

Design of Ergonomics-Based Bath Chair for the Elderly

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ABSTRACT

With the global population increasingly aging, more and more older adults live alone. For these older adults living alone with inconvenient legs and feet, daily bathing has become extremely difficult and even dangerous. This study adopts the method of a questionnaire survey. A total of 195 older adults were invited to participate in the questionnaire, and three were interviewed in depth. To better understand the process and needs of bathing, the user journey map of bathing for the elderly is also drawn. Combined with the physiological and psychological characteristics of the elderly, the existing problems of elderly bathing products are analyzed. The product combines ergonomic principles and FBS design theory. Subsequently, the evaluation experiment was carried out through the prototype. We also added product details according to the activities of the elderly during bathing to achieve comprehensive safety protection for the elderly. This study can effectively reflect the potential perceived needs of the elderly for furniture products, update relevant ergonomic data, and provide valuable references for the elder's furniture design practice.

Keywords: Elderly, Bath chair, Ergonomics, Integrated design

INTRODUCTION

Since the 21st century, the world has generally entered into an ageing population society. The degree of population ageing in developed countries has deepened significantly while developing countries have not yet entered the ranks of an ageing population. From a global perspective, the world's total population has increased by 1.65 billion people from 2010 to 2020; during the same period, the ageing population in developed countries is relatively deep and much higher than the overall level of the world. Developing countries (excluding China) have a milder degree of population ageing (Tong Yufen. 2021), and the process is significantly slower than in the rest of the world. They have not yet entered an ageing society in general. (See Table 1) The ageing process of China's population is significantly faster than that of the whole world and faster than that of developed countries (Liu houlian et al. 2021). From 2000 to 2020, 130 million of the 440 million older people in the world will be contributed by China. China will still bear the pressure of a huge population aging in the future.

Table 1. Population aging in the world and China from 2000 to 2020. (Liu houlian et al. 2021).

Population aging in the world and China from 2000 to 2020					
	Year	Worldwide	Developed countries	Developing countries	China
Total population (100 million)	2000	61.4	11.9	36.4	12.6
	2010	69.6	12.3	43.2	13.4
	2020	77.9	12.7	50.5	14.2
Population over 60 years old (100 million)	2000	6.1	2.3	2.5	1.3
	2010	7.6	2.7	3.2	1.8
	2020	10.5	3.3	4.7	2.6
Proportion of population over 60 years old (%)	2000	9.9	19.5	6.8	10.0
	2010	11.0	21.8	7.5	13.3
	2020	3.5	25.7	9.2	18.7

RESEARCH STATUS OF BATHING PRODUCTS

The elderly industry has received early attention in developed countries such as Europe and the United States. The research results and practices of bathroom products for the elderly are relatively advanced, and the functions and details are very humanized. Based on thoroughly studying the needs of the elderly, the concept of universal design has been integrated to meet the psychological needs of the elderly who refuse to be considered particular users (He Jingnan et al. 2011).

As the first country in Asia to enter the aging society, Japan has formed a significant market scale and has many mature product designs for the elderly, such as special seats for the elderly, special health monitors, and safety handrails to help the elderly get up. Given the bathing problem of the elderly, Japan has divided the elderly toilets into various types according to the physiological needs of the elderly at different ages. 1) Toilet for people who can stand on their own. 2) A toilet for people who can move in a wheelchair but can stand independently. 3) Toilet for people who can move in a wheelchair but cannot stand independently. Japanese designers' research on toilets used by the elderly is not limited to their internal layout and bathroom product configuration. They also designed and studied sanitary products according to the needs of the elderly at different stages and their physiological dimensions and characteristics, including installation location, installation form, operation mode, color, and materials (Chen Xin et al. 2012).

Europe was the first to enter the aging era (Long Lili. 2006), and the UK, which was the first to implement the welfare policy, paid particular attention to the living life of the elderly. As early as 1969, it stipulated the classification requirements of the classification standard of residential buildings for the elderly. According to the physical conditions of the elderly at different stages, it divided the types of elderly buildings accordingly. It adopted a series of unique bath ware for the elderly that is convenient for the elderly to use (Zheng Lin. 2015).

The United States has made outstanding contributions to the humanized bathroom design for the elderly through innovative research. Michael Graves, an American postmodern architect, designed a bathing appliance for the physically disabled in 2003. This bathing appliance is a removable hand-held shower head with a brush designed for the physically disabled and the elderly. The shower head is appropriate to the size of the palm of the elderly, and it is convenient for the elderly to hold the shower head with one hand. When the user needs to wash locally, he can press the red button on the shower head to remove the original shower head and replace it with a shower head with a brush. The soft brush can help the user complete the action of one hand rubbing the body (Huang Qun. 2019).

USER RESEARCH

Human physiological functions reach their peak after the age of 18. After 30, human physiological functions will continue to decline and are irreversible. By the age of 70 or so, people's physiological function is only about 50% of the peak period. With the increase of age, the elder's ability to care for themselves will gradually decrease or eventually become completely exhausted. This physiological law also reflects the health law of the elderly. (Xiang Xin and Wang Yi. 2021).

Most of the actions of the elderly in the process of bathing need lower limb strength to achieve. However, with the gradual decline of human physiological function, lower limb strength will also gradually lose, and the more inferior limb ligaments and muscles will significantly decline and decline with the increase of age. The loss of various functional elements of the elderly will lead to the elderly becoming weak. If we ignore the fall, it will have dire consequences, which will be a heavy blow to the physical and psychological health of the elderly (Zhao Fang. 2003). The results of the sampling survey show that 90.8% of the elderly have difficulties completing bathing activities independently, and bathing as an essential daily activity needs help urgently (Mei Yangyang et al. 2015).

QUESTIONNAIRE SURVEY ON BATHING FOR THE ELDERLY

In order to fully understand the difficulties and specific needs of the elderly when bathing, we obtained the bath problem descriptions of 195 elderly people (over 70 years old) in Hangzhou Binfen Community through offline survey. The research results show that more than 62.05% of the elderly complete bathing with the help of their families and nursing staff. 75.90% of the elderly are worried about the slippery floor and fall down when taking a bath, and 82.56% of the elderly will feel tired when taking a bath.

To further understand the actual demands of older adults on bathing, we selected several older adults in the course of the questionnaire to conduct in-depth interviews. Through talking with them, we learned about the problems that older adults often encounter in bathing and their views and feelings about it. We drew the user journey map (see Figure 1) and summarized opportunities that can help the following design research.

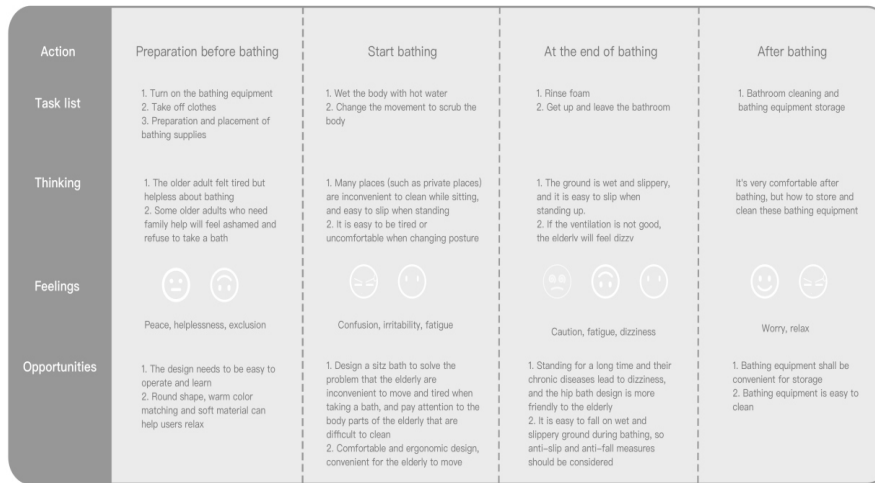


Figure 1: User journey map.

DESIGN PROCESS

User interviews and desktop research provide clues for the design scheme. According to the above study and data, even the elderly who seem healthy and able to complete the bath independently also need the help of others. Generally speaking, the elderly have difficulty in joint movement due to decreased body function. The help bath can help clean the parts that the elderly can not wash and are not convenient to pass, such as the back, the belly of the legs, and private functions. Among them, the elderly's need for assisted bathing is extreme when their body is not in good time. This behavior can effectively reduce the burden on the elderly and protect their safety. Therefore, this paper proposes an improved solution of independent bath chair for the elderly family.

FBS MODEL DESCRIPTION

FBS is an innovative design model proposed by Professor Gero (GERO J S. 1990), which includes three variables: "function," "behavior," and "structure." (see Figure 2) Designers can transform user needs into expected product functions through this model, thus obtaining a specific implementation structure. Researchers usually supplement the design process with other models to get user needs. Zhou Qi and others proposed an innovative design method based on fuzzy Kano and situational FBS models (Zhou Qi et al. 2020), which is used to solve the problem of insufficient innovation of situational products to improve user satisfaction with the product.

FBS DESIGN PROCESS FOR BATHING BEHAVIOUR OF THE ELDERLY

Based on the FBS model and from the perspective of user needs, this paper finds out the opportunity points of product design by mapping the pain

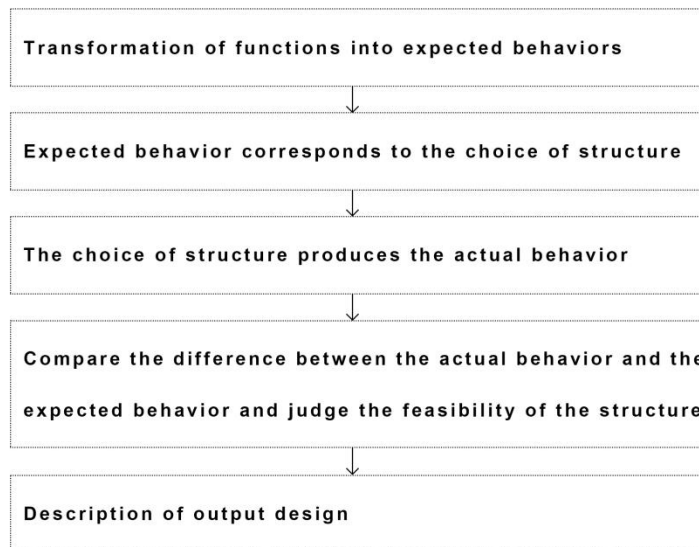


Figure 2: FBS model.

points in the elderly bathing scene to the functions, behaviours, and structures of the FBS layer by layer and then proposes feasible product solutions. The design process of bathing behavior for the elderly based on FBS is shown in the figure(see Figure 3). The results of the FBS model provide a basis for the subsequent improvement of product usability and comfort. In behaviour-function mapping, there is a one-to-many relationship between behaviour and function. To ensure the integrity of the process, different structural modules are required to meet the corresponding user behaviour.

ERGONOMIC ANALYSIS BASED ON USER REQUIREMENTS

To better meet the user's user experience in the bathroom environment, the structure is quickly hand-painted, modelled, and verified, which is conducive to the overall control of the product, and the specific functions are sorted out to avoid functional omission and contradiction in the complex environment. Finally, the product is designed to be suitable for the elderly to wash independently and others to help bath(see Figure 4).

A. Back bath aid

The handrails on both sides are provided with expandable planes, which can be easily flipped. (see Figure 5) Considering that the elderly need to maintain a comfortable and safe position when they are served and bathed by others, the design case proposes a multi-directional armchair in which the elderly can lie on the armchair facing left or right. The width of the standard seat armrest is about 70mm. The product increases the width of the armrest to 152mm through the folding structure, which increases the contact area

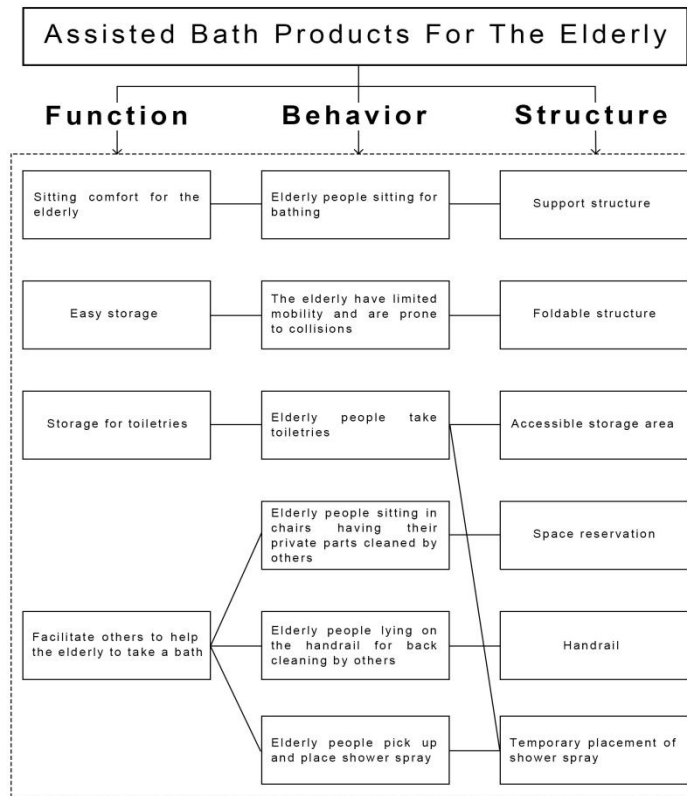


Figure 3: Design of elderly bathing chair based on FBS model.



Figure 4: Bath chair rendering.

between the user's hand and the armrest, and improves the comfort of the elderly in the use process.

B. Private bath aid

The chair surface is designed as a "U" shape (see Figure 6). Bathing attendants can more easily clean up the private places of the elderly. The elderly can



Figure 5: Assistance with back bathing.



Figure 6: Assistance with private bathing.

only move forward slightly to clean up the private places, avoid the elderly needing to stand to complete this process, and reduce the risk of the elderly sliding.

C. Foldable seats

The product uses an innovative structure to enable the elderly to fold the chair independently and efficiently. (see Figure 7) Considering the inconvenience of the elderly, increasing the available space in the bathroom and reducing the volume of collision objects can effectively reduce the risk. At the same time, anti-skid pads are set on the legs of the chair to make it firmly rely on the wall.

D. Storage structure

Two storage structures are designed in this scheme. (see Figure 8) An iron basket that temporarily stores bath articles is hung at the left armrest, and the structure is removable. In the sitting position, the elderly can get the bathing

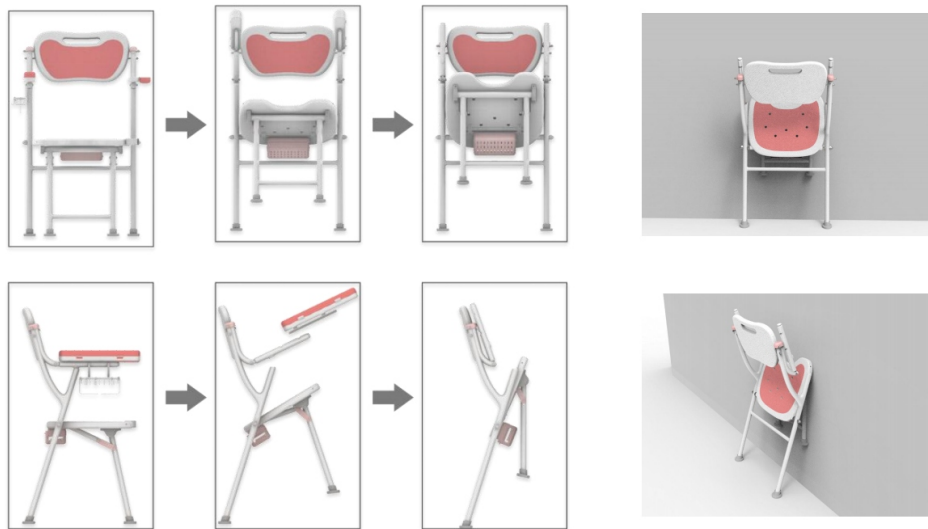


Figure 7: Bath chair folding process.

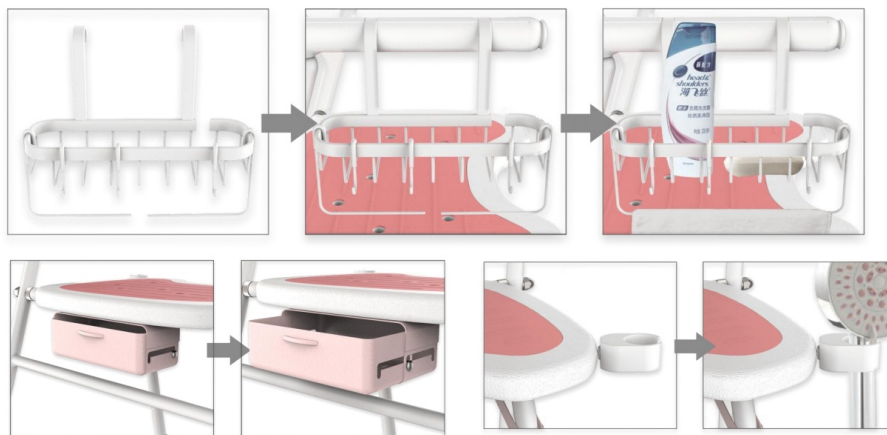


Figure 8: Toiletries, shower spray storage.

supplies he wants within the range of hand movement. Similarly, there is a storage box under the chair, which can store clothes. To prevent the clothes of the elderly from getting wet in the bath, the storage box is designed as a retractable pull-out structure. In addition, there is a socket at the right front of the chair surface where the shower nozzle can be temporarily placed, which is convenient for the elderly and bath attendants to take and place the shower nozzle.

E. Seat ergonomic dimensions

To improve the comfort of the elderly using the bath chair, the product refers to the human body static measurement method, which calculates the average height of the elderly, the width between the two elbows, and the length of the lower limbs in the sitting posture (Yu Yang et al. 2016). It obtains that the chair height of the product is 480mm, the seat depth is 390mm, the

seat width is 520mm, and the arm height is 700mm. The pillow surface is skin-friendly protein skin, and the internal soft support material is a sponge. Through this program, the sense of the bathing experience of the elderly can be improved, and the safety and space utilisation rate can be increased.

CONCLUSION

The case design of the innovative bath chair solves the safety and comfort problems of the elderly in the complex bathroom environment. Through user interviews and desktop research, this paper analyzes the behavioral characteristics and physiological needs of the elderly, establishes the FBS model to determine the specific design elements to obtain a reasonable and feasible solution strategy, and carries out the model production to verify the feasibility of the innovative design of the elderly bathing chair. In terms of solving the problem of bathing for the elderly, the integrated innovative design method helps researchers find real user needs and provides a practical reference for developing products for the elderly.

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