Ergonomic Approach: Posture Analysis and Design of Activity Aids for the Elderly

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Abstract. The ratio of dependence of the elderly to the productive age in Indonesia continues to increase which correlates with the need for facilities. One of the facilities needed and commonly used together with the productive age is the bathroom. Most Indonesians have permanent bathtubs and toilet squats that cause the elderly to move with a hunched and crouched posture, endangering the safety and health of the elderly and the potential for MSDs. The purpose of this study is to design bathroom activity aids that are safe for the elderly and can still be used by the productive age. The methods used are NBM, REBA, and anthropometry. The results of the study found 1 elderly at "high" NBM risk, 15 at "Medium" risk, and 14 at "Low" risk. REBA calculations found 1 "High" risk posture and 2 "Medium" risk postures. The recommended aids is the "Multifunctional Bath Chair" designed with SOLIDWORKS with an Anthropometric adjustable size. Aids are designed for bathing, urination or defecation activities that can be folded against the wall. Of the 3 proposed postures that Mannequin CATIA simulated, it resulted in a decrease in the risk level of REBA after using the tool, thereby reducing the risk of MSDs complaints in the elderly.

Keywords: Productive age, MSDs, Design, Bathroom

1 Introduction

An elderly person is someone who has reached the age of 65 or older, according to the United Nations [1]. According to data from the “Badan Pusat Statistik” [2], there would be 29.3 million senior persons in Indonesia, or 10.82% of the total population. In the previous 50 years, this number has doubled. The rise in the number of households with older residents is another indicator of the population's aging. In Indonesia, one in every four homes is currently occupied by an older person.

Comparatively speaking, the elderly is an age group that needs more care. They complain of musculoskeletal disorders as well as a variety of physiological losses (MSDs) [3]. Decreased physiological conditions in the elderly include decreased sensory function, which results in aberrant sensory sensitivity, decreased sensoromotor function, which causes balance difficulties, and diminished motor function, which is

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defined by decreased strength of bodily tissues [4]. Meanwhile, common MSDs concerns range from knee pain to neck discomfort to low back pain by Puspitasari & Ariyanto [5]. The combination of declining physiological circumstances and concomitant MSDs complaints might result in a variety of difficulties for senior people when it comes to engaging in daily activities or ADLs (ADL). Even if they are subject to restrictions, older people still choose to live alone. According to research by Sari [6], older people who live with their own families have an independence level of 80%, whereas those who reside in nursing institutions have an independence level of 41%. According to Sumbara et al. [7], older adults who are autonomous lead better lives. Elderly people do have limitations, though, and their yearning for independence comes with a significant risk. There must be effective K3 management in the home where the elderly reside [3]. The place where you reside is frequently thought of as the safest and coziest place to be, yet inadvertently, the house can also put its occupants in danger while engaging in certain activities [8].

In Indonesia, the dependency ratio of those who are aged to those who are working continues to rise, which is related to the demand for facilities. The bathroom is one of the amenities used frequently and required in a productive age. One of the things that older people still prefer to do independently is bathroom chores including bathing, peeing, and defecating. They are happier when they can complete tasks on their own, but they also feel embarrassed and concerned by their seclusion, which makes them hesitant to accept help with simple tasks like taking off or putting on clothes or even cleaning intimate body areas [9]. This goal, however, conflicts with the bathroom's unsuitable state for the elderly. The bathroom is the most dangerous room in a house, according to Habib [10]. Typically, bathrooms are simply created with adult ergonomics, without taking into account the restrictions of the elderly [11].

The placement and amenities of bathrooms in Indonesia are often the same, including the use of a bathtub that is high enough and a squat toilet. This ailment necessitates that the elderly bathe while stooping, urinate or defecate while squatting, and repeatedly drink water from a ladle. Young folks may fin these exercises simple to complete. However, activities in the bathroom become uncomfortable and risky to perform for the elderly whose physical condition has deteriorated and who are complaining of numerous MSDs. According to Syamzalisman [12], the consequent bending and squatting positions are among the unnatural postures that may lead to MSD problems.

Elderly interviewing improved the findings from the observation. They express discomfort using a dipper to the appearance of a fear of falling. They also complain of difficulty standing and bending for an extended period of time while bathing, pain or discomfort in several body parts, particularly the knees to the feet when urinating or defecating with a squatting posture. According to Vera [13] research, 29% of elderly fall accidents happened in the restroom. Falling is a major issue, particularly for the elderly whose physical decline makes it more likely to result in injuries, broken bones, decreased mobility, and even death [14].

It is vital to have activity aids that support the activities of the elderly in the bathroom because the existing state of the bathroom makes it desirable for the elderly to undertake activities independently with unnatural postures like bending and crouching. After doing study, Kuboshima et al. [9] created a new restroom that is safe for senior people to

use independently and is comfortable for them as well. Using an anthropological approach, the restroom is thoroughly designed, from seats and handles for the elderly to emergency buttons. In order to preserve the squatting position, Dewantoro [15] created an aid in his research. The major purpose of this assistive device's design is to allow people to urinate or defecate while squatting down on a sitting toilet. A shower chair that can also serve as a wheelchair and has a size that fits the body dimensions of the elderly was the focus of Nugraha et al's [16] design work. A handrail on the toilet seat, created by John et al. [17], serves as both a place to rest your hands and a handle for standing up from a seated position. Using the RULA approach, this tool is intended to address the issue of awkward upper body posture. According to the requirements of those who have quadriplegia, Prasetyo et al. [18] designed assistive devices. The gadget also serves the purpose of being foldable, which makes it portable when traveling. Additionally, the user's preferences can be taken into account while adjusting the tool's height, allowing it to be used on either a sitting or squat toilet. Cheng & Hao [19] created a gizmo that is only useful for old people who are bathing. It uses hydraulics to assist the elderly in standing and sitting, bathing using a shower, massaging their backs, and storing belongings like towels and clothing. According to prior study, the bathroom design that is utilized by other family members who are still working is not taken into account when designing assistive devices; rather, it is solely built to make it easier for senior people to perform bathroom tasks. It is not acceptable to make hasty restroom modifications, such as switching from a squat to a sitting toilet. Elderly people use the restroom, but so do other family members who might feel more at ease given the circumstances. In order to lower the incidence of MSD injuries in the elderly without altering the current bathroom circumstances, this project will build a bathroom activity aid.

2 Method

The restroom used by senior citizens for washing, peeing, or defecating is the subject of this study. The Nordic Body Map (NBM) technique, the Rapid Entire Body Assessment (REBA), and anthropometric data were all used in this investigation. NBM is a technique for quantifying how much pain someone feels while engaging in an activity [20]. A posture analysis technique called REBA is used to determine the risk of MSDs related with an activity [21]. The proportions of the human body can serve as a guide for ergonomic product sizing thanks to anthropometry [22].

This study is divided into four stages. First, data from the Nordic Body Map (NBM) questionnaire will be gathered to learn more about the likelihood that elderly people would experience MSD problems when performing tasks in the restroom. The study will stop at this point if it is determined that all elderly respondents have "low" NBM risk levels, as it does not call for corrective action. The activity in the restroom, however, needs to be corrected if an aged person is discovered to have a "moderate," "high," or "very high" NBM risk level in order for the research to move on to the next stage, which is posture analysis utilizing the REBA method [23]. Second, different activities performed by the old in the bathroom resulted in a variety of postures, thus a number

of positions that were thought to be severe and out of the ordinary but frequently utilized by the elderly were chosen. If the analysis shows that all of the postures pose a "low" REBA risk level, the research is stopped because posture change is not necessary; however, if the analysis shows that 1 or more postures pose a "Moderate," "High," or "Very High" REBA risk level, then posture change action is necessary in order for the research to move on to the next stage, which involves developing recommendations for assistive devices (Ind. Third, the primary reference for the idea of assistive devices is the outcomes of the actual posture analysis performed using the REBA method. After that, specifications will be determined using earlier research that has been utilized to build instruments for bathroom activities. SOLIDWORKS software is used to create a 3D model of the design to help in understanding the tool's physical form. Based on the gathered anthropometric data, the size of the assistive device is determined. Which body dimension will be utilized in the design is decided in advance. Additionally, it is established which percentile, whether for extreme, adjustable, or medium sizes, is in compliance with the design objectives. Fourth, the Mannequin component of the CATIA program simulates the suggested posture after utilizing the tool. The simulation-derived postures underwent a second round of REBA analysis. The research concludes if the REBA risk level produced by all suggested postures is "Low" since the tool was successful in lowering the REBA risk level. However, if a recommended posture still carries a "Moderate," "High," or "Very High" REBA risk rating, the research goes back to the earlier stage to make changes to the tool's design [24].

3 Result and Discussion

3.1 Results of the Nordic Body Map (NBM) on Elderly Activities in the Bathroom

The Nordic Body Map data was obtained from 30 elderly respondents, consisting of 15 male elderly and 15 female elderly. The criteria for pain start from Not Painful (TS), Somewhat Painful (AS), Pain (S) to Very Painful (SS) [23]. Based on the results of the classification of the NBM risk level, it can be seen that there is 1 elderly with a “High” risk level, which means it requires immediate repair, 15 elderly with a “Moderate” risk level, which means it may need repair and 14 elderly with a “Low” risk level, meaning they do not need corrective action. Because it was found that there were elderly people with a "moderate" and even "high" NBM risk level, a decision could be made that the elderly's activity in the bathroom required corrective action. Therefore, the research continued to the next stage, namely the analysis of the actual posture of the elderly in the bathroom using the REBA method.

3.2 Analysis of the Actual Posture of the Elderly Using the Rapid Entire Body Assessment (REBA) Method

The process of analyzing the actual posture of the elderly begins with taking documentation of the posture when carrying out activities in the bathroom to determine the size of the angle generated. The angle generated is then analyzed to find out the level of risk

along with the changes that need to be carried out [12]. Fig 1 shows the Actual Posture of the Elderly.

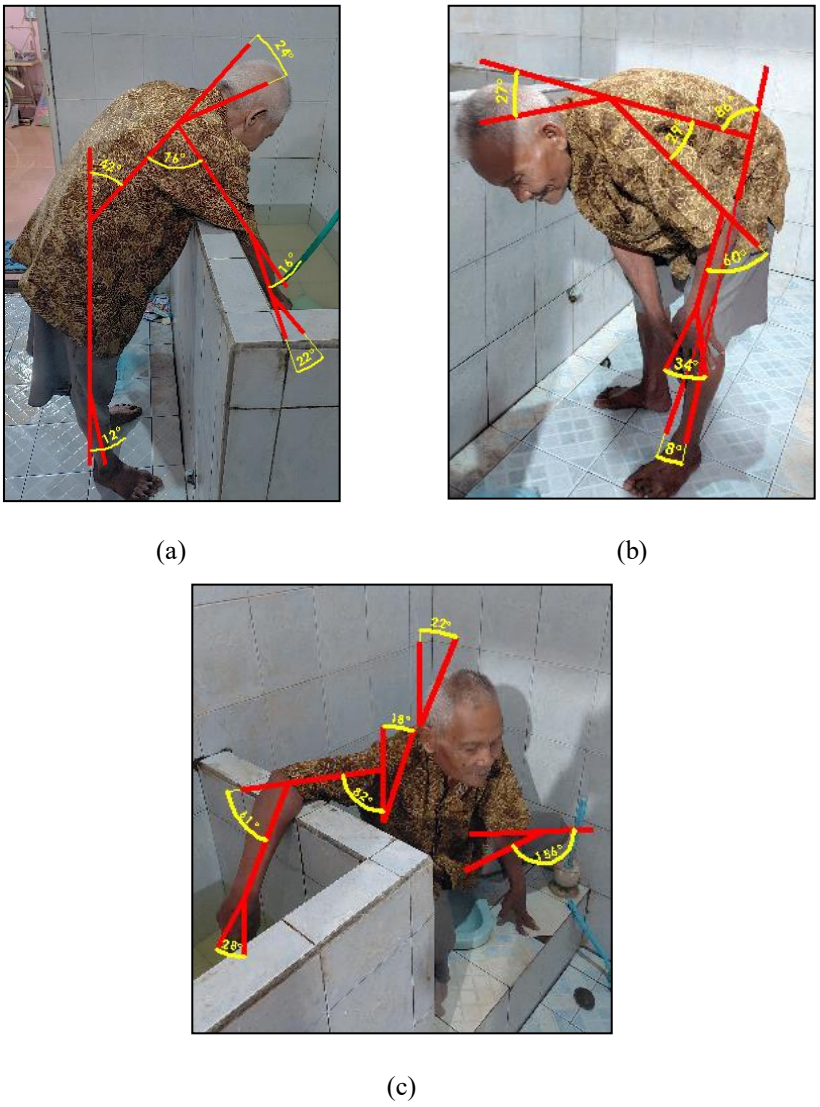


Fig. 1. (a) Age-related Actual Posture 1, (b) Age-related Actual Posture 2, and (c) Age-related Actual Posture 3

Table 1 shows the findings of the examination of elderly people's actual posture. The findings of the REBA analysis of the actual posture of the elderly are shown in Table 1 A REBA score of 7 is derived for the real posture of the elderly 1 based on the analysis's

findings, which are presented in Table 2 (bathing, taking water in the tub using a dipper). This score falls under the "Moderate" risk category, indicating that posture correction is necessary.

Table 1. Elderly Actual Posture REBA Analysis Results 1

Body Segment	Description	Score
Neck	The neck bends down at a 24° (+2) angle	2
Back	Back bent at a 42° (+3) angle	3
Foot	Both legs straight support the body at an angle of 12° (+1)	1
Group A score	Table A scores based on the neck, back and leg segment scores + weight less than 5 Kg (+0)	4
Upper Arm	Upper arms reach forward at 76° (+3) + shoulders raised (+1)	4
Forearm	The forearm swings the dipper at an angle of 16° (+1)	1
Wrist	Wrist forms a 22° angle (+2) + Spins when scooping up water (+1)	3
Group B score	Table B scores based on the upper arm, forearm and wrist segment scores + Hand grip is not ideal but still acceptable (+1)	6
REBA score	Table C scores based on group A and group B scores + Movement repetition more than four times per minute (+1)	7

The outcome of the REBA study of the actual posture of the elderly is shown in Table 2. A REBA score of 5 is derived for the real posture of the elderly 2 based on the findings of the analysis provided in Table 2 (bathing, cleaning the lower body). This score falls within the category of "Moderate" danger, necessitating action to improve one's posture.

Table 2. Elderly Actual Posture REBA Analysis Results 2

Body Segment	Description	Score
Neck	The neck bends down at a 24° (+2) angle	2
Back	Back bent at a 42° (+3) angle	4
Foot	Both legs straight support the body at an angle of 12° (+1)	1
Group A score	Table A scores based on the neck, back and leg segment scores + weight less than 5 Kg (+0)	5
Upper Arm	Upper arms reach forward at 76° (+3) + shoulders raised (+1)	2
Forearm	The forearm swings the dipper at an angle of 16° (+1)	1
Wrist	Wrist forms a 22° angle (+2) + Spins when scooping up water (+1)	3
Group B score	Table B scores based on the upper arm, forearm and wrist segment scores + Hand grip is not ideal but still acceptable (+1)	3
REBA score	Table C scores based on group A and group B scores + Movement repetition more than four times per minute (+1)	5

The findings of the REBA analysis of the actual posture of the elderly are shown in Table 3. A REBA score of 10 is produced for the real posture of elderly 3 based on the

analytical results in Table 3 (urinating or defecating, taking water in the bath). Given that this score falls inside the "High" risk category, quick posture adjustments are required.

Table 3. Elderly Actual Posture REBA Analysis Results 3

Body Segment	Description	Score
Neck	The neck bends down at a 24° (+2) angle	2
Back	Back bent at a 42° (+3) angle	2
Foot	Both legs straight support the body at an angle of 12° (+1)	3
Group A score	Table A scores based on the neck, back and leg segment scores + weight less than 5 Kg (+0)	5
Upper Arm	Upper arms reach forward at 76° (+3) + shoulders raised (+1)	4
Forearm	The forearm swings the dipper at an angle of 16° (+1)	2
Wrist	Wrist forms a 22° angle (+2) + Spins when scooping up water (+1)	3
Group B score	Table B scores based on the upper arm, forearm and wrist segment scores + Hand grip is not ideal but still acceptable (+1)	8
REBA score	Table C scores based on group A and group B scores + Movement repetition more than four times per minute (+1)	10

According to the analysis of the three actual postures of the elderly performed using the REBA method, one posture has a "High" risk level, necessitating the implementation of a posture change action right away, and two postures have a "Moderate" risk level, necessitating the implementation of a posture change action. This leads to the conclusion that all of the elderly people's actual postures need to be changed. As a result, the research kept developing tool recommendations.

3.3 Creating Recommendations for Tools

The "Multifunctional Bath Chair" that the researcher has designed as the assistive gadget can be used for bathing, urinating, and defecating. The suggested item can prevent older people from adopting awkward positions while keeping the current restroom setup. The design of the gadget was created by a mixture of earlier study that resulted in the creation of a tool for toilet activities. Fig 2 depicts the tool's structure, and Table 4 contains a description.

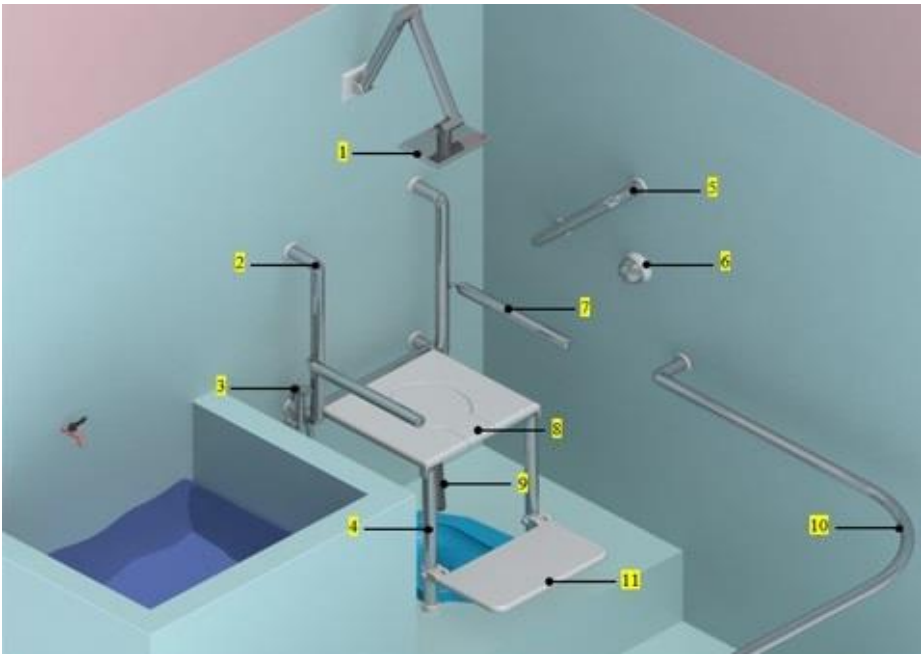


Fig. 2. 3D Design of the "Multifunctional Bath Chair" Tool

Table 4. Description of Tools

No	Component	Function
1	Shower	Helping the elderly take a bath, eliminating the activity of repeatedly taking water when using a dipper.
2	Support Frame	Supports the auxiliary equipment and distributes water to the Jet Shower and Flush
3	Jet Showers	Helping the elderly to urinate or defecate, eliminating the activity of repeatedly taking water using a dipper.
4	Chair Legs	Support tools.
5	Standing Handrails	Handles for the elderly when they want to get up from a sitting posture.
6	Emergency Bell	Facilities for the elderly to ask for help if they have an accident.
7	Armrest	A place for the elderly to rest their hands.
8	Cushion	As a seat for the elderly, eliminating crouching postures.
9	Flush	Means for cleaning urine or defecation.
10	Walking Handrails	Handrails for the elderly when walking to or from assistive devices.
11	Footrest	A place for the elderly to rest their feet.

Fig 3 shows the Mechanism of the "Multifunctional Shower Chair". In Mechanism 1, all bathroom activities for the elderly can be completed with the use of assistive technology.

(Mechanism 1) (Mechanism 2) (Mechanism 3)

Fig. 3. Mechanism of the "Multifunctional Shower Chair"

The seat cushion cover is still in place if you simply plan to use it for bathing. However, the cover may be taken off like a toilet seat if you need to use it for urinating or feces. Mechanism 2: The auxiliary device's shower can be folded and elevated or lowered as needed. The Shower's regular posture allows it to shoot water into the upper body region, but the lower body is not well served. As a result, the Shower may be folded and lowered to more effectively reach the lower body. Mechanism 3: If older people aren't utilizing the assistive gadgets for activities, they can be folded into the wall. This feature is meant to prevent the tool from interfering with other family members' activities. The squat toilet can be used as intended when it is folded up against the wall.

Anthropometric information was used in this study as the standard for tool size. The website anthropometriindonesia.org's article "Indonesian Anthropometry," which contains anthropometric data, was used to compile the results. The choice of data use is made with the intention of allowing future public use of the tool's design. Table 5 illustrates how anthropometric data is used.

Table 5. Using anthropometric information to design tools

No	Component	Description	Anthropometric Dimensions	Code	Percentile	Size
1	Shower	Height	Hand Grip Height Up	D35	5-th	80 cm
2	Support Frame	-	-	-		-
3	Jet Showers	-	-	-		-
4	Chair Legs	Height	Popliteal Height	D16	50-th	40 cm
5	Standing Handrails	Placement	Long Hand Span Forward	D24	5-th	48 cm
		Diameter	Hands [25]	D37	50-th	3,8 cm
6	Emergency Bell	Placement	Long Hand Span Forward	D24	5-th	48 cm
7	Armrest	Long	Lower Arm Length	D23	50-th	41 cm
		Height	Elbow Height in Sitting Position	D11	50-th	25 cm
		Diameter	Hands [25]	D37	50-th	3,8 cm
8	Cushion	Long	Popliteal Length	D14	50-th	40 cm
		Wide	Hip Width	D19	95-th	43 cm
9	Flush	-	-	-	-	-

No	Component	Description	Anthropometric Dimensions	Code	Percen-tile	Size
10	Walking Hand-rails	Height	Elbow Height	D4	50-th	96 cm
		Diameter	Hands [25]	D37	50-th	3,8 cm
11	Footrest	Wide	Leg Length	D30	50-th	23 cm

The 50th percentile is selected since the design approach for the average size was employed in this investigation. However, certain anthropometric data do not utilize the 50th percentile due to the different physical circumstances of the elderly. For senior adults with small stature to easily access the shower, the D35 employs the 5th percentile. Seniors with short arms can easily reach the standing handrail and emergency bell because the D24 employs the 5th percentile. D19 makes advantage of the 95th percentile so that older individuals with chubby bodies can sit without feeling crammed. Fig 4 illustrates how anthropometric information on tool sizes is used.

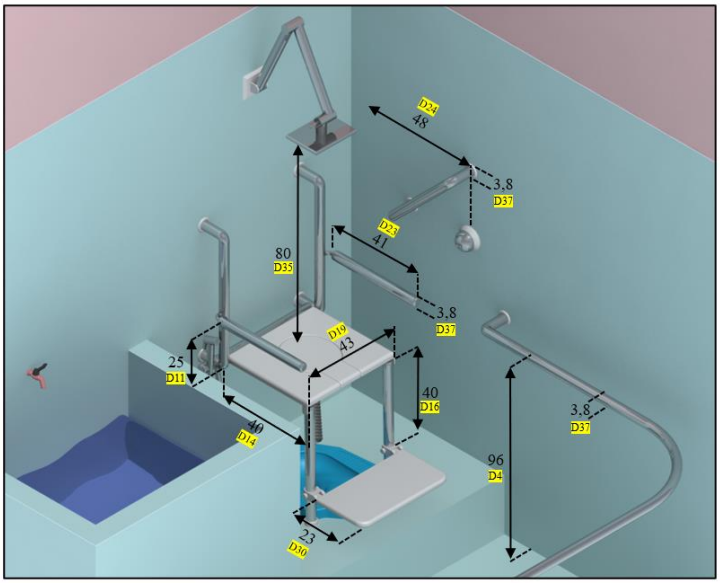
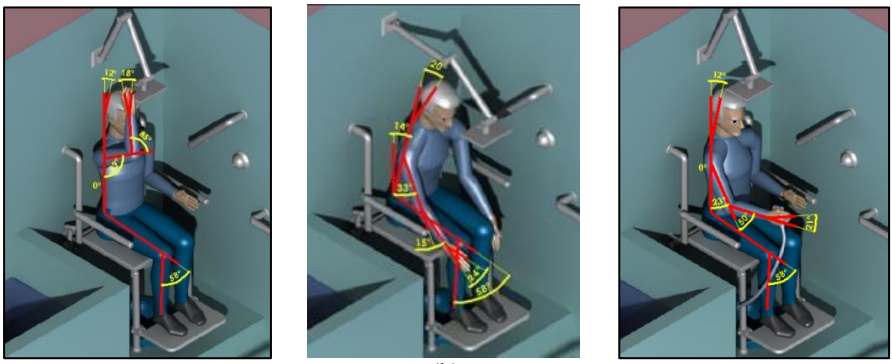


Fig. 4. The "Multifunctional Bath Chair Dimensions'

3.4 Re-analysis of Posture of Proposed Elderly After Using Assistive Device Recommendations with the Rapid Entire Body Assessment (REBA) Method

All of the real postures of the elderly can be transformed into new suggested postures using the previously designed "Multifunctional Bath Chair" tool. In order to assess the effectiveness of implementing the suggestions to lower the risk level, the proposed posture is also examined using the REBA method. To mimic the suggested posture, however, CATIA software's Mannequin simulation capability is utilized as the instrument

is only available in design form. Through its posture modeling capability, the design program CATIA can determine how people and their designs interact [26]. Fig 5 shows the Proposed Posture of the Elderly designed using the CATIA program.



(a) (b) (c)

Fig. 5. (a) Elderly Proposed Posture 1, (b) Elderly Proposed Posture 2, and (c) Elderly Proposed Posture 3

Table shows the findings of the suggested analysis of old posture. A REBA score of 3 was calculated for the suggested elderly posture 1 based on the research shown in Table 6. (Showering, reaching out to turn on and adjusting the direction of the shower). Since the score falls inside the "Low" risk category, no change actions may be required.

Table 6. REBA Posture Analysis for the Elderly 1 Results

Body Segment	Description	Score
Neck	Neck bends down at a 12° (+1) angle	1
Back	Straight back (+1)	1
Foot	Both legs sit supporting the body (+1) at an angle of 58° (+0)	1
Group A score	Table A scores based on neck, back and leg segment scores + weight less than 5 Kg (+0)	1
Upper Arm	Upper arms reach up at a 99° (+4) angle	4
Forearm	Forearm bent at an angle of 85° (+1)	1
Wrist	Wrist forms an angle of 18° (+2)	2
Group B score	Table B score based on upper arm, forearm and wrist segment scores + Comfortable and anthropometrically appropriate hand grip (+0)	5
REBA score	Table C scores based on group A and group B scores	3

The REBA analysis of the suggested elderly posture 2 is displayed in Table 7. A REBA score of 3 is achieved for the suggested elderly posture 2 based on the data reported in Table 7 (bathing, cleaning the lower body). Since the score falls inside the "Low" risk category, no change actions may be required.

Table 7. REBA Posture Analysis for the Elderly 2 Results

Body Segment	Description	Score
Neck	Neck bends down at a 12° (+1) angle	1
Back	Straight back (+1)	2
Foot	Both legs sit supporting the body (+1) at an angle of 58° (+0)	1
Group A score	Table A scores based on neck, back and leg segment scores + weight less than 5 Kg (+0)	2
Upper Arm	Upper arms reach up at a 99° (+4) angle	2
Forearm	Forearm bent at an angle of 85° (+1)	1
Wrist	Wrist forms an angle of 18° (+2)	3
Group B score	Table B score based on upper arm, forearm and wrist segment scores + Comfortable and anthropometrically appropriate hand grip (+0)	3
REBA score	Table C scores based on group A and group B scores	3

Table 8 shows the REBA analysis of the proposed elderly posture 3. Based on the analysis published in Table 8, a REBA score of 3 is obtained for the proposed elderly posture 3 (defecation or urination, holding a jet shower to clean up residual faeces). The score is included in the "Low" risk level, which means that change actions may not be needed.

Table 8. REBA Posture Analysis for the Elderly 3 Results

Body Segment	Description	Score
Neck	Neck bends down at a 12° (+1) angle	1
Back	Straight back (+1)	1
Foot	Both legs sit supporting the body (+1) at an angle of 58° (+0)	1
Group A score	Table A scores based on neck, back and leg segment scores + weight less than 5 Kg (+0)	1
Upper Arm	Upper arms reach forward at a 37° (+2) angle	2
Forearm	Forearm forms a 36° (+1) angle	1
Wrist	Wrists form a 21° angle (+2) + Spin to clean dirt with the Jet Shower (+1)	3
Group B score	Table B score based on upper arm, forearm and wrist segment scores + Comfortable and anthropometrically appropriate hand grip (+0)	3
REBA score	Table C scores based on group A and group B scores + Movement repetition more than 4 times per minute (+1) + Maintaining posture more than 1 minute (+1)	3

It is clear from the REBA method analysis of the three suggested geriatric postures that all of the postures create a "low" REBA risk level, indicating that change activities might not be required. As a result, it is possible to decide that the tool's size and design don't need to be improved and go on to the study of the data processing's outcomes.

3.5 Analysis of Data Processing Results

The "Multifunctional Bath Chair," a product that is advised, can convert all current elderly bathroom activity postures into a new, suggested position. The risk level of REBA between the actual posture and the suggested posture is carried out in order to assess the effectiveness of implementing the suggested assistive equipment. Table 9 displays the comparison.

Table 9. Actual Posture and Proposed Posture Comparison

Comparison	Before Tools	After Tools
Posture	1. Take a bath, take water in the tub using a ladle	1. Take a shower, reach out to turn on and set the direction of the shower
	2. Bathing, cleaning the lower body	2. Bathing, cleaning the lower body
	3. 3. Urination or defecation, taking water in the tub	3. Defecate or urinate, hold the jet shower to clean up the remaining dirt
REBA Score (Risk Level)	1. 7 (Medium)	1. 3 (Low)
	2. 5 (Medium)	2. 3 (Low)
	3. 10 (High)	3. 3 (Low)
Action	1. A change of posture is required	1. Probably not needed
	2. A change in posture is required	2. Probably not needed
	3. Changes in posture must be implemented immediately	3. Probably not needed

The risk of REBA is reduced both before and after using the suggested tools. Therefore, it can be concluded that the researchers' suggestion for the "Multifunctional Bath Chair" equipment can lower the likelihood that MSDs will strike older people who are moving around in the bathroom.

4 Conclusion

According to the study's findings, one elderly person had a "high" risk, 15 people had a "moderate" likelihood, and 14 people had a "low" risk. One "High" risk posture and two "Medium" risk postures were discovered by REBA calculations. As a result, it can be said that all of the older individuals whose postures were examined need to adjust their posture. The "Multifunctional Bath Chair," which was created using SOLIDWORKS and has dimensions adjusted for anthropometry, is the suggested tool. a toilet accessory that may be folded into the wall and used for activities like bathing, urinating, or defecating. The CATIA Mannequin's simulation of the three suggested postures led to a lower risk level of REBA following the use of assistive equipment, lowering the likelihood of MSD complaints in the elderly.

This research is limited to recommended product designs and has not been prototyped so there is a possibility of errors in the assessment of posture with the proposed

product design. Further research can create a tool design that takes into account the wishes of the user as well as the engineering mechanics of the tool structure.

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