Design and Ergonomic Assessment of an Ergonomic Toilet Stool for Promoting Healthier Defecation Posture

Ismail Abu Shah*

Faculty of Industrial and Manufacturing Technology and Engineering, Universiti Teknikal Malaysia Melaka, 76100 Melaka, Malaysia

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.100800128

Received: 11 August 2026; Accepted: 17 August 2026; Published: 27 August 2026

ABSTRACT

Constipation, hemorrhoids and other bowel related disorders have become common worldwide, among others because so many people have adopted the Western style sitting toilet, which may encourage the defecation posture to be inefficient. The purpose of this study was to create and test an ergonomic toilet stool that would promote a healthier squatting position when using a conventional sitting toilet. A questionnaire survey of 100 respondents was conducted using a mixed-method approach, starting with the requirement of users, discomfort and acceptance of a toilet-stool intervention. The findings were translated into product design specification which was used in guiding the concept generation process and four conceptual designs were generated and objectively compared using Pugh Selection Matrix and the best design was picked for detailed development. The anthropometric analysis of the geometry of the stool was carried out using digital male and female manikins in MakeHuman and Blender software, and Computer-Aided Design (CAD) software was then used to model the stool in SOLIDWORKS. Finite Element Analysis (FEA) in SOLIDWORKS simulation was used to compare the performance of two different types of plastics: Acrylonitrile Butadiene Styrene (ABS) and Polypropylene (PP) under the same loading conditions. The Rapid Entire Body Assessment (REBA) method was used to assess ergonomic effectiveness. The proposed design made an approximate hip flexion angle of 35°, which downgraded the REBA from 8 (High Risk) to 3 (Low Risk) resulting in a 62.5% decrease in postural risk. FEA results revealed that ABS had a better structural performance than PP as the maximum displacement of ABS was 0.42 mm and PP was 0.68 mm, while the factor of safety of ABS was 3.8 and PP was 2.1. The ergonomic toilet stool is considered a viable and cost-effective toilet design to improve defecation posture, but further recommendation is prototype fabrication and clinical validation before generalizing health outcomes.

Keywords: Ergonomics; Defecation Posture; Toilet Stool; REBA.

INTRODUCTION

Constipation, hemorrhoids and other gut disorders are more and more common around the world, and are affected by diet, lifestyle and defecation posture. Adoption of western type sitting toilets has changed the natural squatting posture, and this could lead to more straining during defecation and to less efficient defecation. Research previously conducted has demonstrated that squatting causes the puborectalis muscle to relax, which leads to a straighter anorectal angle, making bowel emptying easier.

The practical solution to imitate the squatting position on a conventional sitting toilet, toilet stools have been developed. Many of the products currently on the market, however, are not designed taking into account comprehensive aspects of ergonomics, anthropometric characteristics and structural performance. Therefore, there is a need for an ergonomic toilet stool that will be scientifically validated to have engineering design as well as an ergonomic assessment.

The objective of this study was to develop and test an ergonomic toilet stool that will encourage a healthier defecation posture. The concept generation and selection process was followed by Computer-Aided Design (CAD), Finite Element Analysis (FEA) and ergonomic assessment (Rapid Entire Body Assessment (REBA)). Results should help inform the design of ergonomically functional assistive products which can facilitate a healthier bowel function and promote public health.

Defecation Process and Anorectal Mechanism

Defecation is a coordinated physiological process that includes rectal contraction, relaxation of the anal sphincters, movement of the pelvic floor, abdominal pressure changes and changes in anorectal angle. The puborectalis muscle is a sling around the anorectal junction and helps to keep the anal canal bent relative to the rectum, which aids in continence. When this muscle relaxes and lengthens during the bowel evacuation it helps straighten the anorectal passage and decreases resistance to the passage of stool [1]–[4]. The gastrointestinal tract, rectum, puborectalis sling, anal sphincter, and anorectal junction were also stated as the main anatomical structures related to the toilet posture evaluation in the original project report.

This mechanism is influenced by body position as changes in hip flexion change the hip orientation and the anorectal canal geometry. Proctographic studies have shown that the anorectal angle is variable from lying to standing, sitting to pushing and squatting [2]–[4]. Thus, the effectiveness of the defecation posture was evaluated in relation to the external body posture and also in regard to the potential effects on internal anorectal posture

Sitting and Squatting Defecation Postures

Most western toilets have the user sitting in a straight position with the thighs around 90 degrees to the body. Squatting, on the other hand, requires more hip and knee flexion, and brings thighs closer to the abdomen. This difference in posture can affect abdominal pressure, anorectal alignment, and the muscular work needed to defecate [1, 3, 5, 6].

Sikirov [1] compared excremental functions with a standard height toilet, a low height toilet, and squatting position. Participants indicated that evacuation times were shorter and less straining in the squat position. Some of the data in this study were subjective, however, and only 28 healthy volunteers participated in the study, so these results cannot be extrapolated to all patients with constipation.

The abdominal pressure and recto anal angle were measured simultaneously in three positions by Sakakibara et al. [3]. Squatting gave a greater recto anal angle than normal sitting and hip-flexed sitting indicating a straighter evacuation pathway. However, the limited number of healthy volunteers (only six) in the study reduces the clinical impact of the results.

Takano and Sands [5] studied the posture in which the patient leans forward, referred to as the “Thinker” position, among those who were unable to evacuate contrast paste whilst in a conventional sitting position. The modified posture led to an increased anorectal angle, puborectalis length and some participants managed to complete evacuation. The results suggest that full squat is not the only posture beneficial, but also correct trunk inclination and hip flexion.

More recent tests have also looked at pressure patterns and expulsion in various body positions with Fecobionics. These investigations support the idea that the defecation is biomechanically complex and that the external hip angle is not the sole explanation for the mechanism of defecation [6]. The following factors also need to be taken into account: rectal pressure, anal resistance, coordination of the pelvic floor, stool consistency and individual anatomy.

Constipation and Defecatory Disorders

Functional constipation is a common gastrointestinal disorder characterized by symptoms such as hard stools, infrequent bowel movements, excessive straining, incomplete evacuation, and anorectal blockage. A large

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026

systematic review involving more than 275,000 adults reported that its estimated prevalence varied according to the Rome diagnostic criteria, ranging from approximately 10% to 15% [7]. A newer meta-analysis covering children, adults, and older individuals similarly found substantial variation according to age, sex, location, and diagnostic method [8].

Constipation is multifactorial. Its development may involve dietary intake, hydration, physical inactivity, medication, neurological conditions, slow colonic transit, pelvic-floor dysfunction, and behavioral factors. Consequently, sitting toilets should not be described as the sole cause of constipation, hemorrhoids, or other gastrointestinal disorders. Similarly, a toilet stool should be regarded as a supportive posture-modification device rather than a medical treatment for all bowel disorders [7]–[9].

The distinction between general constipation and a defecatory disorder is particularly important. A person with pelvic-floor dyssynergia may fail to relax the relevant muscles even when the hips are placed in a more flexed position. Therefore, the effectiveness of a toilet stool may differ between healthy users, individuals with mild evacuation difficulty, and patients with clinically diagnosed anorectal dysfunction.

Toilet Stools as Posture-Modification Devices

A toilet stool elevates the user's feet while maintaining contact with a conventional toilet seat. Foot elevation increases hip and knee flexion and partially reproduces a squatting posture without requiring the user to balance over a floor-level squatting toilet. The concept is therefore potentially suitable for homes and facilities where replacement of existing Western toilets is impractical.

Modi et al. [9] evaluated a commercially available defecation-posture modification device among healthy participants. The intervention was associated with less reported straining, shorter bowel-movement duration, and an increased sensation of complete evacuation. These results support the practical potential of a foot-elevation device, although the study population consisted primarily of healthy users rather than patients with diagnosed defecatory disorders.

Clinical findings are not entirely consistent. In a randomised trial involving patients with undifferentiated constipation, Trieu et al. [10] found that footstools significantly changed the angle between the spine and femur but did not improve balloon-expulsion time or subjective evacuation outcomes. This demonstrates that a visible postural change does not necessarily produce improved anorectal function in every user.

Other evidence indicates that selected patients may benefit. The effect may depend on the nature of the defecatory disorder, the height of the stool, the resulting hip angle, pelvic-floor coordination, and individual anatomical characteristics. Accordingly, the present study should evaluate whether the proposed stool produces an ergonomically improved posture without claiming that it will universally prevent or treat constipation.

The original project identified several weaknesses in existing toilet stools, including fixed height, storage difficulty, limited adaptability to different toilet heights, and inadequate accommodation of varying user dimensions. It proposed that the product should be lightweight, strong, easy to clean, convenient to position, and sufficiently stable to support adult users. These requirements support the need for an integrated product-design study rather than relying solely on clinical posture observations.

Anthropometry in Toilet-Stool Design

Anthropometry provides quantitative information on human body dimensions and is fundamental to matching a product with its intended users. In ergonomic design, reliance on average dimensions alone may exclude users located near the lower and upper ends of the population distribution. Product dimensions should therefore consider relevant percentile ranges and the functional relationships between body dimensions, posture, movement, clearance, stability, and comfort [11], [12].

For a toilet stool, relevant dimensions include foot length, foot width, lower-leg length, hip position, knee position, foot inclination, lateral foot spacing, and the distance between the toilet bowl and foot platform. The stool height affects hip flexion, while the width and depth of the platform affect foot support and stability. An excessively low stool may produce insufficient postural change, whereas an excessively high stool could create discomfort, restrict movement, or be unsuitable for users with limited hip or knee mobility.

Cheng and Lee [13] demonstrated the value of anthropometric and experimental evaluation in squatting-toilet design. Their study assessed several foot-platform slopes and found differences in users' comfort preferences, illustrating that platform geometry should be established through user-centered testing rather than arbitrary selection.

Research on bathroom equipment has also shown that commercially available products do not always correspond adequately to users' anthropometric characteristics, especially among older adults [12]. Local anthropometric data are particularly relevant because body dimensions vary between populations. A Malaysian study similarly emphasized the importance of population-specific measurements when designing domestic furniture and household facilities [14].

The original project generated male and female digital manikins and assessed hip angle, foot length, foot width, foot contact length, foot slope, and relative foot-to-buttock distances. These dimensions were used to establish the geometry of the proposed stool and its interaction with the toilet bowl. This approach provides a stronger ergonomic basis than directly copying the dimensions of a commercial product.

Digital Human Modelling

Digital human modelling enables designers to evaluate product–user interaction before prototype fabrication. A digital manikin can be positioned within a Computer-Aided Design environment to examine reach, clearance, joint angles, visibility, and posture. Such methods support early design modification and may reduce the time and cost associated with repeated physical prototypes [11], [15].

In the present project, male and female manikins were generated and repositioned to simulate the proposed toilet posture. The models were used to measure hip and foot positions and to examine contact between the lower limbs and the stool. The report also included multiple views of the manikin–stool interaction.

Rapid Entire Body Assessment

Rapid Entire Body Assessment (REBA) was developed as an observational method for evaluating postures involving the neck, trunk, legs, upper arms, lower arms, and wrists. It also incorporates load, coupling, and activity factors to produce a final risk score and recommended action level [16]. The original development involved the coding of more than 600 postural examples and was intended to assess static, dynamic, unstable, and rapidly changing tasks.

REBA is useful in the present study because it provides a standardized framework for comparing the original and proposed postures. The project report used REBA to examine the neck, trunk, and leg positions associated with the two toilet-posture arrangements and processed the observations through ErgoPlus.

However, REBA was originally developed for occupational tasks rather than defecation. Its risk categories should therefore be interpreted as indicators of postural loading and not as direct measures of bowel health. It also depends on the posture selected for assessment and the evaluator's interpretation of joint angles. Studies have shown that REBA reliability can vary according to assessor experience, posture complexity, and data-collection method [17]–[19].

Digital posture-recognition systems may improve repeatability by estimating joint angles from motion-capture or video data. Research comparing automated systems with expert assessments has reported promising agreement, although inaccuracies can remain in body segments such as the neck, wrist, and lower arm [18], [19].

For this reason, REBA scores in the current study should be supported by clearly presented manikin views, recorded joint angles, and transparent scoring procedures.

Structural Performance and Material Selection

A toilet stool must withstand the user's applied load without excessive deformation, local failure, instability, or permanent damage. Material selection should account for stiffness, strength, impact resistance, manufacturability, weight, surface finish, moisture resistance, cleaning requirements, cost, and expected service conditions. The suitability of a material cannot be determined from strength alone.

The original project compared Acrylonitrile Butadiene Styrene (ABS) and Polypropylene (PP) through finite element simulation. The analysis included displacement, factor of safety, percentage of yield, tension and compression, maximum shear stress, von Mises stress, and principal stress. The resulting geometry was subsequently optimized and re-evaluated.

Finite Element Analysis is valuable for identifying critical stress regions and comparing alternative materials before fabrication. However, simulation results depend on the accuracy of material properties, boundary conditions, mesh quality, contact definitions, applied loads, and assumptions concerning product support. Therefore, prototype load testing is still necessary to confirm that the manufactured stool performs as predicted under actual use.

Research Gap

Existing literature can be divided into several separate areas: physiological studies comparing defecation postures [1]–[6], clinical investigations of footstool use [9], [10], anthropometric studies of toilet and bathroom design [11]–[14], and observational methods for ergonomic posture assessment [16]–[19]. These studies provide valuable evidence, but few combine all these elements within a single engineering product-development framework.

Furthermore, previous clinical studies produced mixed findings regarding the effectiveness of foot elevation. Some reported reductions in straining and evacuation time, whereas others observed postural changes without significant improvement in simulated evacuation. This inconsistency indicates that the value of a toilet stool should be examined through a multidimensional approach rather than relying on hip angle alone.

The present study addresses this gap by integrating user surveys, concept generation, Pugh selection, anthropometric measurements, digital human modelling, CAD development, finite element analysis and REBA assessment. Its principal contribution is therefore the systematic development and ergonomic evaluation of a toilet stool rather than a claim of universal clinical treatment for constipation.

METHODOLOGY

Research Framework

This study adopted a mixed-method research approach that integrated user requirement analysis, engineering product design, structural simulation and ergonomic assessment. The research framework was carried out through seven sequential phases, beginning with a questionnaire survey and the establishment of Product Design Specifications (PDS), followed by concept generation and concept selection, anthropometric analysis and digital human modelling, Computer-Aided Design (CAD) development, structural performance evaluation using Finite Element Analysis (FEA), and finally ergonomic assessment. The overall research methodology is illustrated in Figure 3.1.

INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026

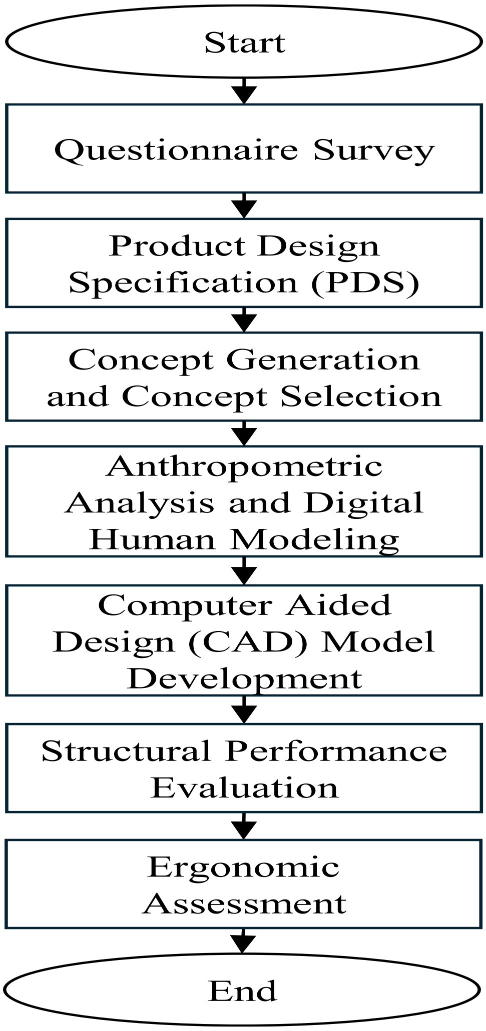


Figure 3.1: Overall flow chart of methodology

Questionnaire Survey

A questionnaire survey was conducted to identify users' toilet usage habits, perceived discomfort, acceptance of toilet stools, and preferred product characteristics. A total of 100 respondents from Universiti Teknikal Malaysia Melaka voluntarily participated in the survey, which was organized into five sections covering demographic information, toilet usage preference, bowel evacuation discomfort, willingness to use a toilet stool, and preferred product characteristics. The collected responses were statistically summarized using descriptive analysis, and the findings were subsequently translated into Product Design Specifications (PDS) that guided the conceptual design process.

Product Design Specifications (PDS)

The Product Design Specifications were developed based on user requirements identified from the questionnaire survey and supported by findings from previous literature, taking into account functionality, ergonomics, structural stability, manufacturability, portability, user safety, hygiene, ease of storage, and aesthetic appearance. The PDS served as the design criteria throughout the product development process and ensured that each conceptual design addressed both engineering requirements and user expectations.

Concept Generation and Selection

Four conceptual toilet stool designs were generated based on the established Product Design Specifications, each proposing different structural configurations, support mechanisms, and ergonomic features. A Pugh Concept Selection Matrix was employed to objectively compare the four concepts against multiple evaluation criteria, including ergonomics, functionality, structural strength, manufacturability, ease of cleaning, storage convenience, user friendliness, and product appearance, with each criterion weighted according to its relative importance.

Anthropometric Analysis

Anthropometric considerations were incorporated to ensure that the proposed toilet stool accommodated the body dimensions of adult users. Male and female digital human models were generated using MakeHuman software and imported into Blender for posture simulation. Seven anthropometric parameters were measured: hip flexion angle, foot length, foot width, foot inclination angle, foot contact length, horizontal foot distance, and vertical foot distance. These parameters were used to determine the optimum stool height, platform width, foot support angle, and overall geometry of the proposed design.

Hip flexion angle was defined as the angle between the longitudinal axis of the trunk and the longitudinal axis of the thigh at the hip joint. The angle was measured from the digital human models positioned on the proposed toilet stool in Blender and compared with the corresponding posture on a conventional Western-style sitting toilet. This parameter was used to quantify the increase in hip flexion achieved by the proposed design and to evaluate its effectiveness in promoting a posture that more closely resembles natural squatting.

Computer-Aided Design (CAD) Model Development

The selected concept was modelled using SOLIDWORKS to produce a complete three-dimensional representation of the proposed toilet stool CAD model. Engineering drawings were prepared to define the overall dimensions, component geometry, assembly configuration, and manufacturing details, and design optimization was performed to ensure adequate structural integrity while maintaining product simplicity and user convenience.

Structural Performance Evaluation

Finite Element Analysis (FEA) was carried out using SOLIDWORKS Simulation to evaluate the structural performance of the proposed toilet stool under static loading conditions. Two commonly used engineering thermoplastics, Acrylonitrile Butadiene Styrene (ABS) and Polypropylene (PP), were investigated, with the simulation evaluating total displacement, factor of safety, von Mises stress, principal stress, maximum shear stress, tensile and compressive stress, and percentage of yield. The simulation results were subsequently used to identify the most suitable material and optimize the structural design before prototype fabrication.

Ergonomic Assessment

The ergonomic validity of the proposed toilet stool was assessed using the Rapid Entire Body Assessment (REBA) method implemented through the ErgoPlus online platform. Digital human models representing the conventional sitting posture and the proposed posture were analyzed, and REBA scores were calculated for the neck, trunk, upper limbs, lower limbs, and overall body posture. The resulting scores were compared to determine whether the proposed toilet stool effectively reduced musculoskeletal risk and achieved the intended ergonomic improvement.

RESULTS AND DISCUSSION

Questionnaire Survey

A total of 100 respondents participated in the questionnaire survey to identify user preferences, perceived discomfort during bowel evacuation, and expectations regarding the use of a toilet stool. The findings as in Figure 1, showed that most respondents preferred using Western-style sitting toilets because of their comfort, accessibility, and familiarity.

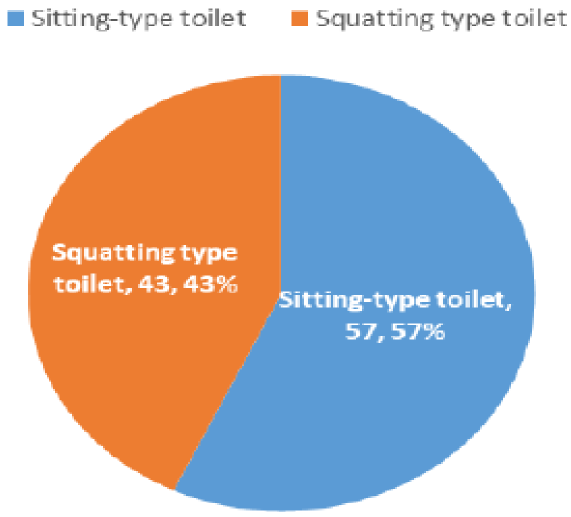


Figure 1: Participants' preferred toilet type for daily use

However, a large proportion of respondents also reported experiencing discomfort or excessive straining during bowel evacuation. Furthermore, as in Figure 2, many respondents expressed their willingness to use a toilet stool if its health benefits were scientifically demonstrated.

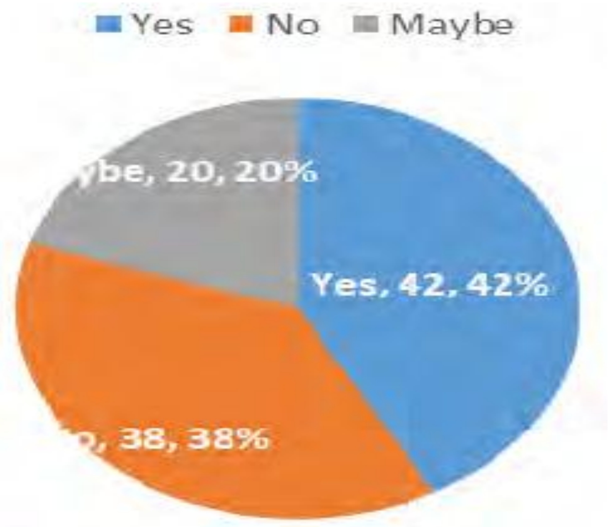


Figure 2: Participants' willingness to use a toilet stool if scientific evidence demonstrates health benefits

Product Design Specifications (PDS)

The survey also identified several important product requirements. Respondents preferred a toilet stool that was stable, lightweight, easy to clean, simple to store, and aesthetically compatible with domestic bathrooms. These findings were translated into Product Design Specifications (PDS) that guided the subsequent concept generation and design stages. From the results, the importance of the features that should be acquired by a toilet stool are arranged in descending order as follows:

1. User-friendly
2. Easily applicable
3. Comfortable to use
4. Overcome legs numbness
5. Shorten straining period of defecation
6. Sanitation hygiene concerns
7. Avoid splashing of urines and feces

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026

Unlike many commercial products that are designed primarily based on market demand, the present design incorporated user requirements obtained directly from the target population. This user-centred approach is consistent with ergonomic product development principles, where design decisions are guided by user needs and functional requirements rather than aesthetic considerations alone.

Concept Generation and Selection

Four conceptual toilet stool designs were generated based on the Product Design Specifications. Each concept incorporated different structural configurations, support mechanisms, and ergonomic features intended to improve the user's defecation posture while maintaining compatibility with conventional Western toilets. The concepts were evaluated using the Pugh Concept Selection Matrix as demonstrated in Table 1.

Table 1: Pugh method analysis

Criteria (Weight)	Concept 1	Concept 2	Concept 3	Concept 4
Comfortable to use (5)	0	0	−1	−1
Easily applicable (6)	0	0	−1	−1
Shortens straining period of defecation (3)	+1	+1	+1	+1
User-friendly (7)	−1	0	−1	−1
Sanitation/hygiene concerns (2)	0	0	+1	+1
Overcomes leg numbness (4)	0	0	+1	0
Avoids splashing of urine and feces (1)	0	0	0	+1
Weighted Overall Score	**−4**	**+3**	**−9**	**−12**
Rank	**2**	**1**	**3**	**4**

Among the four alternatives, Design Concept 2 obtained the highest overall score due to its superior ergonomic characteristics, structural simplicity, ease of manufacture, user convenience, and storage capability. Consequently, Design Concept 2 was selected for detailed engineering development. The conceptual designs are presented in Figure 3, the sketch corresponding to the selected Design Concept 2.

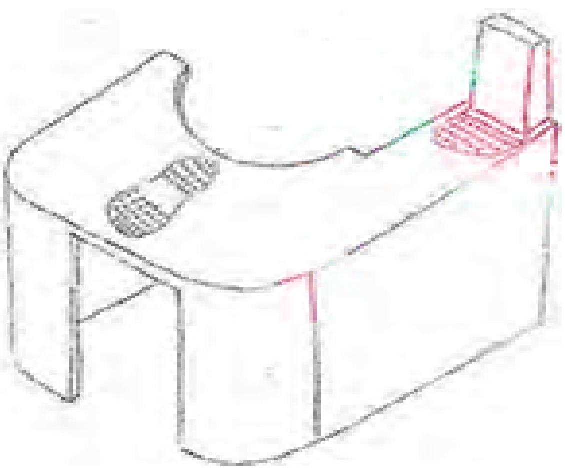


Figure 3: Selected Design Concept (Concept 2)

The use of the Pugh method enabled an objective comparison of alternative concepts by considering multiple design criteria simultaneously. This systematic approach reduced subjectivity during concept selection and ensured that the final design satisfied both engineering and user requirements.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026

Anthropometric Analysis and Digital Human Modeling

Anthropometric analysis was conducted using digital male and female manikins to establish the dimensions of the proposed toilet stool. Measurements including hip angle, foot length, foot width, foot inclination, and the relative positions of the feet and buttocks were obtained to optimize the geometry of the stool. The manikin view as in Figure 4, showing the proposed posture with the hip flexion angle of approximately 35° annotated.

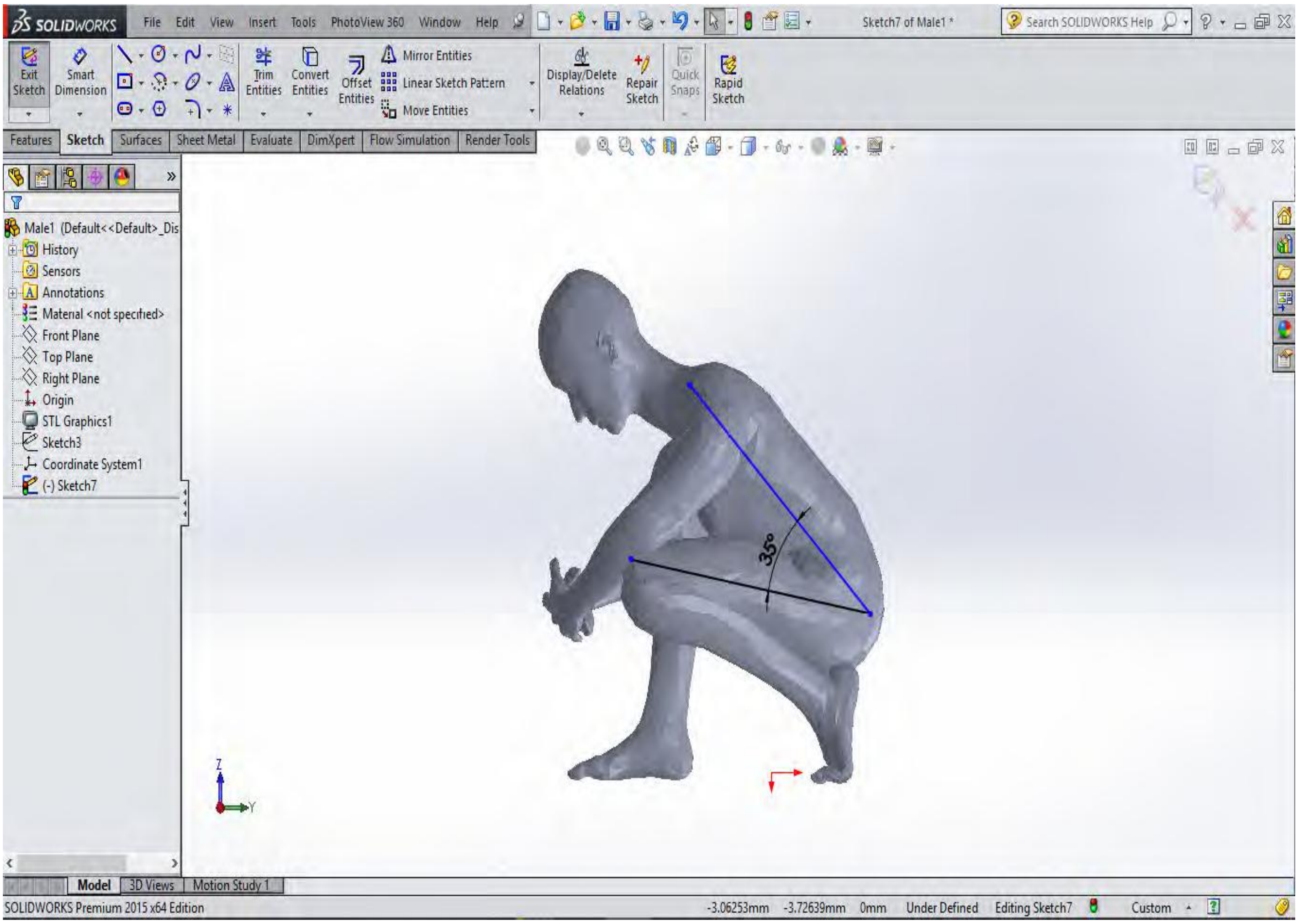


Figure 4: Figure 4.4: Digital human model illustrating the proposed posture with the hip flexion angle (measured between the trunk and thigh) of approximately 35°.

The anthropometric analysis demonstrated that the proposed toilet stool produced approximately 35° of additional hip flexion relative to the conventional sitting posture. The hip flexion angle, defined as the angle between the trunk and the thigh at the hip joint, indicates that elevating the feet using the proposed stool increased thigh elevation and promoted a posture that more closely resembles natural squatting. This increase in hip flexion is expected to improve anorectal alignment while maintaining user stability and comfort.

Computer Aided Design (CAD) Model Development

After the overall dimensions had been finalized, the next stage involved developing a detailed Computer-Aided Design (CAD) model based on the selected conceptual design and the measured dimensions. At this stage, a detailed 3D model of the toilet stool was created using SolidWorks. To ensure dimensional accuracy and realistic assembly, a toilet bowl model was also developed based on actual dimensions obtained from publicly available manufacturer specifications. Several features of the toilet stool were designed to conform to the geometry of the toilet bowl, ensuring proper fit, compatibility, and realistic visualization during assembly. The complete assembly of the toilet stool and toilet bowl was then generated in SolidWorks, as illustrated in Figure 5.

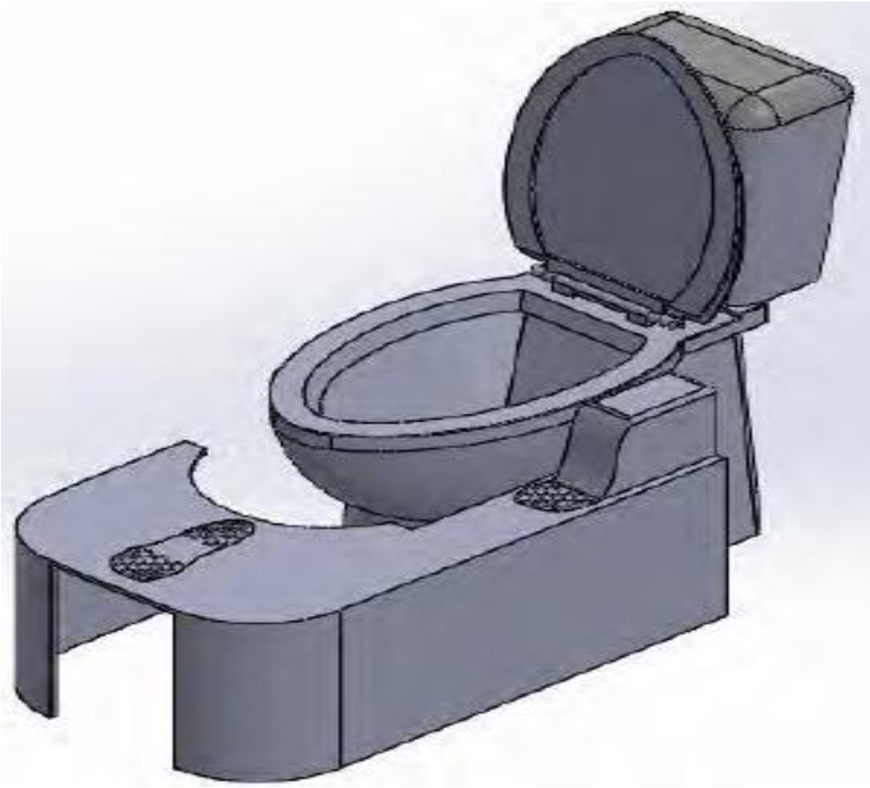


Figure 5: CAD assembly of the proposed toilet stool with the toilet bowl

Structural Performance Evaluation

The structural performance of the proposed toilet stool was evaluated using Finite Element Analysis (FEA). Two thermoplastic materials, Acrylonitrile Butadiene Styrene (ABS) and Polypropylene (PP), were analyzed under identical loading conditions. The simulation considered total deformation, factor of safety, von Mises stress, principal stress, maximum shear stress, and percentage of yield. The ABS displacement contour plot underlying the values reported in Table 2.

Among the two materials evaluated, ABS demonstrated superior structural performance. It exhibited lower maximum displacement and a higher factor of safety than PP, indicating greater stiffness and better resistance to deformation under loading. Table 2 summarizes the key structural performance indicators.

Table 2: Comparison of Structural Performance

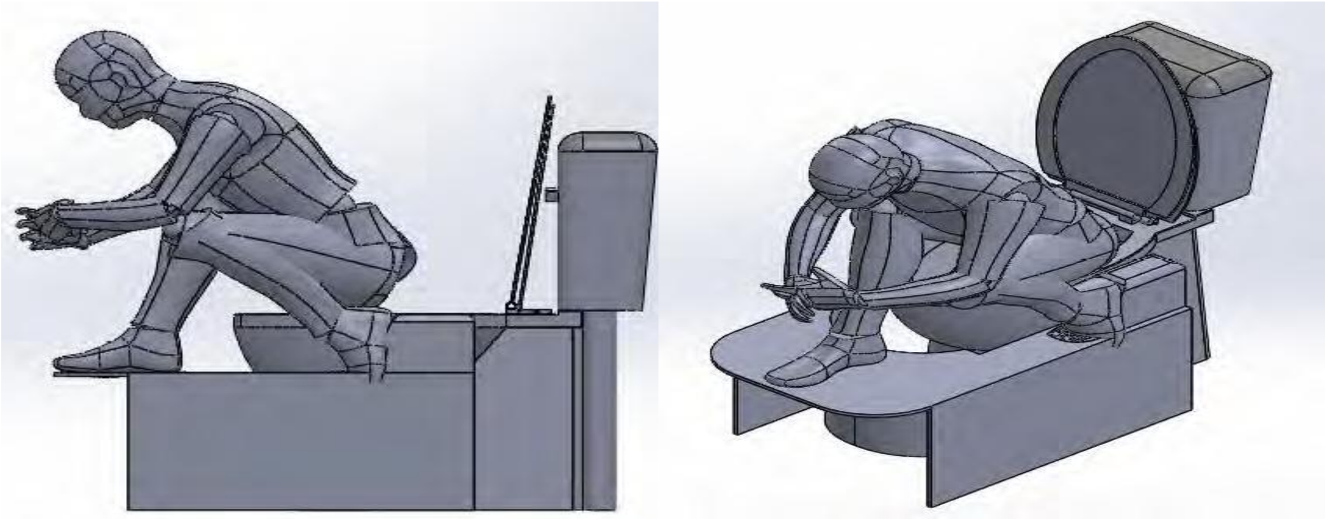
Material	Maximum Displacement (mm)	Factor of Safety
ABS	0.42	3.8
PP	0.68	2.1

The results indicate that ABS is more suitable for the proposed toilet stool because it offers greater structural stability while maintaining relatively low weight and ease of manufacturing. Nevertheless, further experimental testing on a fabricated prototype is recommended to verify the numerical simulation under actual loading conditions.

Ergonomic Assessment

The ergonomic effectiveness of the proposed squat toilet posture was assessed using Rapid Entire Body Assessment (REBA). The proposed squat toilet posture is illustrated in Figure 6. The REBA assessment scoring is shown in Table 3, the REBA output screen for the proposed posture (score = 3, Low Risk).

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VIII August 2026



a) b)

Figure 6: Digital human model interacting with the proposed toilet stool

(a) isometric view and (b) right view

The results demonstrated a substantial improvement in ergonomic performance. The REBA score decreased from 8, corresponding to High Risk, to 3, corresponding to Low Risk, representing a 62.5% reduction in musculoskeletal risk.

Table 3. REBA Assessment Results

Posture	REBA Score	Risk Level
Conventional sitting	8	High Risk
Proposed toilet stool	3	Low Risk

The reduction in REBA score indicates that the proposed toilet stool promotes a more favourable lower-body posture by increasing hip flexion while reducing postural loading on the trunk and lower extremities. Although REBA was originally developed for occupational tasks, it provides a consistent framework for comparing postural differences between the two toilet configurations.

DISCUSSION

The findings demonstrate that integrating user-centred design, anthropometric analysis, structural simulation, and ergonomic assessment provide a systematic framework for developing an improved toilet stool. The questionnaire survey ensured that user requirements were incorporated into the design, while the Pugh method provided an objective basis for concept selection. Anthropometric modelling contributed to an ergonomically appropriate geometry, whereas FEA confirmed that the selected design possessed sufficient structural integrity.

The ergonomic evaluation further demonstrated a considerable reduction in postural risk, while anatomical visualization suggested improved anorectal alignment compared with the conventional sitting posture. Taken together, these findings indicate that the proposed toilet stool offers an ergonomic improvement over conventional footstool. Nevertheless, because the present study relied on digital simulations and observational assessment methods, future work should include prototype fabrication, experimental load testing, and clinical evaluation involving a broader population before conclusions regarding health outcomes are generalized.

CONCLUSION

In conclusion, this study successfully developed an ergonomic toilet stool intervention through a systematic engineering design framework integrating user-centered design, anthropometric analysis, CAD modelling, finite element analysis, and ergonomic assessment. The proposed design demonstrated favorable structural integrity and significantly improved defecation posture by reducing the REBA score from 8 (High Risk) to 3 (Low Risk), indicating a substantial reduction in musculoskeletal risk associated with conventional sitting toilets.

Beyond its engineering contribution, the proposed toilet stool has the potential to serve as a simple, low-cost, and non-invasive public health intervention for promoting healthier defecation posture. By facilitating a posture that more closely resembles natural squatting, the design may help reduce excessive straining during bowel evacuation and support bowel health among users of conventional Western-style toilets. Such ergonomic interventions may contribute to preventive health strategies aimed at improving daily toileting practices, particularly among ageing populations and individuals susceptible to functional bowel disorders.

Although the present study was based on engineering simulations and ergonomic assessment, future research should include prototype fabrication, biomechanical measurements, user-centered trials, and clinical evaluation to determine the long-term effectiveness of the proposed design in improving bowel function and health outcomes. Successful validation through clinical studies would further strengthen the potential of this intervention as an accessible assistive device that supports health promotion and preventive healthcare within the community.

ACKNOWLEDGEMENTS

This research received no financial support. The author gratefully acknowledges Universiti Teknikal Malaysia Melaka (UTeM) and the Faculty of Industrial and Manufacturing Technology and Engineering for providing the laboratory facilities.

REFERENCE

1. Sikirov, D. (2003). Comparison of straining during defecation in three positions: Results and implications for human health. Digestive Diseases and Sciences, 48(7), 1201–1205. doi:10.1023/A:1024180319005.
2. Bartram, C. I., Turnbull, G. K., & Lennard-Jones, J. E. (1988). Scintigraphic assessment of the anorectal angle in health and after ileal pouch-anal anastomosis. Gut, 29(7), 918–923.
3. Sakakibara, R., Tsunoyama, K., Hosoi, H., et al. (2010). Influence of body position on defecation in humans. Lower Urinary Tract Symptoms, 2(1), 16–21. doi:10.1111/j.1757-5672.2009.00057.x.
4. Jorge, J. M. N., Wexner, S. D., Ehrenpreis, E. D., et al. (2001). Contribution of posture to the maintenance of anal continence. International Journal of Colorectal Disease, 16, 51–55.
5. Takano, S., & Sands, D. R. (2016). Influence of body posture on defecation: A prospective study of "The Thinker" position. Techniques in Coloproctology, 20, 117–121.
6. Sun, D., Huang, Z., Zhuang, Z., et al. (2021). Fecobionics assessment of the effect of position on defecatory efficacy in normal subjects. Techniques in Coloproctology, 25, 559–568.
7. Barberio, B., Judge, C., Savarino, E. V., & Ford, A. C. (2021). Global prevalence of functional constipation according to the Rome criteria: A systematic review and meta-analysis. The Lancet Gastroenterology & Hepatology, 6(8), 638–648. doi:10.1016/S2468-1253(21)00111-4.
8. Youn, J. W., Joo, H., Kim, S., et al. (2026). Global prevalence of functional constipation across all age groups according to Rome II–IV criteria, 1999–2025: A systematic review and meta-analysis. Clinical and Translational Gastroenterology, 17(6), e01029. doi:10.14309/ctg.0000000000001029.
9. Modi, R. M., Hinton, A., Pinkhas, D., et al. (2019). Implementation of a defecation posture modification device: Impact on bowel movement patterns in healthy subjects. Journal of Clinical Gastroenterology, 53(3), 216–219.
10. Trieu, R. Q., Prott, G., Sequeira, C., et al. (2023). Using a footstool does not aid simulated defecation in undifferentiated constipation: A randomized trial. Neurogastroenterology & Motility, 35(7), e14580. doi:10.1111/nmo.14580.
11. Dianat, I., Molenbroek, J., & Castellucci, H. I. (2018). A review of the methodology and applications of anthropometry in ergonomics and product design. Ergonomics, 61(12), 1696–1720. doi:10.1080/00140139.2018.1502817.

12. Başıbüyük, G. Ö., Güler, Z. Ö., Kılıç, B., et al. (2024). Designing ergonomic toilets and bathrooms for older adults: A study on anthropometric dimensions and recommendations. Geriatric Nursing, 55, 1–10. doi:10.1016/j.gerinurse.2023.11.017.
13. Cheng, C. Y., & Lee, Y. H. (1998). An ergonomic approach to public squatting-type toilet design. Applied Ergonomics, 29(2), 147–153. doi:10.1016/S0003-6870(96)00023-3.
14. Taifa, I. W. R., & Desai, D. A. (2015). Anthropometric measurements for ergonomic design of domestic furniture and appliances. Measurement, 61, 205–215.
15. Chaffin, D. B. (2005). Improving digital human modelling for proactive ergonomics in design. Ergonomics, 48(5), 478–491.
16. Hignett, S., & McAtamney, L. (2000). Rapid Entire Body Assessment (REBA). Applied Ergonomics, 31(2), 201–205. doi:10.1016/S0003-6870(99)00039-3.
17. Janowitz, I. L., Gillen, M., Ryan, G., et al. (2006). Measuring the physical demands of work in hospital settings: Design and implementation of an ergonomics assessment. Applied Ergonomics, 37(5), 641–658. doi:10.1016/j.apergo.2005.08.004.
18. Li, L., Xu, X., Hu, X., et al. (2020). An evaluation of posture recognition based on an intelligent Rapid Entire Body Assessment system for determining musculoskeletal disorders. Sensors, 20(16), 4414. doi:10.3390/s20164414.
19. Balogh, A., et al. (2025). Reliability and agreement during the Rapid Entire Body Assessment: Comparing rater expertise and artificial intelligence. PLOS ONE, 20, e0322998.