such a tool by comparing existing tools. This tool was created to give sufficient detail within a wider range with respect to load handling (Hignett et al., 2000). Much like other tools, REBA is used to perform postural analysis to identify MSD risks. REBA divides the body into segments to be separately studied, since each body part requires a different approach. The two groups of body parts are Group A (trunk, neck, and legs) and Group B (upper arms, lower arms, and wrists) (Appendix D). This tool also provides a different scoring system that encompasses static, dynamic, rapid changing, or unstable postures. Much like the RULA analysis, REBA requires no tools except the tables provided. While using REBA, the user will provide three separate scores based on the three tables provided and a final result is then deduced. Based on the obtained result the user will know the level of urgency for a corrective action if needed. A score of 1 means that the risk level is negligible and no action is needed, a score of 2-3 presents a low risk level and some action might be necessary, a score of 4-7 means that the risk level is medium and action is required to mitigate this risk, a score of 8-10 means that there is a high risk level and action should be taken soon to prevent this risk, and finally a score of 11-15 means that the risk level is very high and the task should be not repeated until action is performed to mitigate the risk level (Hignett et al., 2000).

All these tools focus on awkward postures while doing a certain task which makes them all satisfactory assessment tools for monitoring the ablution process. On the other hand, some of the mentioned tools are more developed than the others. As for the WISHA checklists, while the ablution process agrees with the first two time-conditions, it disagrees with the third. The ablution process is performed a maximum of five times per day with a maximum of five minutes (two minutes average) spent each time (Zaeid, 2016). This totals to a maximum of 25 minutes (10 minutes average) per day which does not satisfy the third condition of performing the task for more than two hours per day. Hence, the WISHA checklists will not be considered for this study. Looking at OWAS, this analysis is the least detailed out of the remaining three. OWAS only focuses on the back, arms, and legs without splitting them into further parts. REBA and RULA are based on OWAS by adding improvements to what OWAS provides. RULA and REBA are very similar tools and this might be due to the fact that they were developed by the same person. The main differences between the two tools are that

RULA gives more information about neck position, lower arm position, wrist twist, and wrist position while REBA gives more information about leg bending and trunk bending backward. Although leg bending is an important aspect to be studied, wrist and arm positions are more important in the ablution task and hence RULA would be the best choice of analysis tool.

| Criteria | RULA | REBA |
| --- | --- | --- |
| **Neck Position** | More details | Fewer details |
| **Trunk Bending Backward** | N/A | Details available |
| **Leg Bending Angles** | N/A | Details available |
| **Sequencing in Combination of Scores (Trunk, Legs, Neck)** | Combines trunk score with legs score first then adds neck score | Combines neck score with legs score first then with trunk score |
| **Lower Arm Position** | More details | Fewer details |
| **Wrist Twist** | Details available | N/A |
| **Wrist Position** | More details | Fewer details |
| **Sequencing in Combination of Scores (Lower Arm, Upper Arm, Wrist)** | Combines lower arm with upper arm first then with wrist scores | Combines lower wrist with lower arm first then with upper arm score |
| **Activity/Muscle Score** | Added twice after both group scores. | Added twice after both group scores |
| **States of Action Urgency** | 4 | 5 |

Table 2: Comparison between RULA and REBA

Several computer programs were developed that could be used to help researchers virtually study certain postures and environments. One of these programs is

Technomatix Jack created by Siemens. This program is used for human modeling and simulations. It includes several toolkits that would allow users to perform ergonomic analysis of virtual environments and products (Siemens, 2018). This program also allows you to generate human models similar to the subjects under study which would increase the reliability of the results. Another program is HumanCad® that also allows users to create three-dimensional models and environments that can be studied and analyzed. This tool is also useful as it provides sample models such as cars and heavy machinery to make world building simple (NexGen Ergonomics, 1999). A third program is the 3D Static Strength Prediction Program (3DSSPP) created and distributed by the University of Michigan (2010). It is mainly used to analyze lifting actions, in addition to pushing or pulling. However, this program falls short when analyzing motion capture data. It also has limited posture representation as some joint angles in addition to movement restrictions (2010). These programs, although might prove helpful, are still limited in terms of exactly modeling real people. Therefore, they should not be used alone in an ergonomic/biomechanics analysis; rather, they should be used as a supplemental tool in an analysis.

### F. Ablution Station Design

Ergonomic analysis of everyday tasks is becoming more important as humankind strives to achieve the utmost comfort in everyday life. To this day, only a few studies have been made that fully examine ablution station designs based on ergonomic analysis. The goal of such an ergonomic analysis would be to provide guidelines for future generations to use, which will help them achieve the optimal station for human comfort.

A recent study by Nazeer et al. (2021) highlights the problems present in current ablution station designs. The main problems tackled were difficulty of washing feet, seats being too close to the faucet, feet being too close to the drain, lack of seats, awkward faucet heights, and shallow drains that cause splashing. The two proposed designs feature a higher platform to place the feet and a deep drain that does not allow any water splashing. The designs' dimensions were based on studies of average body dimensions. The two designs differ in that one has two steps of elevation while the other has one singular step of elevation.

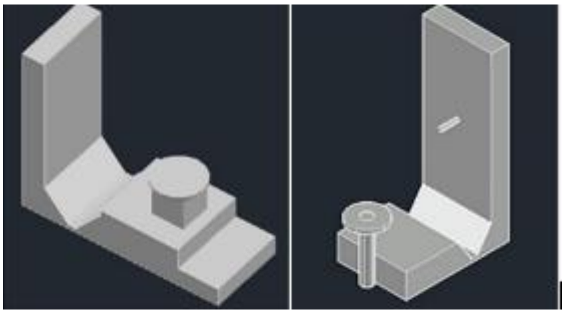


Figure 7: Nazeer et al. (2021) proposed design

The new proposed designs were implemented in four mosques and a survey was conducted to measure the overall impression towards these new stations. The results were satisfactory with more than 85% of the respondents preferring the new designs.


Figure 8: Design still requires reaching forward

Although these designs solve some problems of water splashing and hygiene, they fail in providing a comfortable posture throughout performing ablution. Figure 8 shows a person using the one of the new stations and it is clear that the problem of frequently reaching forward persists. Another issue that comes with this station is the increase in risk of falling and slipping. These designs introduce steps, which might seem helpful, but might also cause slipping injuries and fall injuries when they become wet. A final issue these designs overlook is that people with physical disabilities will have a hard time performing ablution with due to the introduction of the higher step. A proper ergonomic study with an approved ergonomic assessment tool should have been performed to confirm the actual risk of injury level posed by these new designs.

A different approach was used by Che Hasbi & Hamat, (2020) where the authors examined existing ablution station designs and critiqued them based on ergonomic observation and innovation. The study mainly focused on the design in BECC mosque in Denver, the auto wudu' washer, and the four designs in (Mokhtar, 2005).

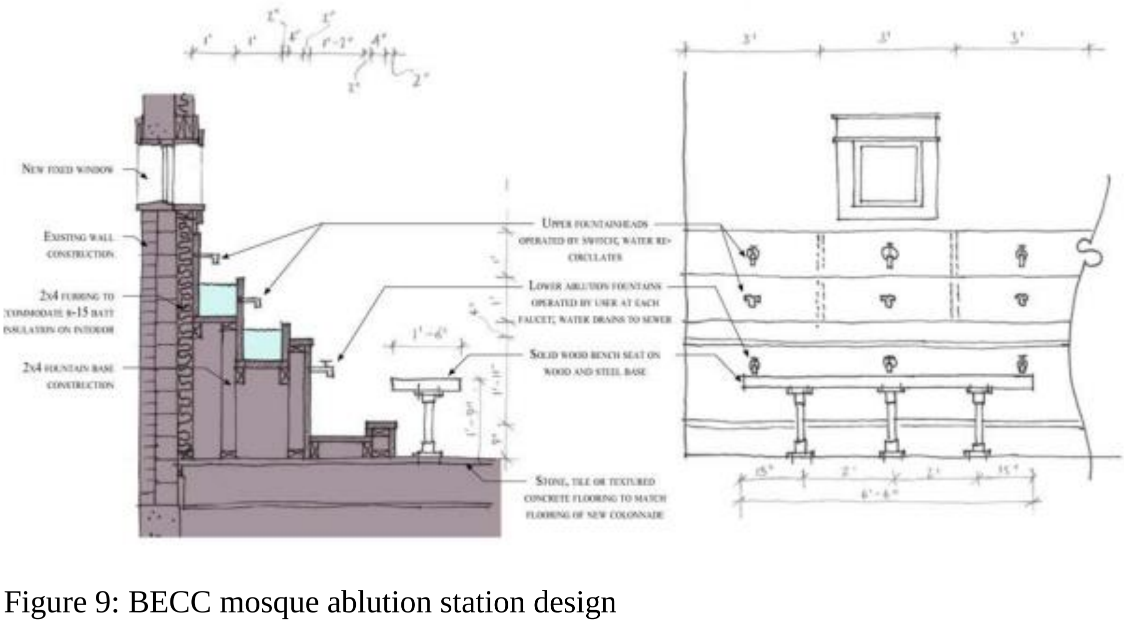



Figure 9: BECC mosque ablution station design

The study found that some stations, like in the BECC mosque, take anthropometric measurements into consideration, and use optimal dimension for things such as seat height and distance. The auto wudu’ washer (Fig. 10) was mentioned as not only an ergonomically sound design but also saves water. However, a lot of mosques lack the funding to obtain and maintain such design as they require high tech sensors and systems.

Figure 10: Auto wudu' washer

This study also critiqued the four designs proposed by Mokhtar (2005). Each design was analyzed based on ergonomic standards and the problems that are present with each station were mentioned. Among those problems are the lack of consideration for wheelchair users and elderly, the high maintenance cost, and the bad postures needed to use these stations. The study concluded by stating some of the required measurements that should be used when designing an ablution station (Che Hasbi & Hamat, 2020). Nevertheless, it was stated that the findings do not fulfil the baseline for all design requirements.

Aman et al. (2017) analyzed one ablution station, which was selected based on anthropometric dimensions of the elderly and disabled populations in Malaysia. The study was based on elderly population to demonstrate movement and functional problems. The station was analyzed using RULA running on the program CATIA V5R21. The study mainly focused on elderly, aged 60 years and above, in the states of Kuala Lumpur, Selangor, Kelantan, and Terengganu. Certain anthropometric measurements were taken of the subjects using tools including a sliding caliper, a standard professional anthropometer, a plastic measuring tape, a weighing scale, and an adjustable chair. In addition to that, the researchers also used a set of measurement tools to measure the circumference, length, and depth of certain objects when needed. Those measurements included 11 body dimensions that were selected based on Malaysian size standards. All statistical data was processed using the IBM Statistical Package for Social Science (SPSS) and the data was expressed as means ± standard deviations, including the 5th and 95th percentile which were also calculated. Certain parameters were used in the RULA analysis of this study, these include intermittent posture, task frequency of less than four times per minute, arms are not working across midline, no check for balance, zero load, and the manikin used was closely resembling an average Malaysian man. The man model was rendered according to these parameters in CATIA. Three posture positions (Fig. 11) were studied in the program. The results were a score of 3 for position 1 and 2, and a score of 2 for position 3. These scores indicate that the design is adequate and that some further investigation might be needed to remove any discomfort that might be caused. The study concluded that the body parts that have the most discomfort while using this design are forearms, neck, trunk and legs. This study also provides useful anthropometric dimensions which might aid future research of ablution station design.

Figure 11: Ablution postures

Another study by Moch et al. (2013) studied the ergonomic aspects of several ablution stations. This study was split into two parts. The first part consisted of surveying 40 participants with ages varying from below 20 to above 40. The results show that 23.33% of these participants experienced injuries while performing ablution. These injuries include waist pain, back pain, and bumping feet or other body parts. The injuries are mainly caused by falling, slipping, or by the limited space of the ablution area. It is worth mentioning that 53% of the participants are over the age of 40. The study also mentions that the difficulties are mainly caused by the lack of seats, the lack of anti-slip floors, the valve height, and the distance between two valves. The second part of the study consists of creating a virtual model analyzed by the program Jack 6.1. This ergonomics program aids researchers in analyzing the postures of everyday tasks by providing them with data about the specified model and parameters. The resulting data is an index number named PEI which stands for posture evaluation index. PEI was created by Caputo, Di Gironimo, and Marzano from University of Naples Frederico II, Italy. It is an integration between three other methods: lower back analysis (LBA), OWAS, and RULA. Since the task of ablution mainly focuses on the upper limb area, the RULA index was multiplied by an amplification factor 1.42 in this study. Data was collected in several locations. It included ablution station dimensions, anthropometric measurements of participants, and posture data in the form of pictures and videos. The data was then used to create the virtual environment and human 3D model which was analyzed. The results were tabulated including the 5th and 95th percentile which were used to resolve any ties between results. The final results of this paper show that the optimal position for ablution is seated, the optimal valve height is 115 to 120 cm, the optimal height for feet holder is 35 to 40 cm, and the optimal distance from the person to the valve is 30 to 35 cm (Moch et al., 2013).

### G. Identifying Gaps

Several gaps can be found in the studies discussed in the previous section. Although the paper by Aman et al. (2017) provides virtual simulation using RULA analysis, it fails to explain the relation between the anthropometric data collected and the design proposed. The analysis was also missing important aspects of checking for balance and checking for limbs working across the midline. These extra variables may prove to be essential to the results and might render further insight in ablution station design. The final major gap in this paper is that the design proposed does not account for users who feel obliged or would prefer to wash/wipe their feet with their hands; rather, the design just allows the feet to be sprayed with water. As such, this design may be avoided by many users.

The other paper by Moch et al. (2013) gives a range of measurements as a guideline for future designs. However, it had some limitations such as not presenting images or figures of the designs analyzed. The final proposed design is also not shown and some dimensions, including seat measurements and distance from the faucet, are not provided. The paper also has some ambiguities such as not properly defining the population that the data collected was collected from. The paper also fails to define the injuries that might be caused by the process, but just groups them all together.

A major gap found in most papers is the lack of proper assessment using reliable ergonomic assessment tools. Studies tend to rely on users' impressions and fail to carry out actual tests that prove the ergonomic capability of the new designs.

While few articles cover the assessment and analysis of existing ablution designs, others take the current designs for granted, and thus, extra research is needed for this topic in order to achieve utmost human comfort while performing ablution.

### H. Research Questions

#### *1. Videotaping part*

1. What are the relations between age, height, and weight and the comfort level per each method of ablution?
2. What is the effect of ablution station design on the comfort level as measured objectively and subjectively?

#### *2. Online questionnaire*

1. What is the effect of gender and presence of disability on perceived comfort per ablution station design?
2. What is the relation between age, height, and weight on the perceived comfort per ablution station design?

3. What is the effect of presence of disability and of a different ablution station design on actual slipping?
4. What is the effect of the four existing ablution station designs on getting wet, ground getting wet, and slippery station?
5. What is the effect of the six ablution station designs (four existing and two new designs) on perceived comfort?

# CHAPTER III

# METHODS

## A. Rationale

Two methods were used to evaluate existing ablution station designs. An interview and observation-based analysis were used to examine the public's perception towards existing designs and to identify areas of improvement. As mentioned in the literature review, many previous studies take current designs for granted as the best designs, without relying on concrete evidence. The use of both methods provides enough information on what people think is the best design and what is the best design based on the postural analysis.

## B. Power Analysis

A power analysis was conducted using G*Power 3.1.9.7. To calculate the required number of people for the indirect method of assessment, the difference between dependent means option was selected under t-tests. Since the groups are based on four completely different designs, it is safe to assume that the effect size will be large. An effect size of 0.5 was used on Cohen's estimate of a medium effect size (Cohen 1977). The obtained results show that a sample size of 45 should be enough to carry out the tests.

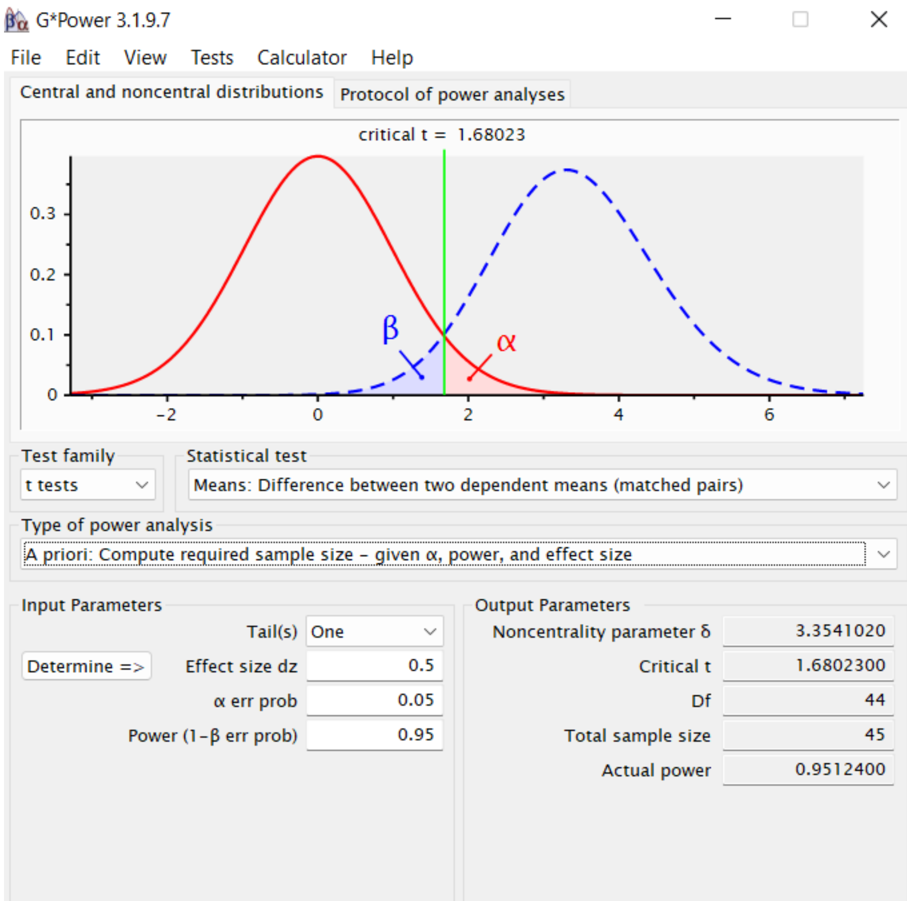



Figure 12: Power analysis

## C. Participants

The study was conducted both remotely and on-site in a selected number of mosques. All participants were selected based on their age, between 18 and 75, religion, and experience in using ablution stations. The recruited participants were of Lebanese, Syrian, and Palestinian nationalities. The participants could have had mobility disabilities. 5 participants were recorded performing ablution in all four mosques; Daouk (Hamra), Aisha Bakkar, Salam (Tallet El Khayyat), and Sultan (Tallet El Khayyat). These recordings were then used to record objective strain levels using RULA and subjective discomfort levels using the LMD scale. Women were excluded since the researcher will not be allowed to record them performing ablution. I was able to survey 40 participants who were split evenly between female and male. This was done to ensure satisfactory results among all the tests. The sampling method, for the 40 survey participants, was snowball sampling through word-of-mouth and social media, such as Facebook, Instagram, LinkedIn, and Twitter.

### D. Existing Ablution Station Designs

To examine the participants' experiences and attitudes toward the comfort of existing ablution station designs, this study used designs Si-F, St-S, St-F, St-FL that were described and analyzed in section Existing Ablution Station Designs of the literature review. These designs, introduced by Mokhtar (2005), were set as the foundations of the newly proposed ablution station designs that are the byproduct of this research study.

### E. Direct Methods of Assessment

#### *1. RULA*

Out of OWAS, WISHA, REBA, and RULA, and as explained in-depth in Chapter II, RULA was used as a direct method of assessment for this study. Four mosques covered the designs mentioned in the literature review. 5 participants, in each mosque, were asked to perform ablution while being video recorded. Three snapshots were taken that show the participants in three predetermined positions: washing the face, washing the arms, and washing the feet. These snapshots along with the RULA score calculator (Osmond Ergonomics), were used to input the body angles and loads to output the RULA score and recommendation. The overall score signifies the potential risk behind using the analyzed design. A score of 1 or 2 being acceptable, 3 or 4 needing further investigation, 5 or 6 needing further investigation and should probably be changed soon, and finally a score of 7 requiring immediate change to achieve optimal ergonomic conditions (McAtamney et al., 1993).

### 2. *Localized Musculoskeletal Discomfort (LMD)*

LMD is the scale used to record the level of discomfort, created by van der Grinten and Smitt in 1992, and based on the category ratio (Cr-10) created by Borg in 1990 (Hamberg-van Reenen et al., 2008). This scale was used in this study by recording the participants' answers after they have performed ablution (Appendix F). This scale ranges from 0 (no discomfort at all) to 10 (extreme discomfort). However, people were free to choose any intermediate decimal number between 0 and 10. It targets 12 body parts, but in this study, we only focused on 6 which are: neck, shoulders, upper arms, lower back, thighs, and legs. LMD will benefit the study by giving an insight on users' experiences with regards to comfort while performing ablution using the stations.

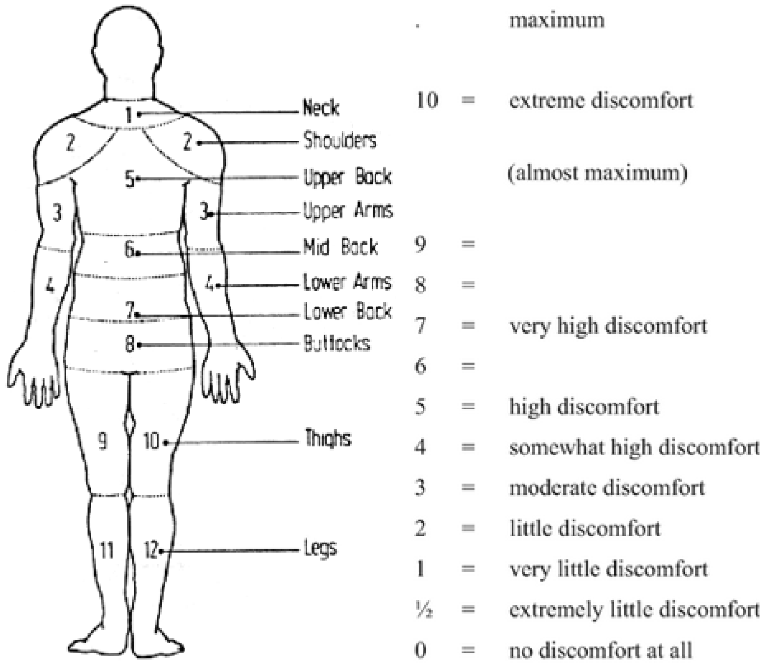



Figure 13: LMD scale

### F. Indirect Methods of Assessment

A structured questionnaire with predefined questions (Appendix E) was conducted with a sample from the Islamic community recruited via snowball sampling. The survey (Appendix E) contains questions about the participant's background, such as age, gender, height, and whether they have any physical or mobility-related disabilities. These background questions were important to better explain and interpret the results. The next part of the questionnaire consisted of a series of questions that were asked about each of the four different ablution designs and the two proposed designs. The questions include two binary questions asking the participants if they have used the specific design and if they have ever slipped or fell while using this design. They also included Likert scale questions that tackle comfort level, risk of injury, and risk of getting wet, while using this design. Finally, the survey included some open-ended questions that ask the users what they like or dislike about the design, and what improvements they would recommend.

## G. Data Analysis

The data collected was entered into SPSS version 26. Before proceeding with the main data analysis, preliminary analysis "data cleaning" was conducted to check for mis-entered data, missing values, reliability of scales, and univariate outliers. Then, sample descriptives were provided with frequency and percentage for categorical variables and range, mean, and standard deviations for continuous variables.

For the videotaping and interview part one-way analysis of variance was used to study subjective comfort levels across the four station designs. If the findings were significant, a comparative Tukey HSD test will be performed to check where the significance lies.

For the online survey part, the 5-point Likert scale was used since parametric analysis (as the Liker scale) is seen as robust when comparing it with non-parametric analysis that lead to the same results (Mircioiu & Atkinson, 2017). As ergonomic studies pertain to human comfort, the Likert scale was chosen since it is mostly used in the medical field to assess satisfaction (Sullivan & Artino, 2013). The effect of gender on perceived comfort per station design was studied using independent sample t-tests. In addition, the relations between "age, height, and weight" and "the perceived level of comfort" per station design was investigated using independent t-tests. Moreover, chi-square tests were conducted to study the relations between the "presence of disability and station design" and "the actual slipping". One-way analysis of variance tests was conducted to study the effect of the four existing ablution station designs on getting wet, ground getting wet, and slippery station. Finally, one-way analysis of variance tests was conducted to study the effect of the six ablution station designs (four existing and two new designs) on perceived overall comfort. If the findings were significant, a comparative Tukey HSD test will be performed to check where the significance lies.

Note: the qualitative questions of the online questionnaire were analyzed separately using thematic analysis. Direct quotes from participants were recorded and analyzed using the inductive method of analysis to extract codes, sub-themes, and themes.

## H. Limitations

The study's results are not generalizable; they cannot apply to all Muslims, all citizens of Lebanon, all age groups, or both genders. The results can only be applied to the target sample. Other limitations of this study include the COVID-19 pandemic which hindered people's access to mosques in the past two years when the data was being collected. The pandemic also led the mosques to restrict access to the ablution stations. Additionally, another limitation is the electricity and internet issues in Lebanon which led to incomplete or unsaved survey results which hindered the data collection process. On the technical end, many Muslim schools require the rubbing of the feet while performing ablution (also validated in the descriptive results). As such, the researcher was not able to recommend more technologically advanced ablution stations wherein the feet cannot be rubbed without awkward postures. Hence, the researcher opted for traditional designs that are more ergonomic.

# CHAPTER IV

# RESULTS

In this chapter, the results of the study will be discussed. To further explore the effect of different ages, heights, weights on the outcome variable comfort levels, the effect of station design on the comfort level, the effect of different genders on perceived comfort, the effect of different ages, heights, and weights on the perceived level of comfort, the effect of the presence of disability and the difference in station design on the actual slipping, the effect of the four existing ablution station designs on wetness, and the effect of all six designs on perceived comfort, the chapter will be divided into eight sections. One of the sections will describe the sample characteristics.

## A. Descriptive of the Sample Characteristics

The sample of the survey was composed of N=40 (50% males and 50% females). Regarding the age groups, the youngest female was 18 years old and the eldest was 61 years old, with the average age being 29.4. The youngest male was 18 years old and the eldest was 72 years old, with the average being 34.3. Regarding the participants' heights, the shortest female was 150cm and the tallest was 180cm, with the average being 162.8cm. The shortest male was 141cm and the tallest was 192cm, with the average being 176cm. Regarding the weights, the female with the smallest weight measured was 44kg and the largest weight measured was 89kg, with the average being 63.2kg. The male with the smallest weight measured was 40kg and the largest weight measured was 123kg, with the average being 80.9kg. None of the participants uses a wheelchair, none uses a cane, none has upper limb differences, only one female has lower limb differences, two females and one male have bodily pain, and none has a medical or genetic condition. 23 (57%) of the participants believe that their clothes becoming wet while performing ablution is an inconvenience. Finally, 37 (93%) of the participants rub their feet while performing ablution.

### B. Ablution Design Usage

The usage of each ablution station was studied using a Chi-Square analysis. The results show that there is no difference between the type of design and the number of people that used it. With Chi-Square p value = .065 > .05. Hence, the type of design does not affect weather people have used it or not. It is worth noting that that 90% of the participants have used Design A, 100% have used Design B, 87.5% have used Design C, and 82.5% have used Design D.

### C. Gender and Perceived Comfort

Gender differences of the participants across the comfort of the existing four designs were studied, using independent t-tests. Levene's test revealed that the homogeneity of variances assumption was met (no significant differences in the variances between males and females) between designs (p = .33; .33; .78; .46 > .05). The independent t-tests showed their gender was significant in perceiving comfort of the design A only (p = 0.05). From the means we can deduce that men preferred design A more than women. This means that the gender of the participants did not affect the perception of comfort of designs B, C, and D.

| | Men | | Women | | | | |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t-test | df | Sig. |
| Comfort Design A | 3.08 | .84 | 2.58 | .71 | -2.02 | 38 | .05 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Comfort Design B | 2.91 | .73 | 3.3 | .91 | 1.46 | 38 | .15 |
| Comfort Design C | 3.38 | .98 | 3.21 | .9 | -.55 | 38 | .58 |
| Comfort Design D | 3.3 | .92 | 2.78 | .78 | -1.9 | 38 | .06 |

Table 3: Genders of participants and perceived comfort per design

### C. Age, Height, and Weight with Perceived Comfort

Age differences of the participants across the comfort of the existing four designs were studied, using independent t-tests. The ages were divided into two categories: less than 33.8 years old and older than 33.8 years old which is the average age. Levene's test revealed that the homogeneity of variances assumption was not met for designs A, B, and C (significant differences in the variances between participants less than 33.8 years and more than 33.8 years) (p = .0.4; .012; .001; < .05), whereas it was met for design D (p = 0.07 > .05). The independent t-tests showed their age was insignificant in perceiving comfort in all four designs (p = 0.24; .11; .43; .21 > .05). This means that the age of the participants did not affect the perception of comfort of designs A, B, C, and D.

| | Age<33.8 | | Age>33.8 | | | | |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t-test | df | Sig. |
| Comfort Design A | 2.68 | .63 | 2.98 | .95 | -1.17 | 38 | .24 |
| Comfort Design B | 3.31 | .97 | 2.89 | .63 | 1.6 | 38 | .11 |
| Comfort Design C | 3.18 | .60 | 3.41 | 1.18 | -.78 | 38 | .43 |
| Comfort Design D | 2.86 | .73 | 3.21 | 1.00 | -1.26 | 38 | .21 |

Table 4: Age of participants and perceived comfort per design

Height differences of the participants across the comfort of the existing four designs were studied, using independent t-tests. The heights were divided into two categories: less than 169.4cm and more than 169.4cm which is the average height.

Levene's test revealed that the homogeneity of variances assumption was met for designs A and D (insignificant differences in the variances between participants less than 169.4 cm and more than 169.4 cm) (p = .17; .61 > .05), whereas it was not met for designs B and C (p = .01; .012 < .05). The independent t-tests showed that height was significant in perceiving comfort in design A (p = .001 < .05). From the means we can see that taller participants preferred design A more than shorter participants. It also showed that participants' heights were insignificant in perceiving comfort in designs B, C, and D (p = .19; .37; .68 > .05). This means that the height of the participants did not affect the perception of comfort of designs B, C, and D.

| | <169.4 cm | | >169.4 cm | | | | |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t-test | df | Sig. |
| Comfort Design A | 2.43 | .61 | 3.23 | .80 | -3.53 | 38 | .001 |
| Comfort Design B | 3.28 | 1.00 | 2.93 | .61 | 1.33 | 38 | .19 |
| Comfort Design C | 3.16 | .65 | 3.43 | 1.15 | -.90 | 38 | .37 |
| Comfort Design D | 3.09 | .89 | 2.98 | .90 | .40 | 38 | .68 |

Table 5: Height of participants and perceived comfort per design

Weight differences of the participants across the comfort of the existing four designs were studied, using independent t-tests. The weights were divided into two categories: less than 73.6kg and more than 73.6kg which is the average weight. Levene's test revealed that the homogeneity of variances assumption was met for all four designs (insignificant differences in the variances between participants less than 73.6kg and more than 73.6kg) (p = .16; .09; .76 > .05) except for design B (p=0.035<0.05). The independent t-tests showed their weight was insignificant in perceiving comfort in designs B, C, and D (p = 0.91; .25; .14 > .05). This means that the height of the participants did not affect the perception of comfort of designs B, C, and D. It also showed that weight was significant in perceiving comfort in design A (p =

.014 < .05). By comparing the means, we can see that participants of a larger weight preferred design A over participants of a smaller weight.

| | <73.6 kg | | >73.6 kg | | | | |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | t-test | df | Sig. |
| Comfort Design A | 2.50 | .65 | 3.16 | .83 | -2.81 | 38 | .008 |
| Comfort Design B | 3.18 | .98 | 3.03 | .69 | .56 | 38 | .57 |
| Comfort Design C | 3.09 | .73 | 3.5 | 1.08 | -1.36 | 38 | .18 |
| Comfort Design D | 2.85 | .86 | 3.23 | .89 | -1.38 | 38 | .17 |

Table 6: Weight of participants and perceived comfort per design

### D. Disability on Actual Slipping

The effect of the disability on the actual slipping was measured using Chi-Square. Each participant had 4 inputs (1 per design), so the total number of inputs from the participants was 160. It is worth noting that only 4 out of the 40 participants recorded having a disability. The test shows that there was no significance between the presence of disability and actual slipping while performing ablution with (p = .065 > .05). Since, the Chi-Square showed no significance, a post hoc testing should not be performed.

| | Slipped | No Slip | | | |
|---|---|---|---|---|---|
| | N | N | Chi-Square | df | Sig. |
| Disability | 6 | 10 | 3.4 | 1 | 0.065 |
| No Disability | 26 | 118 | | | |

Table 7: Disability on actual slip per design

### E. Designs and Perception of Wetness of Clothes and Ground and Slipping

To check the effect of the designs themselves on the perception of wetness of clothes and ground, an ANOVA test followed by a comparison Tukey HSD test was done. The ANOVA results show that there is a significance between the station used and the perception of clothes getting wet with p=.00<0.05. Similarly, there is a significance between the station used and the perception of ground getting wet with p=.00<0.05. The Tukey HSD shows that there is significant difference between Design A with designs B, C, and D on perception of wetness of clothes and ground with p(clothes) = .00, .001, and .019 < .05 respectively and p(ground) = .00, .00, and .00 < .05 respectively. This, with the addition of the positive mean difference, show that design A is perceived to make the clothes and the ground the most wet. The test also shows significance between Designs B and D in perception of wetness of clothes only with p(clothes) = .026 < .05. This, with the addition of the negative mean difference, show that design B is perceived to wet the clothes less than design D. There are insignificant differences between Designs B and C with regards to perception of wetness of clothes and ground with p = .2 and p = .34 > .05 respectively; Designs B and D with regards to perception of wetness of ground with p = .4 > .05; and Designs C and D with regards to both perceptions with p(clothes) = .81 and p(ground) = 1.0 > .05.

| | | Clothes | | Ground | |
|---|---|---|---|---|---|
| | | Mean Diff. | Sig. | Mean Diff. | Sig. |
| Design A | Design B | 1.3 | .00 | .92 | .00 |
| | Design C | .87 | .001 | 1.3 | .00 |
| | Design D | .67 | .019 | 1.2 | .00 |

| | | Clothes | | Ground | |
|---|---|---|---|---|---|
| | | Mean Diff. | Sig. | Mean Diff. | Sig. |
| Design B | Design A | -1.3 | .00 | -.92 | .00 |
| | Design C | -.45 | .20 | .37 | .34 |
| | Design D | -.65 | .026 | .35 | .40 |

| | | Clothes | | Ground | |
|---|---|---|---|---|---|
| | | Mean Diff. | Sig. | Mean Diff. | Sig. |

| | | Mean Diff. | Sig. | Mean Diff. | Sig. |
|---|---|---|---|---|---|
| Design C | Design A | -.87 | .001 | -1.3 | .00 |
| | Design B | .45 | .20 | -.37 | .34 |
| | Design D | -.20 | .81 | -.02 | 1.0 |

| | | Clothes | | Ground | |
|---|---|---|---|---|---|
| | | Mean Diff. | Sig. | Mean Diff. | Sig. |
| Design D | Design A | -.67 | .019 | -1.2 | .00 |
| | Design B | .65 | .026 | -.35 | .40 |
| | Design C | .20 | .81 | .02 | 1.0 |

Table 8: Perception of wetness of clothes and ground across designs

To check the effect of the designs themselves on the perception of risk of slipping, an ANOVA test followed by a comparison Tukey HSD test was done. The participants were asked to rate their perception of slipping when using the design from low risk to high risk of slipping. The ANOVA result showed that there was a high significance between the type of station and the perception of risk of comfort with p = .00<0.05. There is a significant difference between Design A with B, C, and D on perception of slipping with p = .036, .00, and .00 < .05 respectively. By looking at the mean difference, we can see that design A was perceived to have a higher risk of slipping than the other designs. There are insignificant differences between Designs B with C and D with regards to perception of slipping with p = .52 and p = .90 > .05 respectively; and Designs C and D with regards to perception of slipping with p = .90> .05. This shows that the 3 designs are seen to cause similar risk of slipping.

| | | Slip | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design A | Design B | .60 | .036 |
| | Design C | .90 | .00 |

| | | | |
|---|---|---|---|
| | Design D | .75 | .005 |

| | | Slip | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design B | Design A | -.60 | .036 |
| | Design C | .30 | .52 |
| | Design D | .15 | .90 |

| | | Slip | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design C | Design A | -.90 | .00 |
| | Design B | -.30 | .52 |
| | Design D | -.15 | .90 |

| | | Slip | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design D | Design A | -.75 | .005 |
| | Design B | -.15 | .90 |
| | Design C | .15 | .90 |

Table 9: Perception of slipping across designs

**F. All Six Designs and Perception of Comfort**

To check the effect of the designs themselves on the perception of comfort, an ANOVA test followed by a comparison Tukey HSD test was done. The test was repeated three times for upper body comfort, lower body comfort, and overall comfort. For the upper body comfort, the ANOVA test was significant with p=0.00<0.05. The Tukey post hoc test showed that the significant lies between design A and designs B, D, 1, and 2 with p values =.00, 0.33, .00, .00 < .05 respectively. It is clear from the mean difference that design A is the least comfortable design for washing the upper body as perceived by the participants. There is also significant difference between Design C with B, 1, and 2 on perception of upper body comfort with p values = .025, .002, .013 < .05. This significance shows that design C was perceived as least comfortable for upper body washing between the mentioned designs. There is also a significant difference between design D and design 1 with p = .025 < .05 showing that design D is perceived as less comfortable for upper body washing than design 1. There are insignificant differences between Designs A with C with regards to perception of upper body comfort with p = .203 > .05; Designs B with D,1, and 2 with p = .16, .97; 1.00 > .05 respectively; Design C with D with p = .97 > .05 respectively; Design D with Design 2 with p = .101 > .05; and Design 1 with Design 2 with p = 0.995 > .05.

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design A | Design B | .000 | .000 |
| | Design C | -.46 | .203 |
| | Design D | -.20 | .033 |
| | Design 1 | -1.1 | .000 |
| | Design 2 | -1.1 | .000 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design B | Design A | 1.3 | .00 |
| | Design C | .75 | .025 |
| | Design D | .57 | .16 |
| | Design 1 | -.17 | .97 |
| | Design 2 | -.05 | 1.00 |

| | | Comfort | |
|---|---|---|---|

| | | Mean Diff. | Sig. |
|---|---|---|---|
| Design C | Design A | .55 | .20 |
| | Design B | -.75 | .025 |
| | Design D | -.17 | .97 |
| | Design 1 | -.92 | .002 |
| | Design 2 | -.80 | .013 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design D | Design A | .72 | .033 |
| | Design B | -.57 | .16 |
| | Design C | -.17 | .97 |
| | Design 1 | -.75 | .025 |
| | Design 2 | -.62 | .10 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design 1 | Design A | 1.47 | .000 |
| | Design B | .17 | .97 |
| | Design C | .92 | .002 |
| | Design D | .75 | .025 |
| | Design 2 | .12 | .99 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design 2 | Design A | 1.35 | .00 |
| | Design B | .05 | 1.00 |
| | Design C | .80 | .013 |
| | Design D | .62 | .10 |
| | Design 1 | -.12 | .99 |

Table 10: Perception of upper body comfort across designs

As for the lower body comfort perception, the ANOVA test was significant with p=0.00<0.05. The Tukey post hoc test showed that the significant lies between design B and designs A, C, D, 1, and 2 with p values =.00, 0.00, .036, .00, .00 < .05 respectively. It is clear from the mean difference that design B is the least comfortable design for washing the lower body as perceived by the participants. There is also significant difference between Design D with designs 1 and 2 on perception of lower body comfort with p values = .002, .001 < .05. This significance shows that design D was perceived as least comfortable for lower body washing between the mentioned designs. The rest of the results were insignificant.

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design A | Design B | 1.15 | .00 |
| | Design C | -.10 | .99 |
| | Design D | .37 | .69 |
| | Design 1 | -.62 | .15 |
| | Design 2 | -.67 | .101 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design B | Design A | -1.1 | .00 |
| | Design C | -1.2 | .00 |
| | Design D | -.77 | .036 |
| | Design 1 | -1.7 | .00 |
| | Design 2 | -1.8 | .00 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design C | Design A | .10 | .99 |
| | Design B | 1.25 | .00 |

| | | | |
|---|---|---|---|
| | Design D | .47 | .44 |
| | Design 1 | -.52 | .33 |
| | Design 2 | -.57 | .23 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design D | Design A | -.37 | .69 |
| | Design B | -.77 | .03 |
| | Design C | -.47 | .44 |
| | Design 1 | -1.0 | .002 |
| | Design 2 | -1.05 | .001 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design 1 | Design A | .62 | .15 |
| | Design B | 1.7 | .00 |
| | Design C | .52 | .33 |
| | Design D | 1.0 | .002 |
| | Design 2 | -.05 | 1.0 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design 2 | Design A | .67 | .10 |
| | Design B | 1.8 | .00 |
| | Design C | .57 | .23 |
| | Design D | 1.05 | .001 |
| | Design 1 | .05 | 1.0 |

Table 10: Perception of lower body comfort across designs

For the overall body comfort perception, the ANOVA test was significant with $p=0.00<0.05$. The Tukey post hoc test showed that the significant lies between design 1 and designs A, B, D with p values =.00, .048, .00 < .05 respectively. It is clear from the mean difference that design 1 is the most comfortable design for overall washing of the body as perceived by the participants. There is also significant difference between Design 2 with designs A, B, C, and D on perception of lower body comfort with p values = .00, .026, .048, .00 < .05. This significance shows that design 2 was perceived as most comfortable for overall body washing between the mentioned designs. Another significant difference is between Design A with Designs B and C on perception of lower body comfort with p value = .026< .05. This shows that design A was perceived as less comfortable for overall body washing than designs B and C. The rest of the results were insignificant.

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design A | Design B | -.67 | .048 |
| | Design C | -.72 | .026 |
| | Design D | -.27 | .84 |
| | Design 1 | -1.3 | .00 |
| | Design 2 | -1.4 | .00 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design B | Design A | .67 | .048 |
| | Design C | -.05 | 1.0 |
| | Design D | .40 | .52 |
| | Design 1 | -.67 | .048 |
| | Design 2 | -.72 | .026 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design C | Design A | .72 | .026 |
| | Design B | .05 | 1.0 |

| | | | |
|---|---|---|---|
| | Design D | .45 | .39 |
| | Design 1 | -.62 | .085 |
| | Design 2 | -.67 | .048 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design D | Design A | .27 | .84 |
| | Design B | -.40 | .52 |
| | Design C | -.45 | .39 |
| | Design 1 | -1.07 | .00 |
| | Design 2 | -1.12 | .00 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design 1 | Design A | 1.35 | .00 |
| | Design B | .67 | .048 |
| | Design C | .62 | .085 |
| | Design D | 1.07 | .00 |
| | Design 2 | -.05 | 1.0 |

| | | Comfort | |
|---|---|---|---|
| | | Mean Diff. | Sig. |
| Design 2 | Design A | 1.4 | .00 |
| | Design B | .72 | .026 |
| | Design C | .67 | .048 |
| | Design D | 1.12 | .00 |
| | Design 1 | .05 | 1.0 |

Table 11: Perception of overall body comfort across designs

**G. RULA Analysis**

Five participants were recorded as they were performing ablution at four different mosques in Beirut and their RULA scores were calculated. The results were obtained by calculating the RULA scores for three postures (washing the face, washing the feet, and washing the arms) and taking the average score. Noting that the averages were rounded to the nearest full number, the first participant (19y.o.;  H:167; W:61kg) scored 3-3-4-4 at the respective designs. The second participant (27y.o.; H:176cm; W:70kg) scored 3-4-5-4. The third participant (35y.o.; H:172cm; W:79kg)  scored 3-4-4-5. The fourth participant (40y.o.; H:184cm; W:98kg) scored 3-5-5-4. Finally, the fifth participant (62y.o.; H:179cm; W:86kg) scored 3-4-5-5. It is noteworthy to mention that the average for the design A was 3 on the RULA score, 4 for the design B, 5 for design C, and 4 for design D.

| | Design A | Design B | Design C | Design D |
|---|---|---|---|---|
| Participant 1 | 3 | 3 | 4 | 4 |
| Participant 2 | 3 | 4 | 5 | 4 |
| Participant 3 | 3 | 4 | 4 | 5 |
| Participant 4 | 3 | 5 | 5 | 4 |
| Participant 5 | 3 | 4 | 5 | 5 |

Table 13: RULA scores for 5 participants in 4 mosques

### H. LMD Analysis

The same five participants were asked to rate their level of discomfort after performing ablution on the 4 designs. They filled out a survey asking them to circle the number on the LMD scale that most accurately represents the level of discomfort for the specific body part. The results are tabulated below:

| | Design A | Design B | Design C | Design D |
|---|---|---|---|---|
| Participant 1 | 3 | 4 | 3 | 0.5 |

| | | | | |
|---|---|---|---|---|
| Participant 2 | 1 | 2 | 1 | 1 |
| Participant 3 | 0.5 | 3 | 4 | 0.5 |
| Participant 4 | 1 | 0 | 5 | 0 |
| Participant 5 | 2 | 5 | 4 | 5 |

Table 14: Neck LMD Scores

| | Design A | Design B | Design C | Design D |
|---|---|---|---|---|
| Participant 1 | 1 | 0.5 | 2 | 0.5 |
| Participant 2 | 4 | 3 | 3 | 2 |
| Participant 3 | 4 | 2 | 2 | 0.5 |
| Participant 4 | 1 | 0 | 7 | 1 |
| Participant 5 | 2 | 5 | 6 | 4 |

Table 15: Shoulders LMD Scores

| | Design A | Design B | Design C | Design D |
|---|---|---|---|---|
| Participant 1 | 1 | 0.5 | 1 | 1 |
| Participant 2 | 3 | 3 | 4 | 4 |
| Participant 3 | 5 | 1 | 2 | 0.5 |
| Participant 4 | 0.5 | 0 | 7 | 1 |
| Participant 5 | 2 | 5 | 7 | 6 |

Table 16: Upper Arm LMD Scores

| | Design A | Design B | Design C | Design D |
|---|---|---|---|---|
| Participant 1 | 4 | 1 | 1 | 2 |
| Participant 2 | 5 | 3 | 7 | 4 |
| Participant 3 | 0.5 | 3 | 8 | 7 |
| Participant 4 | 0.5 | 0.5 | 8 | 2 |
| Participant 5 | 2 | 1 | 6 | 5 |

Table 17: Lower Back LMD Scores

| | Design A | Design B | Design C | Design D |
|---|---|---|---|---|
| Participant 1 | 1 | 4 | 2 | 1 |
| Participant 2 | 3 | 6 | 6 | 3 |
| Participant 3 | 0 | 4 | 1 | 3 |
| Participant 4 | 0.5 | 5 | 8 | 4 |
| Participant 5 | 4 | 1 | 5 | 7 |

Table 18: Thighs LMD Scores

| | Design A | Design B | Design C | Design D |
|---|---|---|---|---|
| Participant 1 | 0.5 | 3 | 3 | 1 |
| Participant 2 | 2 | 5 | 5 | 2 |
| Participant 3 | 0.5 | 7 | 8 | 5 |
| Participant 4 | 1 | 5 | 7 | 4 |
| Participant 5 | 4 | 1 | 6 | 4 |

Table 19: Legs LMD Scores

# CHAPTER V

# DISCUSSION

## A. Ablution Design Usage

In the survey, people were asked if they have used each of the four existing designs. Most participants have used the designs with percentages falling above 82.5% reaching 100%. Design B, the regular sink, was the most used design and this is expected as it is the design found in all homes and in some mosques. Design D was the least used design among the 40 participants, and this may be due to that few mosques use this design. However, the results show that the design type does not affect its usage. Hence, no design is more popular than the rest.

## B. Gender

This study has shown that different factors affect the perception of comfort differently, per design. The results show that there is no significance in perception of comfort across designs B, C, and D between genders. This shows that males and females perceive the designs to be similarly comfortable/uncomfortable. On the other hand, there is a significant difference between genders while perceiving the comfort of design A, where males tend to find it more comfortable than females. This can be explained due to the presence of a far chair in design A that requires bending of the torso and head to reach the faucet. According to Summers et al. (2010), women have a lower center of gravity than men which means that their lower body can be stronger than their upper body. This result coincides with the findings of Abd Ghani et al. (2021)

which shows that females are more comfortable standing up while performing ablution than sitting down and having to bend.

### C. Ablution Design Usage

In the survey, people were asked if they have used each of the four existing designs. Most participants have used the designs with percentages falling above 82.5% reaching 100%. Design B, the regular sink, was the most used design and this is expected as it is the design found in all homes and in some mosques. Design D was the least used design among the 40 participants, and this may be due to that few mosques use this design. However, the results show that the design type does not affect its usage. Hence, no design is more popular than the rest.

### D. Age

Age was one of the factors that was expected to have an influence on perception of comfort of the designs. Hasbi and Hamat (2020) state that seniors attend the mosque more frequently than middle and young age individuals. In this study, the results show that age was not correlated to the perception of comfort of the designs, which means that it did not matter whether the respondent was young or old while perceiving how comfortable a design is. This contradicts a recent finding by Hasbi and Hamat (2020) that states that the participants who belonged to the older age groups suffered from back aches while performing ablution at the mosque due to frequent bending. This can be explained by the fact that the majority of the participants were of young and middle ages and only few were of old ages, particularly that the study did not include individuals who were above 75 years of age who would experience higher percentage of lower back pain and other forms of discomfort (Knezevic et al., 2021).

### E. Height and Weight

Height is another factor that was significantly correlated to design A. Since the design has a seat, it was expected that those who were taller perceived the design to be more comfortable, which was proven to be correct. With such a design, if a tall individual were to stand up to perform ablution, they would have to bend their back to wash their upper body parts since the faucet is of a low height. The taller participants found the design to be more comfortable than the shorter participants. This result is confirmed by Hasbi and Hamat (2020) who conducted interviews at Masjid Universiti Malaysia Terengganu concerning the perception of comfort of the present designs and showed that having no seats would be seen as comfortable for those who are shorter who do not need to bend their backs and necks to reach the faucet while standing up, showing the important of the seat for the taller population. Similar to the height, participants with a larger weight perceived design A as more comfortable than those with the smaller weight. The factor of the seat has been playing a big role in the perception of comfort for the participants. Although none of the previous literature entails weight as an important factor, this study would argue that having a seat would allow individuals with larger weights to bend over and reach their feet in an easier way than having to do so while standing up.

### F. Disability

Very few participants recorded a visible/known disability and those who did mainly had lower back pain which pertains to many people. The results do not show significance of slipping of people with disability, except for design C where people with no disability recorded slipping more than those with disability. This significance could be explained due to the large gap in number of participants, with and without a disability.

### G. Designs

Each design's perception of wetness was seen differently from the participants' perspectives. The results show that design A was seen to be the design that would wet the ground and the performer's clothes the most. This could be explained by the fact that when they are seated, and since it is the only design with a seat, their knees and legs are closer to the faucet which might wet their clothes more. One participant noted that since the faucet is high, splashing might occur, and the clothes would become wet. Additionally, when they are washing their face, they would be carrying water from the faucet over their pants which might wet the clothes. As for wetness of the floor, Dawal et al. (2016) state that when there is a floor elevation, performers are less likely to wet the floor. In design A, the floor is not elevated and there is no gap to release the excess water, which explains why the participants view the design to have the wettest floor. Several participants have also noted that the seat would always be wet. Similarly, design D is perceived to cause wetting of the clothes more than design B since it allows performer to raise their feet onto the step which might cause more water getting to the pants, while design B requires frequent bending to reach the feet or raising of the feet onto the sink, being further away from the clothes. Moreover, the first design A had the highest perception of slipping with regards to the other designs. This can be analyzed by the fact that the ablution performers would have to stand up while the floor is still wet which might cause them to slip, while in the others, they are already standing up.

In this study, the researcher designed two new ablution stations adhering to ergonomic standards. The designs have a seat, with the difference being the ability to stand up and wash the upper body or having a lower faucet to wash the upper body while being seated. The results showed that designs A and C were the least comfortable designs for washing the upper body parts. This is expected as in design A people would be sitting down and trying to reach a far faucet which causes many inconveniences. Additionally, design C only has a low height faucet making it extremely difficult to wash the upper body as it requires the back to be constantly bent.

As for the lower body, design B was seen as the most uncomfortable design to utilize. Using design B requires the individual to raise their foot to the sink level and ultimately standing on one leg with the second leg being much higher above the ground level. This not only causes discomfort as the back would not be aligned, but this is also poses a big risk of slipping or causing back problems. Design D was also deemed less comfortable than designs 1 and 2 showing that the new designs were perceived as more comfortable with the downward faucet rather than a faucet with a ledge.

Finally, the results for overall comfort show that the participants prefer both new designs over all four existing designs and perceive them as comfortable. Overall, participants preferred design 1 over design 2 and explained that being able to stand up to wash the upper body is more convenient for them than washing the upper body while being seated. This goes in tandem with the better perception of comfort of the design A that has the seat which is integrated in the new designs.

### H. RULA Scores

The obtained results show us that each design would score differently on the RULA scale. As these results are mostly objective and most people will have similar methods when performing ablution on these stations, we can assume that if the number of participants increased, the average RULA scores for the designs will remain close to the obtained average. However, more participants are needed to confirm this assumption. For design A, the results are 3 for all five participants. As this design is the only one with a seat, there is little to no variation in the method of ablution and most people will have the same posture. In design B, the results varied between 3 and 5 with an average of 4 showing slight discrepancy between method of ablution while using this station. As this station is available in homes as well as some mosques, people tend to use it more often than the other designs. Hence, people have gotten used to using this design even if at the first glance it seems uncomfortable to use. It is worth noting that the elderly and people with larger weights will tend to carry water from the faucet down to their feet rather than placing the foot on the sink. This leads to an extreme back bending position, thus increasing the RULA score. As for design C, the scores were mainly tending towards a score of 5. The main noticeable difference here is the back inclination while reaching for the water. Faucets are mainly elevated at 1.5 meters (Abd Ghani et al., 2021) to account for below the average shoulder height and above elbow height. This causes shorter and thinner people to have lower RULA scores on this design as they require less back bending to reach the water. Finally, design D scores are also inclined towards 4 and 5 and this is expected as design C and D are extremely similar. In fact, 3 of the 5 participants opted to disregard the ledge and just went with holding their foot in midair while washing it. This can be explained by the water falling far from the ledge due to poor design. This method of disregarding the ledge makes design D and C exactly alike; design D only offers a minimal advantage with the ledge as not all people use it to hold their feet. This shows that among these 5 participants, design A had the lowest RULA score which means it should be the most comfortable to use.

### I. LMD Scores

Each of the five participants expressed their subjective comfort level on the LMD scale. As this was a pilot study, more participants are needed to provide adequate testing. The obtained results show that the participants scored the body parts similarly with an average score of 2.7/10 overall. The body part with the highest rated scores were the legs with an average of 3.1/10 and the lowest rated body part was the neck with an average score of 2.38/10.

# CHAPTER VI

# CONCLUSION

This study aimed to further analyze and compare the four mostly used ablution station designs. These designs were compared using a survey by collecting people's experiences and perceptions towards the four existing designs. A significant result showed that males, in comparison to females, preferred design A which shows the effect of body form and center of gravity while performing ablution on comfort while performing ablution. Age difference did not yield significant results as all age groups have a similar view as to what can be seen as a comfortable or uncomfortable design. However, height and weight both showed a significant difference between design A and the rest of the designs in terms of perceived or experienced comfort. Being the only design with a seat, design A was favored by taller and heavier people as they find sitting while performing ablution a much more comfortable experience. Although favored in terms of comfort, design A was seen as the design that makes the user and the ground around the station the most wet. Design A was also perceived to cause slipping more than the rest of the designs. In addition, many participants stated that they usually had to clean the seat before use as it would be wet from previous users. The two newly proposed designs offered a separation between upper and lower body washing. Having a downward faucet for the feet alone would solve the issue of becoming more wet than necessary and the problem of awkward postures when washing the feet. The new stations were positively perceived by the public as almost all participants would prefer using the new designs over the existing designs. In addition, the participants also viewed the new designs, overall, as more comfortable to use. A different approach was also used by conducting a pilot study of the existing designs where 5 participants were asked to perform ablution live on the 4 existing stations. The RULA results confirmed that design A is objectively the most comfortable design as it had the lowest score. Further to that, the participants also filled an LMD scale to measure their discomfort after using each of the four designs. The results were tabulated as a reference for future studies to build upon as more participants are needed to perform adequate testing. The two new designs with the addition of the down faucet are highly recommended by this study for further studies and testing. This study is a big step towards ergonomic ablution stations designs. In the future, we hope to see these designs implemented, tested, and used in mosques throughout the world.

# APPENDIX A

(Not to be used by neither the researcher nor the participants)

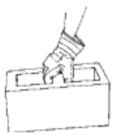
WISHA Caution Zone Checklist

ERGONOMICS PLUS // **WISHA Caution Zone Checklist**

**Caution Zone Checklist** Use one sheet for each position evaluated.

| Movements or postures that are a regular and foreseeable part of the job, occurring more than one day per week, and more frequently than one week per year. | If done in this position ... ✓ the box | Job Position Evaluated:<br>Date: | # of employees in these jobs? |
|---|---|---|---|

| | **AWKWARD POSTURE** | | **COMMENTS / OBSERVATIONS** |
|---|---|---|---|
|  | **1.** Working with the hand(s) above the head, or the elbow(s) above the shoulders more than 2 hours total per day. | ☐ | |
|  | **2.** Working with the neck or back bent more than 30 degrees (without support and without the ability to vary posture) more than 2 hours total per day. | ☐ | |
|  | **3.** Squatting more than 2 hours total per day. | ☐ | |
|  | **4.** Kneeling more than 2 hours total per day. | ☐ | |

| | **HIGH HAND FORCE** | | **COMMENTS / OBSERVATIONS** |
|---|---|---|---|
|  | **5.** Pinching an unsupported object(s) weighing 2 or more pounds per hand, or pinching with a force of 4 or more pounds per hand, more than 2 hours total per day (comparable to pinching half a ream of paper). | ☐ | |
|  | **6.** Gripping an unsupported objects(s) weighing 10 or more pounds per hand, or gripping with a force of 10 or more pounds per hand, more than 2 hours total per day (comparable to clamping light duty automotive jumper cables onto a battery). | ☐ | |

www.ergo-plus.com | 765.384.4499 Source: Washington State Department of Labor and Industries

| HIGHLY REPETITIVE MOTION | | | COMMENTS / OBSERVATIONS |
|---|---|---|---|
|  | **7.** Repeating the same motion with the neck, shoulders, elbows, wrists, or hands (excluding keying activities) with little or no variation every few seconds, more than 2 hours total per day. | | |
|  | **8.** Performing intensive keying more than 4 hours total per day. | | |
| **REPEATED IMPACT** | | | **COMMENTS / OBSERVATIONS** |
|  | **9.** Using the hand (heel/base of palm) or knee as a hammer more than 10 times per hour, more than 2 hours total per day. | | |
| **HEAVY, FREQUENT OR AWKWARD LIFTING** | | | **COMMENTS / OBSERVATIONS** |
|  | **10.** Lifting object weighing more than 75 pounds once per day or more than 55 pounds more than 10 times per day. | | |
|  | **11.** Lifting objects weighing more than 10 pounds if done more than twice per minute, more than 2 hours total per day. | | |
|  | **12.** Lifting objects weighing more than 25 pounds above the shoulders, below the knees or at arms length more than 25 times per day.. | | |
| **MODERATE TO HIGH HAND ARM VIBRATION** | | | **COMMENTS / OBSERVATIONS** |
|  | **13.** Using impact wrenches, carpet strippers, chain saws, percussive tools (jack hammers, scalers, chipping hammers) or other tools that typically have high vibration levels, more than 30 minutes total per day. | | |
|  | **14.** Using grinders, sanders, jigsaws or other hand tools that typically have moderate vibration levels more than 2 hours total per day. | | |

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# APPENDIX B

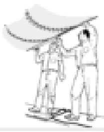
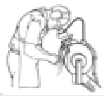
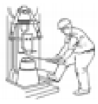
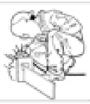
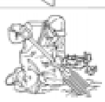
(not to be used by neither the researcher nor the participants)

WISHA Hazard Zone Checklist

ERGONOMICS PLUS // **WISHA Hazard Zone Jobs Checklist**

## Hazard Zone Jobs Checklist

For each "caution zone job" find any physical risk factors that apply. If a hazard exists, it must be reduced below the hazard level or to the degree technologically and economically feasible.

| Movements or postures that are a regular and foreseeable part of the job, occurring more than one day per week, and more frequently than one week per year. | | **Hazard Exists** ✓ | | Job Position Evaluated:<br>Date: | # of employees in these jobs? |
|---|---|---|---|---|---|
| **AWKWARD POSTURE** | | | | **COMMENTS / OBSERVATIONS** | |
|  | **1.** Working with the hand(s) above the head, or the elbows above the shoulders | More than **4 hours total** / day | ☐ | | |
|  | **2.** Repeatedly raising the hand(s) above the head, or the elbow(s) above the shoulder(s) more than once per minute | More than **4 hours total** / day | ☐ | | |
|  | **3.** Working with the neck bent more than 45° (without support or the ability to vary posture) | More than **4 hours total** / day | ☐ | | |
|  | **4.** Working with the back bent forward more than 30° (without support or the ability to vary posture) | More than **4 hours total** / day | ☐ | | |
|  | **5.** Working with the back bent forward more than 45° (without support or the ability to vary posture) | More than **2 hours total** / day | ☐ | | |
|  | **6.** Squatting | More than **4 hours total** / day | ☐ | | |
|  | **7.** Kneeling | More than **4 hours total** / day | ☐ | | |

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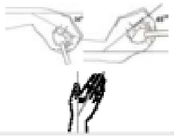
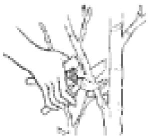
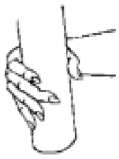
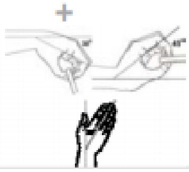
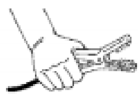
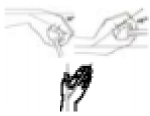
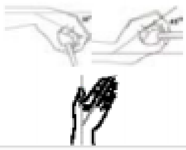
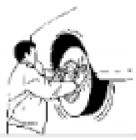
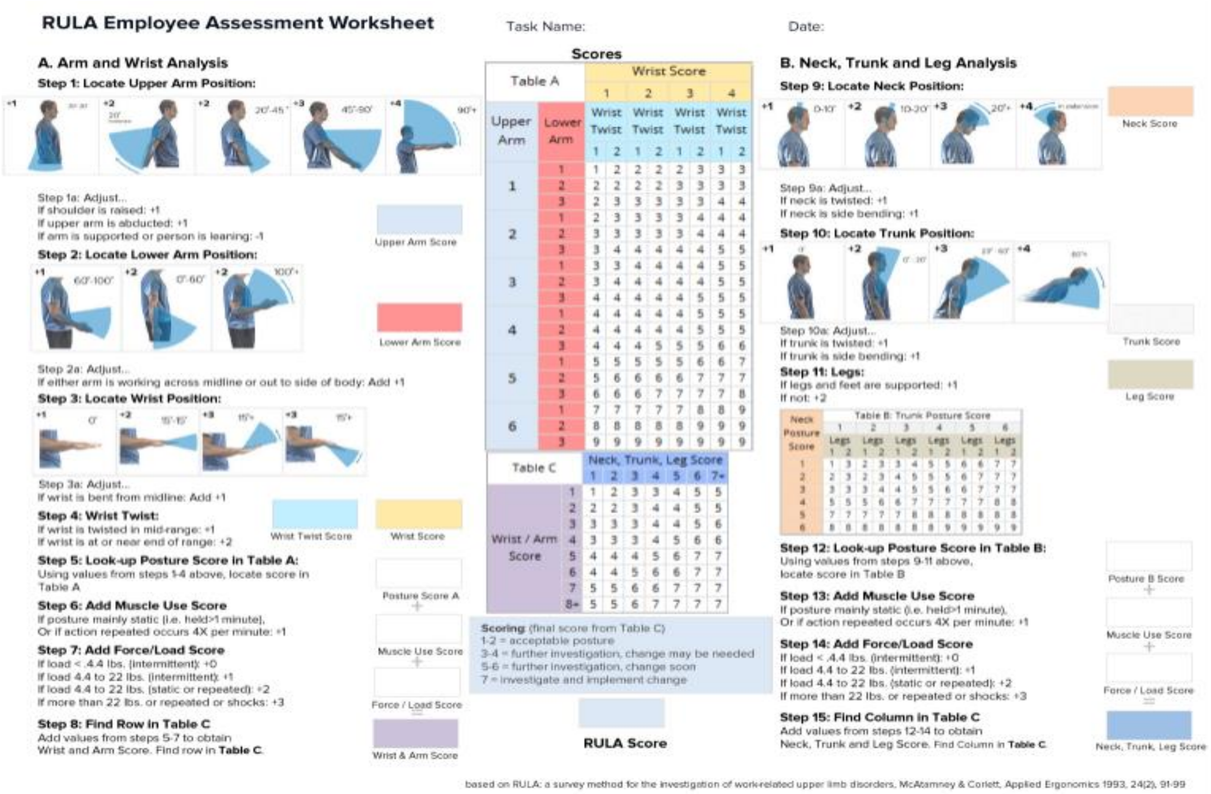
| HIGH HAND FORCE | | | | COMMENTS / OBSERVATIONS |
|---|---|---|---|---|
| **Pinching** an unsupported object(s) weighing 2 lbs. or more per hand, or pinching with a force of 4 lbs. or more per hand (comparable to pinching a half a ream of paper) | | | | |
|  | + **8.** Highly Repetitive Motion | + More than **3 hours total** / day | ☐ | |
|  | + **9.**  | + More than **3 hours total** / day | ☐ | |
|  | + **10.** No other risk factors | + More than **4 hours total** / day | ☐ | |
| **Gripping** an unsupported object(s) weighing 10 lbs. or more per hand, or gripping with a force of 10 lbs. or more per hand (comparable to clamping light duty automotive jumper cables onto a battery) | | | | |
|  | + **11.** Highly Repetitive Motion | + More than **3 hours total** / day | ☐ | |
|  | + **12.**  | + More than **3 hours total** / day | ☐ | |
|  | + **13.** No other risk factors | + More than **4 hours total** / day | ☐ | |

| **HIGHLY REPETITIVE MOTION** | | | **COMMENTS / OBSERVATIONS** |
|---|---|---|---|
| Using the same motion with little or no variation every few seconds (excluding keying activities) | | | |
|  | +  **14.** + Forceful exertions with the hand(s) | + More than **2 hours total** / day | ☐ |
|  | + **15.** No other risk factors | + More than **6 hours total** / day | ☐ |
| Intensive Keying | | | |
|  | **16.** +  | + More than **4 hours total** / day | ☐ |
|  | + **17.** No other risk factors | + More than **7 hours total** / day | ☐ |
| **REPEATED IMPACT** | | | **COMMENTS / OBSERVATIONS** |
|  | **18.** Using the hand (heel/base of palm) as a hammer more than once per minute | + More than **2 hours total** / day | ☐ |
|  | **19.** Using the knee as a hammer more than once per minute | + More than **2 hours total** / day | ☐ |

# APPENDIX C

(To be used by the researcher to conduct the analysis after collecting mosque data)

RULA Assessment Worksheet



**RULA Employee Assessment Worksheet**

Task Name:

Date:

**A. Arm and Wrist Analysis**

**Step 1: Locate Upper Arm Position:**

+1   +2   +2 20°-45°   +3 45°-90°   +4 90°+

Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

**Step 2: Locate Lower Arm Position:**

+1 60°-100°   +2 0°-60°   +2 100°+

Lower Arm Score

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

**Step 3: Locate Wrist Position:**

+1 0°   +2 15°-15°   +3 15°+   +3 15°+

Step 3a: Adjust...
If wrist is bent from midline: Add +1

**Step 4: Wrist Twist:**
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score   Wrist Score

**Step 5: Look-up Posture Score in Table A:**
Using values from steps 1-4 above, locate score in Table A

Posture Score A
+

**Step 6: Add Muscle Use Score**
If posture mainly static (i.e. held>1 minute),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score
+

**Step 7: Add Force/Load Score**
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score
=

**Step 8: Find Row in Table C**
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

Wrist & Arm Score

**Scores**

| Table A | | Wrist Score 1 | | Wrist Score 2 | | Wrist Score 3 | | Wrist Score 4 | |
|---|---|---|---|---|---|---|---|---|---|
| Upper Arm | Lower Arm | Wrist Twist 1 | Wrist Twist 2 | Wrist Twist 1 | Wrist Twist 2 | Wrist Twist 1 | Wrist Twist 2 | Wrist Twist 1 | Wrist Twist 2 |
| 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 |
| 2 | 1 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 |
| 3 | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 5 |
| | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 |
| | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| 4 | 1 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| | 2 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 6 |
| 5 | 1 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 7 |
| | 2 | 5 | 6 | 6 | 6 | 6 | 7 | 7 | 7 |
| | 3 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 8 |
| 6 | 1 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 9 |
| | 2 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 |
| | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

| Table C | | Neck, Trunk, Leg Score 1 | 2 | 3 | 4 | 5 | 6 | 7+ |
|---|---|---|---|---|---|---|---|---|
| Wrist / Arm Score | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 |
| | 2 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| | 3 | 3 | 3 | 3 | 4 | 4 | 5 | 6 |
| | 4 | 3 | 3 | 3 | 4 | 5 | 6 | 6 |
| | 5 | 4 | 4 | 4 | 5 | 6 | 7 | 7 |
| | 6 | 4 | 4 | 5 | 6 | 6 | 7 | 7 |
| | 7 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |
| | 8+ | 5 | 5 | 6 | 7 | 7 | 7 | 7 |

**Scoring** (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

**RULA Score**

**B. Neck, Trunk and Leg Analysis**

**Step 9: Locate Neck Position:**

+1 0-10°   +2 10-20°   +3 20°+   +4 in extension

Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

**Step 10: Locate Trunk Position:**

+1   +2 0°-20°   +3 20°-60°   +4 60°+

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

**Step 11: Legs:**
If legs and feet are supported: +1
If not: +2

Leg Score

| Neck Posture Score | Table B: Trunk Posture Score 1 Legs 1 | 1 Legs 2 | 2 Legs 1 | 2 Legs 2 | 3 Legs 1 | 3 Legs 2 | 4 Legs 1 | 4 Legs 2 | 5 Legs 1 | 5 Legs 2 | 6 Legs 1 | 6 Legs 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 3 | 2 | 3 | 3 | 4 | 5 | 5 | 6 | 6 | 7 | 7 |
| 2 | 2 | 3 | 2 | 3 | 4 | 5 | 5 | 5 | 6 | 7 | 7 | 7 |
| 3 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |
| 4 | 5 | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 8 | 8 |
| 5 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 |

**Step 12: Look-up Posture Score in Table B:**
Using values from steps 9-11 above, locate score in Table B

Posture B Score
+

**Step 13: Add Muscle Use Score**
If posture mainly static (i.e. held>1 minute),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score
+

**Step 14: Add Force/Load Score**
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score
=

**Step 15: Find Column in Table C**
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

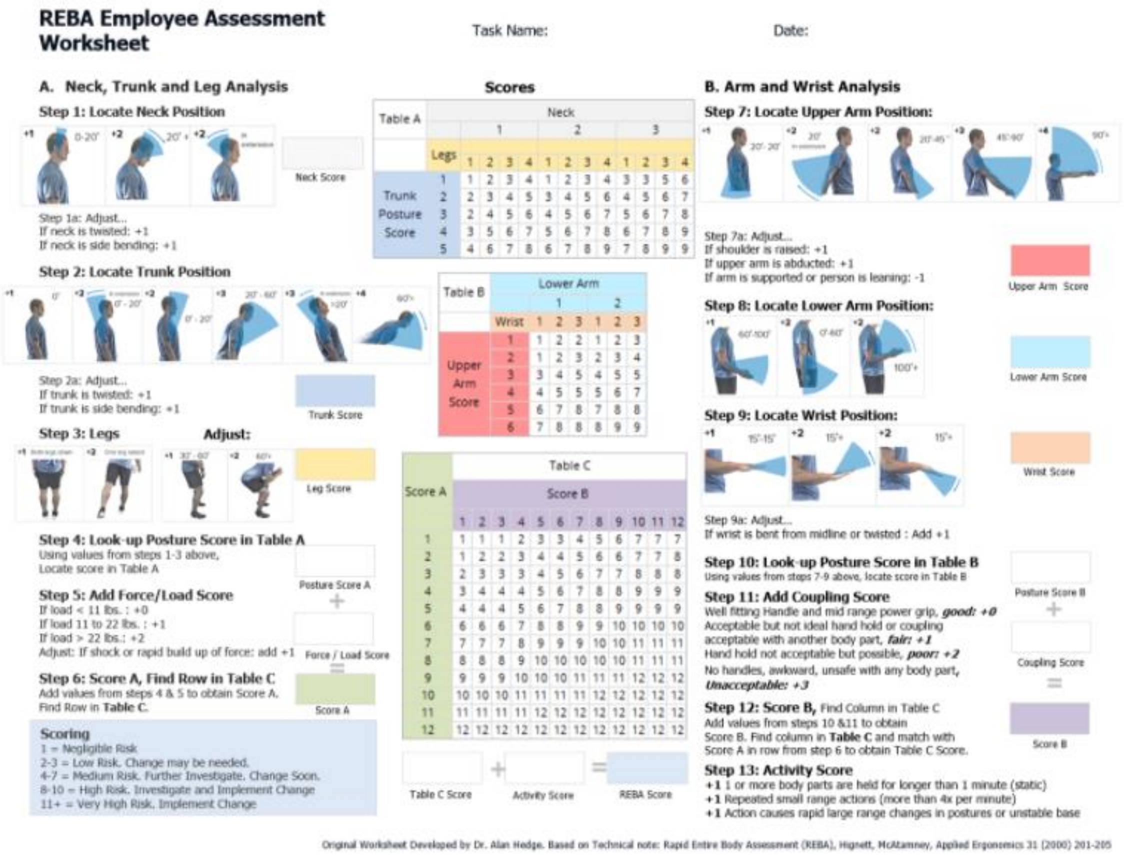
Neck, Trunk, Leg Score

based on RULA: a survey method for the investigation of work-related upper limb disorders, McAtamney & Corlett, Applied Ergonomics 1993, 24(2), 91-99

# APPENDIX D

(Not to be used by neither the researcher nor the participants)

REBA Assessment Worksheet



**REBA Employee Assessment Worksheet**

Task Name: Date:

**A. Neck, Trunk and Leg Analysis**

**Step 1: Locate Neck Position**

+1 0-20° +2 20°+ +2

Neck Score

Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

**Step 2: Locate Trunk Position**

+1 0° +2 0°-20° +2 0°-20° +3 20°-60° +3 >20° +4 60°+

Trunk Score

Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

**Step 3: Legs** **Adjust:**

+1 +2 +1 30°-60° +2 60°+

Leg Score

**Step 4: Look-up Posture Score in Table A**
Using values from steps 1-3 above,
Locate score in Table A

Posture Score A
+

**Step 5: Add Force/Load Score**
If load < 11 lbs. : +0
If load 11 to 22 lbs. : +1
If load > 22 lbs.: +2
Adjust: If shock or rapid build up of force: add +1

Force / Load Score
=

**Step 6: Score A, Find Row in Table C**
Add values from steps 4 & 5 to obtain Score A.
Find Row in **Table C**.

Score A

**Scoring**
1 = Negligible Risk
2-3 = Low Risk. Change may be needed.
4-7 = Medium Risk. Further Investigate. Change Soon.
8-10 = High Risk. Investigate and Implement Change
11+ = Very High Risk. Implement Change

**Scores**

| Table A | | Neck | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | | | 2 | | | | 3 | | | |
| | Legs | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Trunk Posture Score | 1 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 3 | 3 | 5 | 6 |
| | 2 | 2 | 3 | 4 | 5 | 3 | 4 | 5 | 6 | 4 | 5 | 6 | 7 |
| | 3 | 2 | 4 | 5 | 6 | 4 | 5 | 6 | 7 | 5 | 6 | 7 | 8 |
| | 4 | 3 | 5 | 6 | 7 | 5 | 6 | 7 | 8 | 6 | 7 | 8 | 9 |
| | 5 | 4 | 6 | 7 | 8 | 6 | 7 | 8 | 9 | 7 | 8 | 9 | 9 |

| Table B | | Lower Arm | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | | | 2 | | |
| | Wrist | 1 | 2 | 3 | 1 | 2 | 3 |
| Upper Arm Score | 1 | 1 | 2 | 2 | 1 | 2 | 3 |
| | 2 | 1 | 2 | 3 | 2 | 3 | 4 |
| | 3 | 3 | 4 | 5 | 4 | 5 | 5 |
| | 4 | 4 | 5 | 5 | 5 | 6 | 7 |
| | 5 | 6 | 7 | 8 | 7 | 8 | 8 |
| | 6 | 7 | 8 | 8 | 8 | 9 | 9 |

| Score A | Table C | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Score B | | | | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 1 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 7 | 7 | 7 |
| 2 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 7 | 8 |
| 3 | 2 | 3 | 3 | 3 | 4 | 5 | 6 | 7 | 7 | 8 | 8 | 8 |
| 4 | 3 | 4 | 4 | 4 | 5 | 6 | 7 | 8 | 8 | 9 | 9 | 9 |
| 5 | 4 | 4 | 4 | 5 | 6 | 7 | 8 | 8 | 9 | 9 | 9 | 9 |
| 6 | 6 | 6 | 6 | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 10 | 10 |
| 7 | 7 | 7 | 7 | 8 | 9 | 9 | 9 | 10 | 10 | 11 | 11 | 11 |
| 8 | 8 | 8 | 8 | 9 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 |
| 9 | 9 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 11 | 12 | 12 | 12 |
| 10 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 |
| 11 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |

Table C Score + Activity Score = REBA Score

**B. Arm and Wrist Analysis**

**Step 7: Locate Upper Arm Position:**

+1 20°-20° +2 20° +2 20°-45° +3 45°-90° +4 90°+

Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

**Step 8: Locate Lower Arm Position:**

+1 60°-100° +2 0°-60° +2 100°+

Lower Arm Score

**Step 9: Locate Wrist Position:**

+1 15°-15° +2 15°+ +2 15°+

Wrist Score

Step 9a: Adjust...
If wrist is bent from midline or twisted : Add +1

**Step 10: Look-up Posture Score in Table B**
Using values from steps 7-9 above, locate score in Table B

Posture Score B
+

**Step 11: Add Coupling Score**
Well fitting Handle and mid range power grip, ***good: +0***
Acceptable but not ideal hand hold or coupling
acceptable with another body part, ***fair: +1***
Hand hold not acceptable but possible, ***poor: +2***
No handles, awkward, unsafe with any body part,
***Unacceptable: +3***

Coupling Score
=

**Step 12: Score B,** Find Column in Table C
Add values from steps 10 &11 to obtain
Score B. Find column in **Table C** and match with
Score A in row from step 6 to obtain Table C Score.

Score B

**Step 13: Activity Score**
**+1** 1 or more body parts are held for longer than 1 minute (static)
**+1** Repeated small range actions (more than 4x per minute)
**+1** Action causes rapid large range changes in postures or unstable base

Original Worksheet Developed by Dr. Alan Hedge. Based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

# APPENDIX E

Ablution Design Survey/Interview

1. Gender: (Male) (Female)

2. Age:

3. Height (in cm):

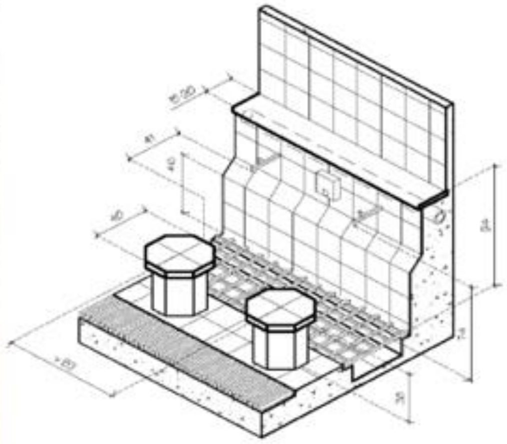
4. Weight (in Kg):

5. Please circle all that apply.
a. Uses wheelchair
b. Uses cane
c. Has upper limb differences
d. Has lower limb differences
e. Has bodily pain/discomfort at: ___________
f. Has medical or genetic condition (pertaining to musculoskeletal system): _____
g. Other: ___________

6. Does it cause you any inconvenience when you or your clothing become more wet than necessary while performing wudu' (i.e. beyond what is expected from wudu')?
a. Yes
b. No

7. Do you rub your feet with your hands while washing them during wudu'?
a. Yes
b. No

Existing Design 1:



1. Have you used this ablution (wudu') station design before?
a. Yes
b. No

2. Does this design cause you or your clothing to become more wet than necessary?
a. Yes, it does a lot.
b. Yes, it does.
c. Yes, it does, but only a little.
d. No, it does not.

3. Does this design cause the ground around you to become wet?
a. Yes, it does a lot.
b. Yes, it does.
c. Yes, it does, but only a little.
d. No, it does not.

4. How would you rate the risk of slipping and/or falling when using this design for ablution?
a. Very low risk
b. Low risk
c. Moderate risk
d. High risk
e. Very high risk

5. Have you ever slipped and/or fell when using this design (skip if 1 was answered 'no')?
a. Yes
b. No

6. Do you think this design is comfortable when washing the upper body parts (excluding feet)?
a. Very uncomfortable
b. Uncomfortable

c. Moderate comfort
d. Comfortable
e. Very comfortable

7. Do you think this design is comfortable when washing the feet (excluding the upper body parts)?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

8. Overall, do you think this design is comfortable for performing ablution?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

9. In terms of comfort, what do you like in this design?

10. In terms of comfort, what do you dislike in this design?

11. Please provide your recommendations (if any) for improving this design.

Existing Design 2:

2. Have you used this ablution (wudu’) station design before?
a. Yes
b. No

3. Does this design cause you or your clothing to become more wet than necessary?
a. Yes, it does a lot.
b. Yes, it does.
c. Yes, it does, but only a little.
d. No, it does not.

4. Does this design cause the ground around you to become wet?
a. Yes, it does a lot.
b. Yes, it does.
c. Yes, it does, but only a little.
d. No, it does not.

5. How would you rate the risk of slipping and/or falling when using this design for ablution?
a. Very low risk
b. Low risk
c. Moderate risk
d. High risk
e. Very high risk

6. Have you ever slipped and/or fell when using this design (skip if 1 was answered ‘no’)?
a. Yes
b. No

7. Do you think this design is comfortable when washing the upper body parts (excluding feet)?
a. Very uncomfortable

b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

8. Do you think this design is comfortable when washing the feet (excluding the upper body parts)?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

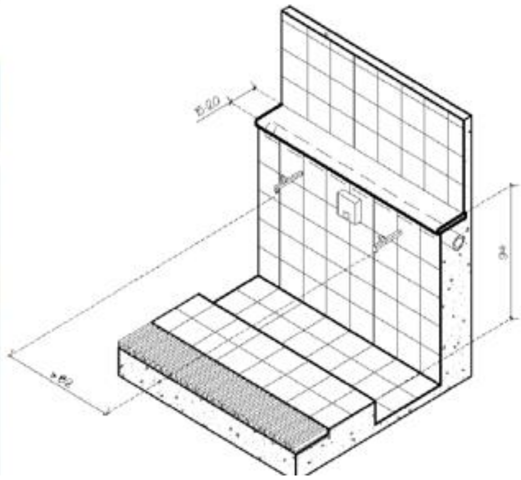
9. Overall, do you think this design is comfortable for performing ablution?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

10. In terms of comfort, what do you like in this design?

11. In terms of comfort, what do you dislike in this design?

12. Please provide your recommendations (if any) for improving this design.

Existing Design 3:



3. Have you used this ablution (wudu') station design before?
a. Yes
b. No

4. Does this design cause you or your clothing to become more wet than necessary?
e. Yes, it does a lot.
f. Yes, it does.
g. Yes, it does, but only a little.
h. No, it does not.

5. Does this design cause the ground around you to become wet?
e. Yes, it does a lot.
f. Yes, it does.
g. Yes, it does, but only a little.
h. No, it does not.

6. How would you rate the risk of slipping and/or falling when using this design for ablution?
f. Very low risk
g. Low risk
h. Moderate risk
i. High risk
j. Very high risk

7. Have you ever slipped and/or fell when using this design (skip if 1 was answered 'no')?
c. Yes
d. No

8. Do you think this design is comfortable when washing the upper body parts (excluding feet)?
f. Very uncomfortable
g. Uncomfortable

h. Moderate comfort
i. Comfortable
j. Very comfortable

9. Do you think this design is comfortable when washing the feet (excluding the upper body parts)?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

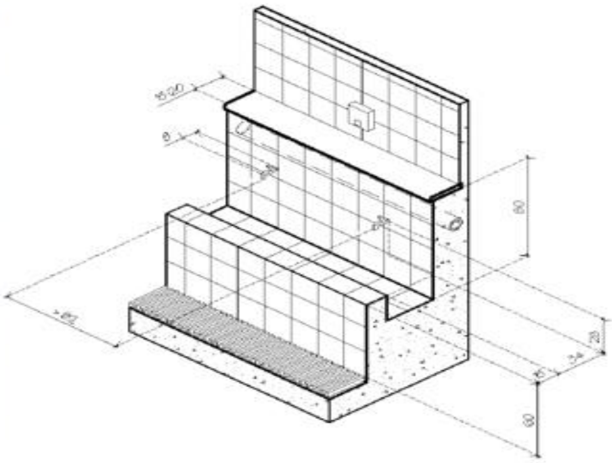
10. Overall, do you think this design is comfortable for performing ablution?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

11. In terms of comfort, what do you like in this design?

12. In terms of comfort, what do you dislike in this design?

13. Please provide your recommendations (if any) for improving this design.

Existing Design 4:



4. Have you used this ablution (wudu') station design before?
a. Yes
b. No

5. Does this design cause you or your clothing to become more wet than necessary?
i. Yes, it does a lot.
j. Yes, it does.
k. Yes, it does, but only a little.
l. No, it does not.

6. Does this design cause the ground around you to become wet?
i. Yes, it does a lot.
j. Yes, it does.
k. Yes, it does, but only a little.
l. No, it does not.

7. How would you rate the risk of slipping and/or falling when using this design for ablution?
k. Very low risk
l. Low risk
m. Moderate risk
n. High risk
o. Very high risk

8. Have you ever slipped and/or fell when using this design (skip if 1 was answered 'no')?
e. Yes
f. No

9. Do you think this design is comfortable when washing the upper body parts (excluding feet)?
k. Very uncomfortable
l. Uncomfortable

m. Moderate comfort
n. Comfortable
o. Very comfortable

10. Do you think this design is comfortable when washing the feet (excluding the upper body parts)?
1. Very uncomfortable
2. Uncomfortable
3. Moderate comfort
4. Comfortable
5. Very comfortable

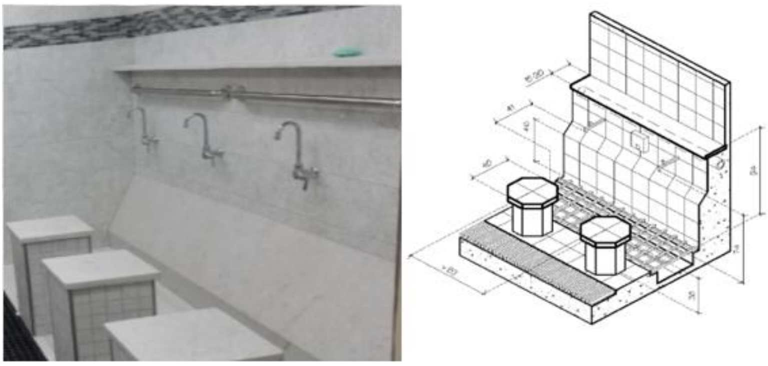
11. Overall, do you think this design is comfortable for performing ablution?
1. Very uncomfortable
2. Uncomfortable
3. Moderate comfort
4. Comfortable
5. Very comfortable

12. In terms of comfort, what do you like in this design?

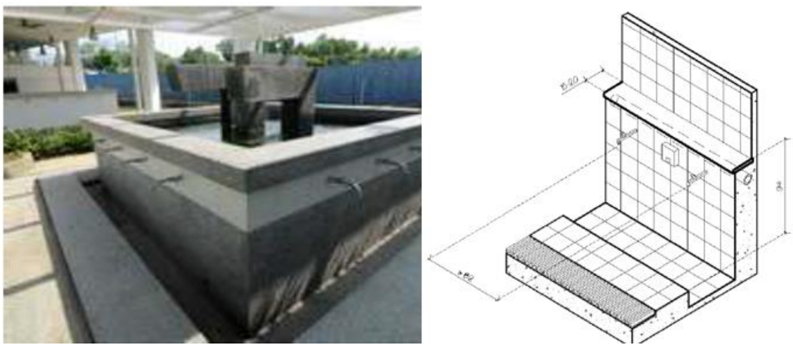
13. In terms of comfort, what do you dislike in this design?

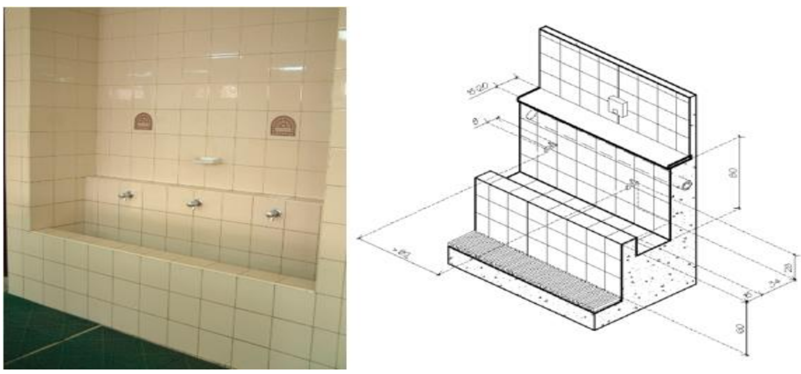
14. Please provide your recommendations (if any) for improving this design.

Which of the four ablution station designs do you favor most, overall? You may select more than one design if a tie exists.


a)


b)


c)


d)

(Proposed Design 1)

1. Do you think this design is comfortable when washing the upper body parts (excluding feet)?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

2. Do you think this design is comfortable when washing the feet (excluding the upper body parts)?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

3. Overall, do you think this design is comfortable for performing ablution?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

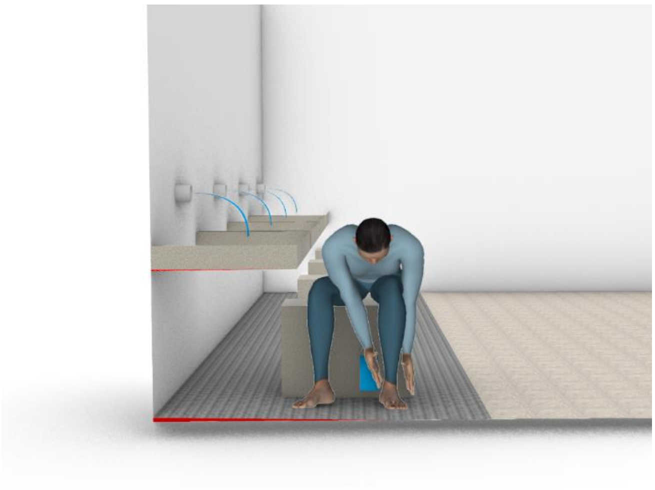
4. In terms of comfort, what do you like in this design?

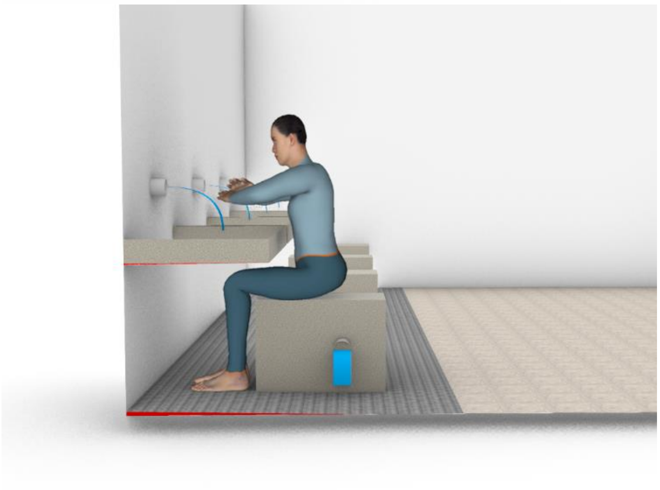
5. In terms of comfort, what do you dislike in this design?

6. Would you prefer using this ablution station design over the four existing designs?
a. Yes
b. No

7. Please provide your recommendations (if any) for improving this design

(Proposed Design 2)





1. Do you think this design is comfortable when washing the upper body parts (excluding feet)?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

2. Do you think this design is comfortable when washing the feet (excluding the upper body parts)?
a. Very uncomfortable
b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

3. Overall, do you think this design is comfortable for performing ablution?
a. Very uncomfortable

b. Uncomfortable
c. Moderate comfort
d. Comfortable
e. Very comfortable

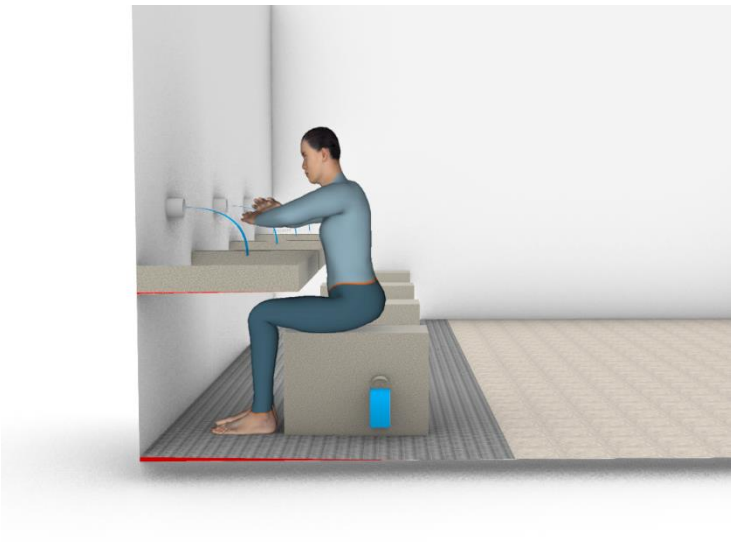
4. In terms of comfort, what do you like in this design?

5. In terms of comfort, what do you dislike in this design?

6. Would you prefer using this ablution station design over the four existing designs?
a. Yes
b. No

7. Please provide your recommendations (if any) for improving this design.

Proposed Designs 1 vs. 2



1. Which of the two proposed designs would you prefer overall?
    1. Design 1
    2. Design 2

2. Justify.

# APPENDIX F

LMD Interview

1. Age:

2. Height (in cm):

3. Weight (in Kg):

4. Please circle the number that best corresponds to your level of strain (discomfort) while performing ablution for each body part.

| 0 | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No Discomfort at all | Extremely Little Discomfort | Very Little Discomfort | Little Discomfort | Moderate Discomfort | Somewhat High Discomfort | High Discomfort | Between High & Very High Discomfort | Very High Discomfort | More Than Very High Discomfort | Less Than Extreme Discomfort | Extreme Discomfort |

| | No Discomfort at all | Extremely Little Discomfort | Very Little Discomfort | Little Discomfort | Moderate Discomfort | Somewhat High Discomfort | High Discomfort | Between High & Very High Discomfort | Very High Discomfort | More Than Very High Discomfort | Less Than Extreme Discomfort | Extreme Discomfort |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neck | 0 | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Shoulders | 0 | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Upper | 0 | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arm | | | | | | | | | | | | |
| Lower Back | 0 | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Thighs | 0 | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Legs | 0 | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

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