ASSISTIVE DEVICES FOR IMPROVING SITTING AND STANDING BALANCE IN ELDERLY INDIVIDUALS

By
Miss Wenjing YAN

A Thesis Submitted in Partial Fulfillment of the Requirements
for Master of Fine Arts Design
Silpakorn University
Academic Year 2023

อุปกรณ์ช่วยเหลือสำหรับการปรับปรุงความสมดุลในการนั่งและยืนสำหรับผู้สูงอายุ

โดย

MissWenjing YAN

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรศิลปมหาบัณฑิต

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Title	Assistive devices for improving sitting and standing balance in elderly individuals
By	Miss Wenjing YAN
Field of Study	Design
Advisor	Assistant Professor Dr. Atithep Chaetnalao

Faculty of Decorative Arts, Silpakorn University in Partial Fulfillment of the Requirements for the Master of Fine Arts

.....Dean of Faculty of
(Dr. Thanatorn Jiarakun) Decorative Arts

Approved by

.....Chair person
(Associate Professor Dr. Kriangsak Khiaomang)

.....Advisor
(Assistant Professor Dr. Atithep Chaetnalao)

.....Committee
(Assistant Professor Dr. Supachai Areerungruang)

.....Committee
(Dr. Isarachai Buranaut)

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Miss Wenjing YAN : Assistive devices for improving sitting and standing balance in elderly individuals Thesis advisor : Assistant Professor Dr. Atithep Chaetnalao

In the context of global population ageing, the issue of mobility among older adults has become a significant social concern. As individuals age, they encounter increasing difficulties in performing fundamental daily activities, such as rising from a seated position, ambulating, assuming a seated posture, and maintaining an upright stance. These obstacles impede their capacity to live independently and elevate the probability of falls, which threaten their health and quality of life. The objective of this research is to develop an innovative assistive device to enhance the autonomy and safety of older adults. A multifaceted approach, encompassing literature reviews, on-site observations, questionnaires, and in-depth interviews, was employed to ascertain the actual needs and challenges faced by older adults. Based on this information, I designed and manufactured a user-friendly, safe, comfortable, and cost-effective assistive device. The device accommodates the physiological and cognitive limitations of older adults, with a focus on adjustability and personalisation. The research integrated knowledge from engineering, ergonomics, geriatrics, and psychology to ensure a practical design. During product development, a series of prototype designs and user tests were conducted to optimise functionality and user experience. Results indicated that over 80% of participants expressed satisfaction, with 20% indicating high satisfaction. The remaining 20% were neutral, and no participants reported dissatisfaction. The findings demonstrated that the assistive device effectively enhances the independent mobility of older adults. It enables older adults to move freely within nursing homes, engage in social and leisure activities, and receive support during sitting and standing, reducing the need for assistance from others. The device's feature for getting up reduces the risk associated with standing by incorporating a balanced design. Its adjustable design adapts to different bed types, enhancing the device's universality. Although the product achieved certain results, there are still design limitations requiring further optimisation. In conclusion, this study provides a foundation for designing assistive devices for older adults, which is significant for improving their quality of life, independence, and optimising care services. These achievements will contribute to the advancement of elderly care technology.

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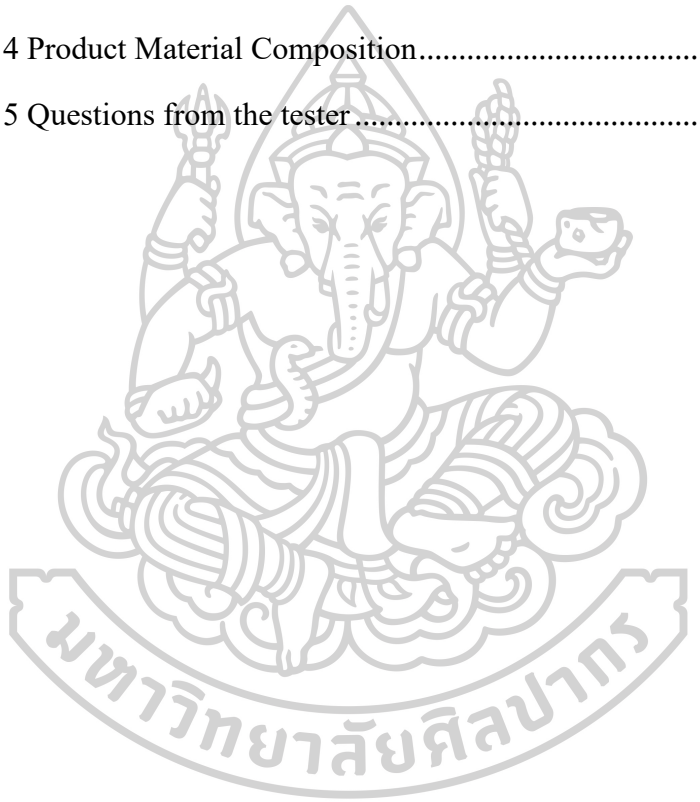

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CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

1.1.1 INCREASING POPULATION AGING

The World Health Organization (WHO) defines a society as aging when the population aged 60 and above constitutes 10% of the total population, or when the population aged 65 and above exceeds 7% of the total population (Li, 2016). The ongoing process of urbanisation and the increasing number of individuals choosing to remain single or have fewer children are accelerating global population ageing, resulting in a continuous increase in the number of individuals aged 60 and above (Lutz et al., 2008). The data from the Seventh National Population Census Bulletin (No. 5) released by the National Bureau of Statistics of China (NBS, 2021) on 11 May 2021 indicates that China's elderly population aged 60 years and above has reached over 264 million, representing a growth of 5%. The proportion of the elderly population aged 60 years and above was 44%, accounting for 18.7% of the total population. The elderly population aged 65 years and above reached more than 190 million, with a rise of 4.63% in proportion, accounting for 13.5% of the total population. It is predicted that the Chinese population will continue to age rapidly, with the proportion of the elderly population aged 60 years and above reaching 371 million in 2030, 437 million in 2040, and 483 million in 2050. The Chinese population aged 60 and above is projected to reach 371 million in 2030, 437 million in 2040, and 483 million in 2050 (National Bureau of Statistics of China, 2021), indicating that China has already entered a serious ageing stage. Since the 1980s, the Chinese government has implemented the one-child policy. However, in August 2021, the Standing Committee of the National People's Congress voted to amend the Population and Family Planning Law, advocating for appropriate marriage and childbirth, promoting quality births, and allowing couples to have up to three children. This policy change has led to a transformation in the traditional nuclear family structure. The "4+2+1" or "4+2+2" or "4+2+3" family structure has become prevalent in Chinese society (Han, 2021). This refers to a family consisting of four elderly individuals, two young adults, and one to three children. As a result, young people face significant pressure and find it challenging to balance the needs of both the elderly and their own lives. The daily and emotional needs of the elderly become increasingly challenging to meet, leading to a decrease in family happiness. Over time, the phenomenon of population ageing has become increasingly evident, characterised by a year-on-year increase in the elderly population. This trend is significant globally and has profound impacts on both the socio-economic aspects and our daily lifestyles. The health, well-being, and care needs of the elderly have become crucial issues that require immediate attention and resolution. It is of paramount importance to direct

greater attention towards the quality of life of the elderly, with a view to providing enhanced medical, nursing, and social support. This will ensure that they are able to enjoy a dignified, healthy, and meaningful late-life experience.

1.1.2 ISSUES AND CHALLENGES FACED BY THE ELDERLY

As the population continues to age, the elderly are confronted with a multitude of challenges and issues, including economic insecurity, social difficulties, housing concerns, and most crucially, health problems. Individuals aged 60 and above experience a significant decline in physical function, leading to height reduction, osteoporosis, and spinal diseases, which impede their ability to sit and stand, thus reducing their capacity for independent living. This can also have a detrimental effect on their self-confidence, contributing to feelings of low mood (Zhang, 2022; Luo, 2021). As they age, the elderly become increasingly susceptible to chronic diseases, declining physical functioning, and cognitive impairment, necessitating more frequent medical and caregiving support. Additionally, they also face psychological health issues such as loneliness, depression, and anxiety. A significant proportion of older adults reside in nursing homes, where they may encounter various challenges and issues related to physical health, mental well-being, and social interaction. For instance, living in a nursing home can contribute to feelings of loneliness, loss, and inferiority as it reduces opportunities for interaction with children or friends. Moreover, the rapid development of the information age may result in older adults feeling marginalised by information technology, which can lead to a sense of being left behind. This can subsequently contribute to a decline in mood and a worsening of physical health. From a physiological perspective, age-related decline in various bodily functions, combined with the presence of chronic conditions such as diabetes and osteoporosis, reduces autonomy in daily living. Furthermore, some older adults may encounter difficulties associated with cognitive decline, including mild cognitive impairment, dementia, or Alzheimer's disease (Yu, 2023).

As the physical functioning of older adults continues to decline and the prevalence of diseases increases, muscle strength, balance, and walking ability in the upper and lower limbs also start to deteriorate. This decline becomes particularly steep after the age of 75, to the point where basic daily activities and movements, such as getting up from a chair or bed, sitting down, climbing stairs, or walking quickly, become challenging. These movements are fundamental to everyday life for everyone, and even when we are tired, completing them can be difficult. For older adults, these basic movements become even more challenging due to the instability in walking and standing that comes with aging. Actions as seemingly simple as getting up and sitting down are difficult for older adults. "Rising" and "sitting" are fundamental bodily movements in daily life. In comparison to walking, these two movements are particularly challenging for older adults (Wang, 2020). Consequently, there is a growing demand for assistive products. Currently, various assistive products

have been introduced in the market, such as those for walking assistance, toileting, and bathing, which have been supported by relevant literature. Nevertheless, there is a paucity of products designed specifically for the act of getting out of bed. Furthermore, these products do not fully meet the needs of older adults in terms of ease of use and user-friendliness when used independently (Wang & Dong, 2020).

In the context of these challenges, particularly in relation to health issues, it is of paramount importance that society at large collaborates to provide better support and care for older adults. This should include the provision of comprehensive healthcare services, the establishment of robust social security systems, the facilitation of opportunities for social engagement among older adults, the provision of suitable living environments and safety measures. Additionally, education and training are required to help older adults adapt to the digital society and technological advancements. It is of significant importance to recognise that as a rapidly expanding consumer group, older adults necessitate the design and provision of a diverse range of products that are tailored to their specific needs and abilities. These products should prioritise their distinctive requirements and capabilities, offering a superior user experience and convenience while ensuring their health and safety.

1.1.3 THE ACCELERATED EVOLUTION OF AGE-FRIENDLY PRODUCT DESIGN

The issue of ageing presents significant challenges, yet also presents unprecedented opportunities for the silver economy. In recent years, the ageing industry in many countries worldwide has been regarded as a sunrise industry of the 21st century (Liu, 2020). With the surge of the ageing population, the design of age-friendly products is experiencing an unprecedented boom. The signs of ageing are no longer seen as constraints but rather as sources of innovative design inspiration. The market is witnessing the emergence of various products aimed at simplifying daily life, enhancing a sense of security, and improving the quality of life, meeting the growing demands of elderly consumers. From accessible home renovations to smart health monitoring devices, the concept of age-friendly design is becoming ubiquitous. This is not just a design revolution but also a symbol of societal progress, demonstrating that we are caring for people of all ages in a more inclusive and intelligent manner.

Firstly, the global market for age-friendly products is continuously expanding, with a rapid growth in market demand. With the advent of new technologies, the design of age-friendly products is also innovating. For instance, smart wearable devices, remote monitoring systems, and smart home devices leverage advanced sensors, artificial intelligence, and the Internet of Things (IoT) technology to provide more personalised and intelligent services for older adults. A number of governments at the national and regional levels are actively promoting the development of age-friendly products by implementing relevant policies and providing financial

support to encourage research and production in this field. For example, the Chinese government has explicitly stated in the "14th Five-Year Plan" to develop the elderly care service industry and promote the development of age-friendly products and services. As the population continues to age, there is an increasing focus on the quality of life for older adults. There is a growing public awareness and acceptance of age-friendly products, which drives the research, development, and market promotion of such products. An increasing number of companies are investing in the field of age-friendly products, including traditional healthcare enterprises, technology companies, and emerging startups. These investments and participations stimulate innovation and market competition in age-friendly product design.

Furthermore, the academic community and research institutions are engaged in active research and development work on age-friendly products. This involves the constant exploration of new design concepts and technological applications, with the objective of providing a scientific basis and technical support for the development of age-friendly products. A plethora of articles pertaining to age-friendly product design research can be found, including studies on clothing (Tian et al., 2021), furniture (Shi & Zhang, 2023), and electronic products (Wan & Li, 2022), food (Norton et al., 2022), medical supplies (Yue et al., 2022), assistive products (Wei, 2023), and various other types of products. As the global population continues to age, the design of products for an aging society presents significant challenges. Understanding and meeting the diverse product needs of older adults is an important topic for designers and researchers across various product categories. Age-friendly product design is a concept that aims to meet the living needs of older adults by providing better comfort, convenience, and safety. This type of design takes into account changes in the physical and cognitive abilities of older adults to ensure that products are easier to use and cater to their specific needs. Designers must typically gain an in-depth understanding of the needs of older adults, based on some basic principles of age-friendly product design, and combine best practices from relevant fields to develop age-friendly products. This ultimately improves the quality of life for older adults and helps them live more independently.

The design and research of age-friendly furniture represents a crucial aspect of age-friendly product design. It plays a pivotal role in enhancing older adults' capacity to live independently, as well as ensuring their safety, comfort, and convenience in daily life. Furthermore, it serves as a vital instrument in alleviating the burden of elderly care on society and younger generations (Ma, 2016). Nevertheless, the current development of age-friendly furniture has focused on redesigning basic functionalities, with insufficient consideration given to the individual differences that arise from aging or specific physical conditions of older adults. Furthermore, it has not fully addressed the common needs of the elderly population (Wang & Dong, 2020). For instance, as individuals age, older adults often face challenges in maintaining sitting and standing balance, which not only limits their daily activities but also increases the risk of falls. Consequently, the utilisation of professional assistive devices to enhance

older adults' sitting and standing balance becomes of paramount importance. Currently, there are a number of commonly used assistive devices available on the market which are designed to enhance the independence and safety of seniors, including walkers, standing aids, canes, grab bars, and various rehabilitation equipment.

Nevertheless, despite these endeavours, the market still lacks comprehensive assistive products that can help older adults sit, stand, and walk safely. Existing assistive devices either have a single function or are overly complex, lacking sufficient user-friendliness, which makes it difficult for older adults to operate independently without assistance. They fail to fully meet the practical needs of older adults for independent use. While some products theoretically aim to provide support, they often do not adequately consider the physical limitations and habits of older adults, resulting in inconvenience and discomfort during use. Therefore, there is an urgent need for more innovative and user-centric products that can assist older adults in sitting and walking. These products should prioritize the actual user experience of older adults in their design, ensuring ease of operation while providing necessary support and stability. Such devices can assist older adults in starting their day in a safer and more confident manner, while respecting and supporting their right to independent living. With the advancement of technology and evolving design concepts, it is anticipated that there will be an increase in the availability of high-quality assistive products that meet the needs of older adults in the future.

1.2 RESEARCH HYPOTHESIS

The hypothesis is that the design and manufacture of age-friendly furniture, such as chairs and beds, based on the physiological and psychological needs of older adults can enhance their comfort and safety in sitting and getting up from the furniture. This can reduce the physical burden on older adults when using furniture and thereby lower the occurrence of difficulties in sitting and getting up, ultimately enhancing their ability to live independently. By focusing on individual differences, safety, and convenience in the design of age-friendly furniture, and incorporating personalised features such as adjustable seat height, ergonomic seat cushions, backrests, and armrests, as well as electric or manual assistance devices, older adults can be assisted in easily performing the actions of sitting and getting up while ensuring their safety, comfort, and convenience. The design of assistive products should prioritise a human-centred approach, adhering to principles such as usability, simplicity, and safety. This approach facilitates independent performance of daily activities, thereby enhancing the ability of older adults to live independently.

1.3 RESEARCH OBJECTIVES

(1) To gain a comprehensive understanding of the challenges, difficulties and needs of the elderly.

(2) To analyse and design products that assist with sitting and rising according to the needs of the elderly.

(3) To evaluate the ability of assistive devices to enhance the independence of the elderly.

1.4 EXPECTED BENEFITS

The primary objective of this study is to design innovative products that assist in maintaining body balance. By developing and implementing technologies that assist in maintaining body balance, the goal is to facilitate easier and safer sitting, standing, and walking for older adults, thereby enhancing their quality of life. This, in turn, provides a safer living environment for older adults, reduces the occurrence of accidents and injuries, and provides peace of mind for older adults and their families. The application of body balance assistance technologies is expected to reduce the occurrence of accidental falls or injuries during sitting, standing, and walking, thus reducing the burden on healthcare systems. Due to a shortage of caregivers in nursing homes, there is a risk of inadequate care and potential dangers. Therefore, it is hoped that body balance assistance technologies can reduce the workload of caregivers in assisting older adults in sitting, standing, and walking, thereby improving caregiving efficiency. The objective of research on assistive technologies for getting up in older adults is to better meet the needs of an ageing society for professional care and enhanced autonomy. It is anticipated that this study will provide valuable data and inspiration for further research in this field.

1.5 SCOPE OF RESEARCH

The primary objective of this study is to examine the difficulties and obstacles encountered by older adults in the execution of activities such as sitting, standing, and walking, and to develop a comprehensive balance assistance product tailored to their specific physical conditions. The research will concentrate on the design and optimization of products incorporating body balance assistance technology to address the unique needs of older adults during these activities. Furthermore, in-depth investigations will be conducted to understand the interaction between older adults and assistive technologies. This will involve examining factors such as user experience, usability, and acceptance, with the aim of ensuring that the developed technologies align with user needs, enhance older adults' willingness to use them, and improve their ability to live independently.

The subjects of this study are older adults who are able to perform self-care or semi-self-care in nursing homes. They are the primary focus of this research. Additionally, nursing home staff will be considered in two distinct groups. The first group is the caregivers in nursing homes, as they are one of the beneficiary groups of this study. It is of great importance to gain an understanding of the work status, conditions, tasks, and professional knowledge of those employed in nursing homes.

This is essential in order to design products that meet the needs of older adults more effectively. The second group is that of management personnel employed in nursing homes. A well-managed nursing home system ensures a well-organised life for older adults, increases trust from older adults and their families, enhances the reputation of the nursing home, and attracts more customers and revenue.

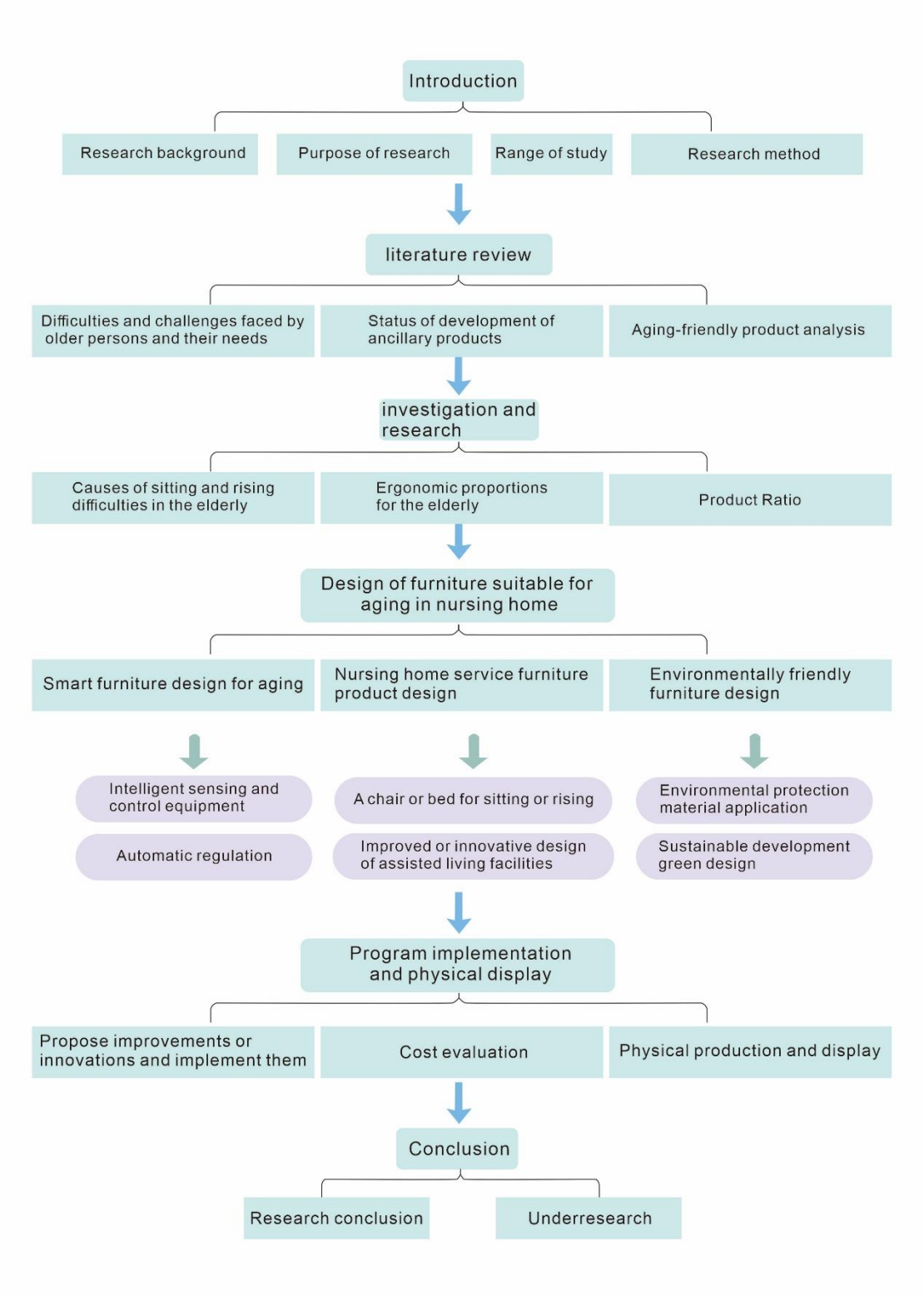
Geographical Scope: This research aims to conduct investigations and in-depth studies in nursing homes located in Dingxi City, Gansu Province, China. Dingxi City is located in the northwest region and is relatively economically underdeveloped, which makes it more susceptible to issues in elderly care services. Additionally, as a local resident with a background in the local culture and language, it enables better integration into the elderly population and improves the accuracy of the research. As most older adults are not proficient in Mandarin Chinese, the use of the local dialect allows for more in-depth communication, enabling a comprehensive understanding of their perspectives on assistive products, physical conditions, and needs. This approach to communication in the local language is expected to uncover the genuine thoughts and experiences of older adults during the research.

1.6 RESEARCH FRAMEWORK

1.6.1 RESEARCH FRAMEWORK

Figure 1 presents a research framework for the design of assistive products for the elderly. The process commences with an introduction to the research background, objectives, scope, and methods. Through a literature review, the difficulties faced by the elderly, the current state of assistive products, and the analysis of age-friendly products are explored. This is followed by a detailed survey research phase, which examines the reasons behind the elderly's difficulty in sitting and standing, ergonomic considerations, and product proportions. The survey results are used to inform the design of age-friendly smart furniture, nursing home assistive furniture, and environmentally friendly furniture. Following the design phase, the solutions are implemented and physical prototypes are showcased, including improved solutions, cost evaluations, and physical production. Finally, the research concludes with a summary and evaluation of the findings.

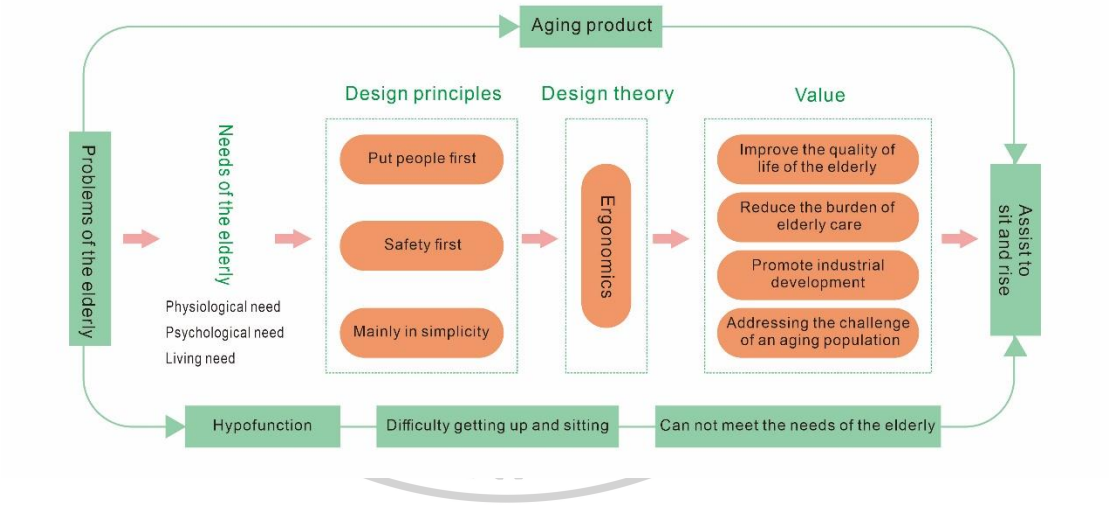
Figure 1 Research Framework



1.6.2 CONCEPTUAL FRAMEWORK

Figure 2 presents the theoretical framework of this study. It commences with an analysis of the physiological, psychological, and living needs of the elderly. Thereafter, based on their declining physical functions and difficulties in sitting and standing, the design principles for assistive products are established. These principles are based on a people-first approach, safety, and simplicity. The design theory employs ergonomics with the aim of improving the quality of life for the elderly, reducing the burden of caregiving, promoting industrial development, and addressing the challenges of an ageing population. The ultimate goal is to design products that assist the elderly in sitting and standing, thereby meeting their needs and resolving their difficulties. This process reflects a systematic approach from problem identification to needs analysis, establishment of design principles, application of theory, and realisation of value.

Figure 2 Conceptual Framework



1.7 RESEARCH METHODS

(1) Literature Review: The internet and available information resources in relevant fields will be utilised to access academic journals, online articles, and books on the subject of ageing-friendly products, the product needs of older adults, elderly balance, getting up, walking assistance, balance-assistive technologies, and assistive product design. A thorough analysis of these materials will be conducted to provide background information and theoretical support for this research, while incorporating existing academic knowledge and achievements.

(2) Case Study: The examination of relevant product cases that assist older adults in sitting, standing, or walking processes will enable the analysis of the design, technology, structure, materials, operation methods, colours, functions, and other

aspects of these products. This analysis will facilitate a deeper understanding of the characteristics and existing issues of current assistive products and the exploration of innovative balance assistance technologies that are suitable for older adults' getting up process.

(3) Field Investigation: Observation of the actual situations of older adults during the basic physical actions of sitting, standing, or walking, and recording of the difficulties and risks they may encounter in these actions will provide a realistic reference for the design of innovative assistive products for older adults. Additionally, observation of the frequency of older adults' use of existing assistive products in the nursing home, as well as identification of any problems and safety hazards during their usage, will provide direction for this research's design.

(4) Questionnaire Survey: The administration of questionnaires is the primary method of gathering research data. The content of the questionnaire survey will involve on-site interviews with older adults residing in nursing homes. These interviews will be conducted to gain insight into the basic physical conditions, family structures, and opinions of older adults in these facilities. Additionally, interviews will be conducted with nursing staff and management staff to gain a deeper understanding of their job responsibilities and strategies for increasing the nursing home's reputation and attracting more older adults. The collection of participants' evaluations, needs, and expectations regarding existing balance-assistive technologies will provide guidance for the design of innovative solutions.

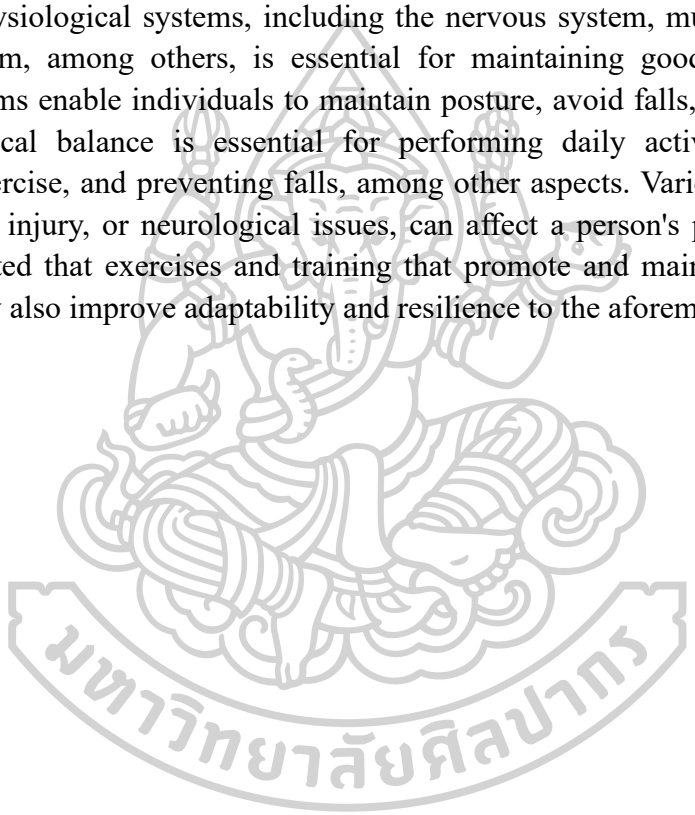
1.8 DEFINITION OF TERMS

(1) Elderly: The term is used to describe individuals who are relatively advanced in age. It is typically used to refer to those who have entered the later stages of life. The specific definition of "older adults" may vary across different cultures, societies, and medical fields. Generally, 65 years of age is widely recognised as a typical retirement age, and thus individuals aged 65 and above are commonly classified as older adults. The process of ageing is associated with a number of changes in physical, cognitive and social functioning. As individuals age, they may encounter challenges such as chronic illnesses, reduced mobility and declining memory. However, the older adult population is also highly diverse, with some individuals maintaining good health and remaining active and engaged in society in their later years. It is important to note that the definition of old age is evolving in line with advancements in medicine and society. While 65 years may be considered a general retirement age, in some countries, individuals may choose to delay retirement to extend their professional careers. Therefore, the definition of older adults is influenced by various factors, including culture, society, and medical advancements.

(2) Assistive Devices: This category of tools, devices, systems, or services is designed to assist, support, or enhance functional abilities in daily life. These technologies are typically designed to meet the everyday needs of individuals with

different levels of ability or specific needs. The goal of assistive technology is to promote individual autonomy, independence, and participation, thereby improving the quality of life in areas such as education, work, social interactions, and other aspects. In this paper, the term "assistive balance technology" is used to refer to the design and development of various devices, tools, apparatuses, or systems through various approaches with the goal of improving, maintaining, or enhancing the physical balance ability of older adults, specifically to assist them in safely getting up from bed.

(3) Physical Balance: This term refers to the ability to maintain bodily stability and posture when standing, sitting, or engaging in other activities. The coordination of multiple physiological systems, including the nervous system, muscular system, and visual system, among others, is essential for maintaining good physical balance. These systems enable individuals to maintain posture, avoid falls, or loss of stability. Good physical balance is essential for performing daily activities, engaging in physical exercise, and preventing falls, among other aspects. Various factors, such as age, illness, injury, or neurological issues, can affect a person's physical balance. It can be posited that exercises and training that promote and maintain good physical balance may also improve adaptability and resilience to the aforementioned factors.



CHAPTER 2

LITERATURE REVIEW

This chapter commences with an analysis of the physiological and psychological conditions of older adults, with particular emphasis on the importance of maintaining sitting balance in this population. It then proceeds to summarise the principles and concepts of design for ageing-friendly products. Secondly, it reviews relevant research on the design of ageing-friendly furniture products, with the objective of understanding the current research status and analysing the types and functions of assistive devices. Additionally, it focuses on reviewing the research status of product design for assisting older adults in maintaining physical balance. The chapter concludes by summarising the above findings and providing references for the design and research of products that assist older adults in sitting and getting up. It also analyses older adults' preferences for assistive devices and presents an ergonomic analysis of assistive products for sitting up.

2.1 THE STUDY OF THE PHYSIOLOGICAL CONDITION OF OLDER ADULTS

In our daily observations of older adults, it is evident that a significant portion of them experience noticeable physical degradation, which makes it challenging for them to rise from chairs or beds. They tend to prefer sitting on beds, chairs with backrests, or firm cushioned sofas. However, soft cushioned sofas can make it more difficult for them to get up. During the process of rising from a seated or lying position, older adults typically require assistance from others or rely on canes, handrails, and other assistive devices. Currently, the variety of assistive devices available in the market for sitting and rising is relatively limited, and they cannot fully meet the comprehensive needs of older adults in terms of sitting, rising, and mobility. Consequently, the development of a product that can assist older adults in independently standing or sitting can not only enhance their ability to live autonomously but also alleviate the caregiving responsibilities of caregivers and family members (Wang & Dong, 2020).

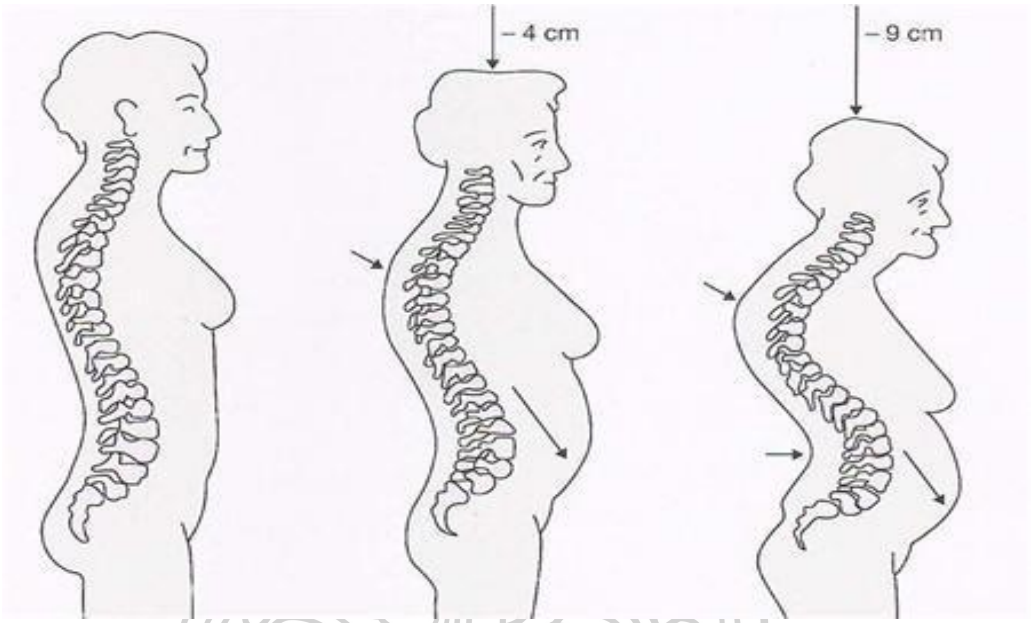
2.1.1 POSTURAL CHANGES

As individuals age, they undergo physiological and physical changes that can affect their posture. These changes not only impact the appearance of older adults but also their mobility, balance, and overall health. The following physiological changes occur due to postural changes in older adults:

(1) Decreased height: As individuals age, their height gradually decreases (Figure 3). This is primarily due to the dehydration and thinning of the intervertebral

discs in the spine, as well as possible curvature of the spine. Furthermore, osteoporosis can result in deformities of the spinal bones, which may also contribute to a reduction in height (Xu, 2022).

Figure 3 Human Aging Process



Note. (Xu, 2022)

(2) Postural changes: Many older adults experience changes in their posture, such as kyphosis (forward curvature of the thoracic spine) and forward head tilt. These postural changes may be caused by a number of factors, including muscle weakness, joint stiffness, and skeletal structural changes.

(3) Gait changes: Gait refers to the posture and stride while walking. The gait of older adults may become slower, with reduced stride length, and they may even exhibit a dragging of the feet. This is due to a reduction in muscle strength and flexibility, as well as a decline in balance.

(4) Joint changes: Joint deterioration, such as osteoarthritis, can cause joint pain and stiffness, which in turn affects normal movement and posture, thereby influencing postural alignment (Li, 2023).

2.1.2 MUSCULOSKELETAL SYSTEM

The musculoskeletal system of the elderly undergoes comprehensive changes, involving bones, muscles, joints, and the nervous system. These alterations significantly impact their mobility, balance, and independence in everyday life.

(1) Osteoporosis: As aging progresses, the bone remodeling process slows down, leading to a decrease in bone density and quality. This makes the bones more fragile, causing most elderly people to suffer from osteoporosis and become more prone to fractures.

(2) Skeletal Morphology Changes: For example, spinal curvature (such as kyphosis) and height reduction are primarily attributable to the loss of intervertebral disc fluid and vertebral compression.

(3) Joint Changes: Joints, the connection points between bones, are composed of two smooth cartilages. As age advances, the cartilage in the joints is significantly worn, resulting in a loss of smoothness. Ligaments, which connect, reinforce, and limit the movement range of the joints, undergo changes and lose elasticity. This results in restricted joint activity, such as the reduced range of motion in the shoulders and elbows of the elderly. Furthermore, the elasticity of soft tissues, including tendons and ligaments, also decreases, limiting joint mobility, flexibility, and movement capability.

(4) Decline in Muscles and Stamina: With increasing age, the mass (muscle atrophy) and strength of muscles gradually reduce, a phenomenon known as sarcopenia. Concurrently, there is a decline in muscle function, manifested in a reduction in the speed and power of muscle contraction, which directly affects the elderly's mobility, standing, and balance-keeping abilities (Wang et al., 2022).

2.2 PSYCHOLOGICAL ANALYSIS OF THE ELDERLY

Old age is a significant phase of life marked by numerous physiological, psychological, and social environmental changes. These transformations can profoundly impact the mental state and emotional well-being of the elderly. Therefore, it is crucial to understand the psychological characteristics of the elderly in order to better support their health and happiness. Key aspects of the psychological characteristics of the elderly include:

(1) Cognitive Changes: With advancing age, certain cognitive abilities may gradually decline, including attention, memory, processing speed, and problem-solving skills. While this is part of the normal ageing process, the rate and extent of cognitive changes vary among individuals. Many elderly individuals maintain good cognitive function and continue to learn new things.

(2) Emotional Stability: Elderly individuals often have more experience and wisdom in emotional regulation. Research indicates that as people age, they become more mature and effective in managing emotions, tending to experience positive emotions and avoid negative ones, a phenomenon known as the "socioemotional selectivity theory" (Wang et al., 2020).

(3) Changes in Social Roles: Retirement, children establishing their own families, the loss of a spouse, or the loss of a partner are significant social role changes that may be encountered in old age. Such changes can impact the elderly's

self-identity, social status, and daily activities, potentially leading to feelings of loneliness, loss, or an identity crisis.

2.3 IMPORTANCE OF SITTING-STANDING BALANCE FOR THE ELDERLY

(1) Fall Prevention: As age increases, the balance ability of the elderly may decrease, increasing the risk of falls. Falls can lead to severe injuries such as fractures or head trauma, and may even result in death.

(2) Maintenance of Self-Care Ability: Good sitting-standing balance allows the elderly to independently complete various activities in daily life, such as sitting down, standing up, walking, and turning, thereby maintaining a high quality of life.

(3) Promotion of Physical Health: Balance training can form part of a comprehensive exercise plan for the elderly, helping to improve overall physical fitness, including muscle strength, flexibility, and coordination.

(4) Improvement of Psychological and Emotional States: Improved balance can increase the self-confidence and sense of security of the elderly, reducing anxiety and depression caused by fear of falling.

(5) Reduction of Healthcare Costs: Improved sitting-standing balance can help reduce healthcare costs and the socio-economic burden caused by fall accidents among elderly individuals.

(6) Increase in Survival Rate: Good balance is associated with longevity in the elderly as it reduces severe injuries and potential fatal consequences caused by falls.

(7) Enhancement of Physical Response Capability: Balance training has been demonstrated to improve the physical response capability of the elderly to sudden situations, thereby reducing accidents caused by delayed responses. Consequently, the sitting-standing balance ability of the elderly is a crucial factor in maintaining an independent life and overall health status. Therefore, product design and research targeting the balance ability of the elderly are especially important (Yuan et al., 2023).

2.4 AGING-FRIENDLY DESIGN CONCEPTS AND PRINCIPLES

2.4.1 AGING-FRIENDLY DESIGN PHILOSOPHY

Aging-friendly design is a philosophy that considers the physical functions and behavioural characteristics of the elderly during the design process. Its objective is to meet the daily life and travel needs of those who have entered or are about to enter old age. This design philosophy emphasises an "elderly-centred" approach. It begins with the perspective of the elderly, deeply senses their distinct needs, and designs works that cater to the physiological and psychological demands of the elderly. The objective is to provide the greatest possible assistance to the elderly, who are susceptible to a range of physical functional declines and impairments due to the natural process of

aging. This assistance is designed to enhance their daily lives and travel experiences (Wang et al., 2023).

2.4.2 PRINCIPLES OF AGING-FRIENDLY DESIGN

(1) Adjustment of Dimensions Based on Demographic Characteristics

In the control of overall scale design for seating, it is important to consider that the elderly typically engage in less physical activity, have sagging skin, and tend to be overweight with slightly wider hips. Therefore, the dimensions of aging-friendly seating should be appropriately enlarged, with a gap of about 2.5 cm on each side for a more spacious and comfortable fit.

Regarding seat comfort, excessively soft cushions can destabilise the elderly's centre of gravity, while harder cushions can slow blood circulation in the skin, potentially leading to osteitis. Additionally, smooth cushion materials can cause the elderly to gradually slide off the seat, leading to safety incidents. Therefore, it is necessary to conduct a careful comparison and experimentation when selecting materials for ageing-friendly products.

In the design of seat height, it is recommended that elderly seats be slightly higher than those for younger adults, with slightly forward-inclined armrests. If an elderly person's feet can fully touch the ground, shifting the centre of gravity forward makes it easier for them to stand up. However, if the seat is too high, causing the elderly person's legs to dangle, the entire weight will press on the thighs and hips, impeding blood circulation. Long periods of sitting can result in the onset of leg numbness, tremors, and weakness, which can lead to discomfort and pose certain safety risks (Zhang, 2022).

(2) Principles of Safe Design

In the design of furniture intended for use by older individuals, it is important to adopt rounded, smooth shapes in order to minimise the risk of accidental bumps or scratches due to unforeseen circumstances or health issues in the elderly. This will help to safeguard their physical well-being. Properly inclined cushions and backrests can help to prevent older individuals from sliding out of their seats due to clothing or cushion materials, and can also alleviate discomfort in the lumbar region. Additionally, while wheels can facilitate the mobility of seating for the elderly, they can also result in falls and instability. Therefore, the use of wheels should be approached with caution, and it is advisable to opt for wheels with braking mechanisms (Fu, 2022).

(3) Stable and Subdued Colour Palette

The choice of colours and materials in aging-friendly products is also crucial. Due to the effects of aging, such as colour weakness, aging, and slow reactions caused by brain degeneration, elderly furniture should feature stable, subdued, and quiet colour tones. It is advisable to use colours with low saturation and brightness, such as commonly used blues, yellows, and grays (Wei et al., 2018).

2.5 CURRENT RESEARCH STATUS OF AGING-FRIENDLY FURNITURE PRODUCT DESIGN

The study of ageing-friendly product design has long attracted academic attention. Among these, Liu and Wang categorised ageing-friendly products into three types. The first is Life Support Products, which cater to the specific behavioural needs of the elderly and allow them to take better care of themselves. The second is Fitness Products, which offer the elderly additional enjoyment in their twilight years through various physical activities, stimulate mental activity, and prevent attention deficits, deteriorating memory, and sluggish responses due to ageing. The third category is that of leisure and entertainment products, which are designed to stimulate the intelligence of the elderly, enhance their hobbies, increase social interaction, prevent brain degradation, and ward off dementia (Liu & Wang, 2022). Aging-friendly furniture product design falls under the first category and is a crucial part of aging-friendly product design.

In developed countries such as Europe, the United States, Japan, and South Korea, which have experienced an earlier transition to an ageing society, furniture design is informed by an understanding of the lifestyles and habits of the users, with in-depth surveys of home environments conducted and well-established norms, theories, and design practices, especially in the design of furniture for the elderly, being referenced. These developed countries have a clear positioning of elderly furniture in the market. For instance, Japan has distinguished between categories of elderly furniture, launching a range of types suitable for both healthy and frail seniors. This exemplifies the professionalism of elderly furniture design. As early as the 1980s, Japan proposed reasonable size designs for elderly living spaces based on changes in their physical conditions and introduced the concept of "barrier-free design" for elderly furniture, outlining schemes for the design and placement of indoor furniture suitable for the elderly (Luo, 2014). In 2020, Feng et al. conducted a comparative analysis of age-friendly furniture design in Japan and China. Their findings revealed significant deficiencies in China's age-friendly furniture market, including a lack of market awareness, limited availability of age-friendly furniture, low age-friendliness, and an inadequate integration of age-friendly furniture design with national conditions. This highlights the urgent need for improvement in the Chinese aging-friendly furniture market and design (Feng, 2020).

A global overview of research progress in the field of ageing-friendly furniture design reveals three common characteristics. First and foremost, the design of ageing-friendly furniture has always prioritised meeting the health and safety needs of the elderly.

Shen and Wang argue that safety is paramount in elderly furniture, which can be subdivided into physiological and psychological safety, ultimately fulfilling the elderly's requirements for comfort in use. As designers of elderly furniture, it is essential to fully understand the physiological and psychological characteristics of the

elderly demographic. In order to create furniture that is both aesthetically pleasing and functional, designers must consider a number of factors, including the form, colour, craftsmanship, materials and interior environments of dining rooms, living rooms and bedrooms. In order to ensure that the furniture is both comfortable and safe, and that it meets the needs of the elderly, designers must adhere to ergonomic principles. This approach allows them to create furniture that is both comfortable and fully functional, offering the elderly security and independence (Shen & Wang, 2020).

Luo, building on situational research, conducted detailed investigations into the issue of falls among the elderly living alone, summarising furniture design strategies to prevent such falls. Practical design interventions were made for drawers, beds, sofas, and desks, incorporating theoretical design methods proposed such as flexible partitioning, specialized compartments, ease of cleaning, ergonomic design, alarms, and self-rescue features (Luo, 2020).

Zheng's research focused on the design of bathroom products that are suitable for older individuals, with a particular emphasis on those who require assistance. He proposed a series of design strategies, which he believed should be employed in the development of such products. These strategies included the following: "optimisation and upgrading, improving functional configuration," "simplification, reducing complex operations," "comprehensive protection, enhancing safety," and "serving the elderly, deepening humanistic care." These strategies can be understood as a design methodology that emphasises systematisation, functionality, safety, and humanism. The practical design of aging-friendly bath-assist systems aims to provide the elderly with safer, more convenient, and humane bathroom products (Zheng, 2022).

Hu and Wu approached from the perspective of flourishing theory, taking experience as the design object. They constructed a flourishing experience model and, based on this model, derived guidelines for aging-friendly design strategies that cater to the experience of prosperity. This model and methodology focus on the overall coherence and harmony of the environmental experience, aligning the design with the instinctual, behavioural, and reflective needs of the elderly. This approach not only ensures aging-friendliness but also cultivates a quality experience, thereby aiding in the restoration of physical functions, reducing psychological stress and anxiety, and fostering feelings of happiness, achievement, and satisfaction among the elderly (Hu & Wu, 2023).

As global ageing intensifies, the elderly population is becoming increasingly diverse, exhibiting a range of characteristics and preferences. Consequently, there has been a surge in interest in user-centred, age-friendly product design in recent years. Researchers have employed a variety of methods, including role-playing, user interviews, behavioural observation and surveys, to analyse the behaviour of the elderly with different products and investigate specific product features. They investigate user-experience-based aging-friendly design ideas and implement them, with the aim of enhancing the user experience of elderly customers by modifying product structures and functional modules.

For instance, Zhang and Jiao conducted research on the home behaviour of the elderly, uncovering multiple needs related to seating. Through their research, they gained an understanding of the functional and aesthetic preferences of the elderly for seating and established a basic framework for aging-friendly chair design. Inclusive design methods were employed in the practical design of aging-friendly chairs, with a focus on the physiological and safety needs of the elderly. By respecting individual differences, functionality was added to the chairs and comfort was increased (Zhang & Jiao, 2023).

Yang and Xiong concentrated on "aging-friendly wardrobes," adhering to people-oriented design principles. A variety of research methods were employed to analyse user behaviour, emotions and needs. Ergonomics and user-experience design were combined to enhance traditional wardrobes. Innovative structural, intelligent and emotional design solutions were proposed, enabling designers to empathise with the elderly and develop convenient wardrobe designs (Yang & Xiong, 2021).

Mu proposed integrating humanistic design principles, summarising the main directions of colour, shape, material, and function. He then explored specific design paths, suggesting effective attempts and concrete applications in barrier-free design, emotional design, and intelligent design. He considers the furniture usage needs and future development ideas for the elderly, asserting that humanistic design thinking and practice can foster beneficial interaction between furniture and the elderly, truly meeting the practical demands for furniture form and function in an ageing society (Mu, 2021).

Dai and his team targeted ageing-friendly chairs for their research, conducting a comprehensive analysis of ageing-friendly furniture in the market to identify design gaps. The researchers employed field interviews to uncover user needs and introduced innovative research methods such as the Analytic Hierarchy Process (AHP), Quality Function Deployment (QFD), and Axiomatic Design (AD) to generate design parameters. They then constructed a product function concept matrix, selected design function concepts structures, and ultimately developed an aging-friendly chair design plan (Dai et al., 2022). Similarly, Wang et al. based their research on Quality Function Deployment (QFD) theory and the Analytic Hierarchy Process (AHP), constructing a House of Quality (HOQ) design theory model for aging-friendly bathroom cabinets. The model was then used to conduct practical design, with the result that the most urgent user needs were uncovered, leading to the production of products that were more scientific, rational, and better able to help the elderly cope with the challenges of aging (Wang et al., 2022).

The research of Shi and Zhang focused on the home care environment and behaviours of self-reliant elderly individuals. They proposed a "behavior-centered" home aging-friendly furniture product design research method, which considered the "elderly—aging-friendly furniture—home care environment" nexus. By analysing the daily living behaviours of the elderly and the spatial environment of living spaces, they collected data on behaviour, activity patterns, furniture dimensions, and spatial

layout in a quantifiable and visual way. This approach revealed design opportunities and addressed issues related to the appearance and size of ageing-friendly furniture, internal segmentation, functional dimensions, and spatial layout (Shi & Zhang, 2023).

In comparison to South Korea, other countries, particularly Japan, have made significant advancements in human-centred and barrier-free design for ageing-friendly furniture. American companies such as DCFS have conducted extensive research and development across various aspects of elderly life, including clothing, food, housing, usage, and mobility, offering a wide range of barrier-free products. These include specialized beds and sofas for the elderly. The German company Tekvorcare has also gained recognition in Europe and the United States for its ergonomically designed nursing beds, which enhance comfort and safety for the elderly. Additionally, Tekvorcare has designed lift wardrobes, taking into account the limited arm strength and difficulties in raising arms that elderly individuals often experience (Cui, 2021).

Finally, the rapid advancement of computer-related technologies has led to the integration of intelligent design becoming a significant trend in the field of ageing-friendly furniture. This trend involves incorporating smart sensing technology, remote monitoring systems, and human-computer interaction interfaces to meet the personalised needs of the elderly. Intelligent furniture can detect user behaviour through sensors, automatically adjusting the height and angle of chairs, beds, and other furniture to provide customised support. Furthermore, intelligent design facilitates the control and operation of furniture through voice commands and mobile applications, enhancing the convenience and autonomy of elderly users. This direction not only strengthens the functionality of aging-friendly furniture but also offers a more intelligent and considerate living experience for the elderly.

Zhou et al. conducted market research on elderly furniture and surveys and interviews with self-reliant elderly individuals to summarize the principles of intelligent design for aging-friendly furniture. Furthermore, the authors propose that design considerations should extend beyond the traditional domains of form, function, and decoration, and instead adapt to the specific usage environment. They introduce the concept of smart furniture, which encompasses a range of application methods, including intelligent recognition, adjustment, health monitoring, and prompts. This approach is designed to create a safe, comfortable, and convenient home environment for the elderly (Zhou et al., 2020).

Fei conducted a comprehensive analysis of exemplary design cases for lifestyle-oriented products for the elderly, both domestically and internationally. From the perspectives of operation, system, experience, and functionality, he identified characteristics such as assistive, connected, emotional, and health-oriented design in lifestyle-oriented products for the elderly. Correlational analysis was employed by Fei to introduce lifestyle-oriented thinking for the elderly into the design of smart furniture. This resulted in the creation of a smart bed that embodies the four characteristics previously mentioned, namely intelligent armrests, televisions, video capabilities, and health monitoring functions (Fei, 2022).

Chen, based on image sensing technology and incorporating elements of Ming-style furniture, proposed four types of smart home scenarios for the elderly through situational theory research: user, task, time, and environmental scenarios. This led to the development of specific strategies for designing voice user interfaces for smart home products. Chen's research provides methods and strategies for the design and development of voice user interfaces, with the aim of offering elderly users a more natural and comfortable experience with smart home products (Chen, 2022).

Zhou et al. employed a scenario-based design approach to analyse the needs of the elderly, integrating findings from scenario theory with research methods in smart home interaction design. Their focus was on the creation of interface navigation styles, slide layouts and button sizes that better align with the cognitive behaviours of elderly users. Based on experimental results and data analysis, they identified three interface factors that are more suitable for age-friendly scenarios. In terms of slide styles, vertically oriented, up-and-down slide layouts demonstrated superior performance in both interaction and subjective evaluations when compared to horizontally oriented layouts. This suggests that smart home interface design should prioritize vertical layouts and up-and-down slide operations. Regarding button styles, simple line-style buttons exhibited the highest interaction performance and subjective evaluations, indicating that icon design should prioritize simple line styles. With regard to button size, functional buttons with a size range of 12-18 millimeters performed best (Zhou et al., 2022). Pan, through specific community research and analysis, summarized design principles and key points for elderly-friendly smart furniture.

Pan found that beds are the most frequently used and problematic furniture in elderly bedrooms. By integrating the Kano model, AHP analysis, and scenario FBS modelling, Pan redesigned elderly beds, incorporating smart technology and human-centric interaction methods to address issues such as difficulty in getting up, poor sleep quality, and fatigue from prolonged sitting (Pan, 2023).

In conclusion, the design of furniture intended for use by older people is evolving in accordance with three principal trends: the provision of products designed with the health needs of the elderly in mind, user-centric product design, and the incorporation of intelligent technologies.

Firstly, the design of furniture intended for use by older people must address the specific health challenges that this demographic faces in their daily lives. Consequently, the focus of aging-friendly furniture design is on providing comfort, support, and safety.

Secondly, the principle of user-centric product design is fully embodied in the field of aging-friendly furniture. The needs and experiences of the elderly should always be at the centre of design. By working closely with the elderly, listening to their feedback and opinions, we can gain an in-depth understanding of their preferences, usage habits, and challenges, thereby offering them more personalised and desirable furniture solutions.

Finally, the application of intelligent technology has become a significant trend in the design of furniture intended for use by older people. By incorporating intelligent elements, such products offer the elderly more convenient and safe features. For instance, smart beds can automatically adjust their height and angle according to the needs of the elderly, and smart chairs can provide personalised support and comfort through sensors and adaptive features. Furthermore, the integration of smart home systems enables the elderly to control furniture through voice control or mobile applications, thereby facilitating a more convenient and intelligent lifestyle. These trends not only enhance the quality of life and happiness of the elderly but also present a plethora of innovation opportunities for related product manufacturers.

2.6 TYPES AND FUNCTIONS OF ASSISTIVE DEVICES FOR THE ELDERLY

The market offers a diverse array of assistive devices for the elderly, including mobility aids, vision aids, hearing aids, wearable devices, home safety equipment, home automation tools, and health monitoring devices. This study focuses on designing furniture to aid the elderly in getting up, walking, and sitting, and thus will only cover relevant mobility aids, which can be categorised into static and dynamic support devices.

2.6.1 STATIC SUPPORT DEVICES

Static support devices provide fixed support for the elderly, either in a stationary or semi-stationary state, with the aim of maintaining or changing their sitting or standing postures. These devices are primarily employed to ensure the stability and comfort of the elderly while sitting or standing.

Figures 4 and 5 illustrate common market solutions, such as bedside rails and smart lifting beds, which assist the elderly in getting up and lying down in a controlled and stable manner.

Figure 4 Handrail by the bed

Note. https://image.baidu.com/

Figure 5 Intelligent lifting bed

Note. https://image.baidu.com/

Figure 6 depicts the "easyUP" chair, a product of the Dutch furniture company Bannink. This chair features a torsion spring mechanism designed to assist the elderly. The chair's spring mechanism gently assists the user in rising from a seated position, thereby reducing the effort required to stand.

Figure 6 An age-appropriate seat designed with torsion spring structure

Note. https://www.sohu.com/a/76043986_222493

Figure 7 displays two distinctive assistive chairs. On the left is "Assunta," a collaborative design by Italian and Singaporean designers. This chair features vibrant

fabric cushions that are tied and secured to the chair for easy removal and washing. On the right is the "Santiago" series of "elder-friendly dining chairs" from the Czech furniture company Ton.

Figure 7 Other support chairs

2.6.2 DYNAMIC ASSISTIVE DEVICES

Dynamic support devices are those that are active during use, moving with the elderly based on their behavioural needs. They provide dynamic, stationary, or semi-stationary support to help the elderly maintain or change their sitting or standing postures, ensuring stability and comfort. Examples of such devices include chairs with casters for easy lifting (Figure 8), wearable walking aids, canes (Figure 9), and walkers (Figure 10).

Figure 8 Chair with casters for easy lifting

Note. https://image.baidu.com/

Figure 9 Wearable walking aid and smart cane

Note. https://image.baidu.com/

Figure 10 Elderly assistive walker

Note. https://image.baidu.com/

The advent of assistive devices has been designed to address the difficulties encountered by the elderly in their daily lives. Devices such as canes, walkers, and risers provide additional support points, enhancing stability during standing and walking. This support significantly reduces the risk of falls and the potential for

bodily harm. With the aid of these devices, the elderly are more inclined to engage in basic activities independently, which also promotes muscle exercise and leg strength, improving sitting and standing balance, and enhancing overall physical coordination. Consequently, the elderly gain greater confidence and independence, are able to conduct daily activities more safely, and are relieved of the burden on their children, thereby enhancing their quality of life.

2.7 CURRENT RESEARCH ON PRODUCTS ASSISTING ELDERLY BALANCE

As previously stated, a plethora of products designed to assist the elderly in maintaining their balance encompass a diverse range of functions and designs. These include walking aids such as canes and walkers; balance training equipment such as balance boards and balls; ergonomically designed chairs and beds; anti-slip carpets and flooring; seat and bed assistance products; and smart assistance devices such as smart canes and shoes. A review of the literature and research on balance assistance products reveals that their design philosophies align with the three major trends in age-appropriate furniture: meeting the health needs of the elderly, user-centred product design, and smart technology integration. Orozco, Stan, Nguyen and others have employed predictive systems, machine learning, and collaborative system architectures to monitor the elderly's condition, preventing falls by designing fall detectors (Nguyen et al., 2018; Orozco et al., 2014; Stan et al., 2017). Wang's smart shoes not only detect elderly behaviours but also alert others in case of falls, thereby ensuring the health and immediate assistance for the elderly (Wang, 2018).

There has been substantial research in academia on product design to prevent falls among the elderly. For instance, P. Rasche developed a smartphone application for self-assessment of fall risk among older patients (Rasche et al., 2017). M.R. Khan developed an innovative posture and mobility assistance device for the elderly (Khan et al., 2017). Zhang designed a device with sensors and a processor that deploys a safety airbag to protect seniors' knees in the event of a fall (Zhang, 2018).

This study primarily focuses on assistive balance products for the elderly, with a particular emphasis on those designed to assist with rising from a seated position. The review encompasses relevant literature on products such as canes, ergonomically designed chairs and beds, and seat and bed assistance devices. Surveys have found that the elderly desire more handrails or other solutions for easier rising and sitting, in both public and private furniture (Fabisiak et al., 2021). Research in this area has made some progress, with the following examples of notable findings:

Zhang and Jiao propose that due to calcium loss and consequent osteoporosis in the elderly, resulting in a reduction in height, actions like sitting and standing are challenging, often requiring external assistance. Thus, age-friendly furniture design should consider these characteristics, centring on the elderly, and acknowledge the diversity and individual differences within this group (Zhang & Jiao, 2023).

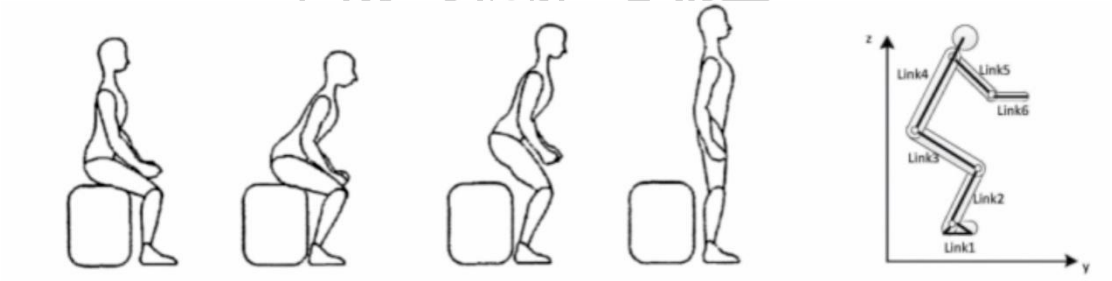
Furthermore, Li and Zhou employed bibliometrics to analyse relevant literature from the core databases on the Web of Science platform. They concluded that future research trends will likely include systematic research on assistance standing furniture, research on passive gravity balance assistance devices, and integrating assistance standing furniture with healthcare equipment. Compared with foreign countries, Chinese domestic assisted standing furniture research has been conducted earlier, especially in Taiwan and Hong Kong. However, the development has been slower, with a single structure and low technology content. Consequently, China's domestic research should be based on cutting-edge basic research in the field of assistive standing furniture. In order to strengthen the docking with market demand, in particular with regard to nursing beds, assisted standing up chairs and intelligent assistive devices, it is necessary to direct research and development in the direction of basic data and technological needs. This will open up the pathway of scientific research and technological transformation (Li & Zhou, 2023).

The decline in physical functions among the elderly has become an international issue, with difficulty in sitting and standing being a significant concern. Scholars and experts worldwide have conducted research in this field, innovating design in assistive products for the elderly. These products offer solutions for sitting and rising, enhancing their independence and quality of life, and boosting their confidence. The American company Endorphin released an assisted standing chair equipped with a closed-loop control system to assist users with standing exercises, improving lower limb strength and cardiovascular adaptability (Dai, 2016).

An Italian company has designed a standing aid named StruzzoPlus, which allows for height adjustment of the seat and provides support through armrests and leg cushions, aiding users in standing up (Kamnik & Bajd, 2004). The Harbin Institute of Technology proposed a stand-up rehabilitation robot, designing a new assistive stand-up rehabilitation robot and analysing its inverse kinematics. Su et al. conducted a simulation analysis of normal human standing, proposing a closed-loop control system and a push-rod motor-driven assistance standing system. The system generates control strategies based on computer control principles using plantar pressure and angular velocity sensors. It simulates the trajectory of normal human standing through feedback signals and controls the motor's speed and direction to minimise the impact of individual weight differences. Experiments have demonstrated the effectiveness of this method for assistance in standing (Su et al., 2018). Zhang and colleagues concentrated on the sitting and rising actions of elderly individuals with lower limb mobility issues. They applied ergonomics, mechanical engineering techniques, and hydraulic actuator technology to innovate the function of the assistive rising cushion and the overall design of the chair. They analysed the development and design process of the elderly-specific barrier-free chair and demonstrated the theoretical significance and practical value of barrier-free design in product development for the elderly (Zhang et al., 2016). Lei and colleagues analysed the centre of gravity movement speed parameters during the elderly's standing process, subdividing it into three

phases and providing differential settings for the assistive chair's rising mechanism, with the objective of determining the appropriate assistive speed for the elderly's standing (Lei et al., 2018). Wang and Dong employed the operational principle of "electric push-pull rods" to propose and refine a design, with a focus on the functionality, aesthetics, and ergonomics of the device. This resulted in the creation of an assistive standing device that met the needs of the elderly. The process from sitting to standing typically involves four stages: an initial leaning phase, a lifting phase, a standing phase, and finally, the phase where the buttocks leave the chair surface. Consequently, the chair's assistive standing function must align with the human sitting and standing process, encompassing initiation devices, a chair surface that tilts forward with the body, and control devices that operate in a specific sequence. This allows the elderly to adjust according to their personal needs. Furthermore, the seat's flipping mechanism can enhance the effective support force, thereby ensuring a stable base for standing throughout the four stages of sitting to standing (Wang & Dong, 2020), as illustrated in Figure 11.

Figure 11The four phases of the human body's rise and joint force diagrams



Note. (Wang & Dong, 2020)

Sun et al. classified the products that assist in rising from a seated position available on the market into two main categories. The first category is motorised assistive rising products, which are the most common among elderly assistance devices. These motorised products adjust the angle of the seat, backrest, and leg rest via a remote control to facilitate sitting down, lying down, and standing up for the elderly. However, due to their considerable bulk, these chairs are usually stationary and not easily moved, limiting their use to specific locations. The second type consists of more conventional lift cushions for the elderly, which use spring tension to adjust the cushion's height and tilt, aiding in the sitting and standing process. In comparison to motorised products, these lift cushions are more lightweight and versatile, fitting a variety of chairs. However, they tend to be less comfortable and offer reduced safety features (Sun et al., 2020).

In summary, the existing market for elderly assistive chairs mainly relies on mechanical structures to change the seat's incline for assistance in rising. However, these products are generally bulky, pose safety risks, and offer a subpar user experience. Furthermore, many assistive chairs have limited functionality. For

instance, fixed assistive chairs only address the issues of standing and sitting, without supporting the elderly in walking or assisting with getting in and out of bed. Consequently, there is a need for in-depth research to design an ergonomic, comfortable, and multifunctional product to assist with rising.

2.8 ERGONOMIC ANALYSIS OF ASSISTIVE SIT-UP PRODUCTS FOR THE ELDERLY

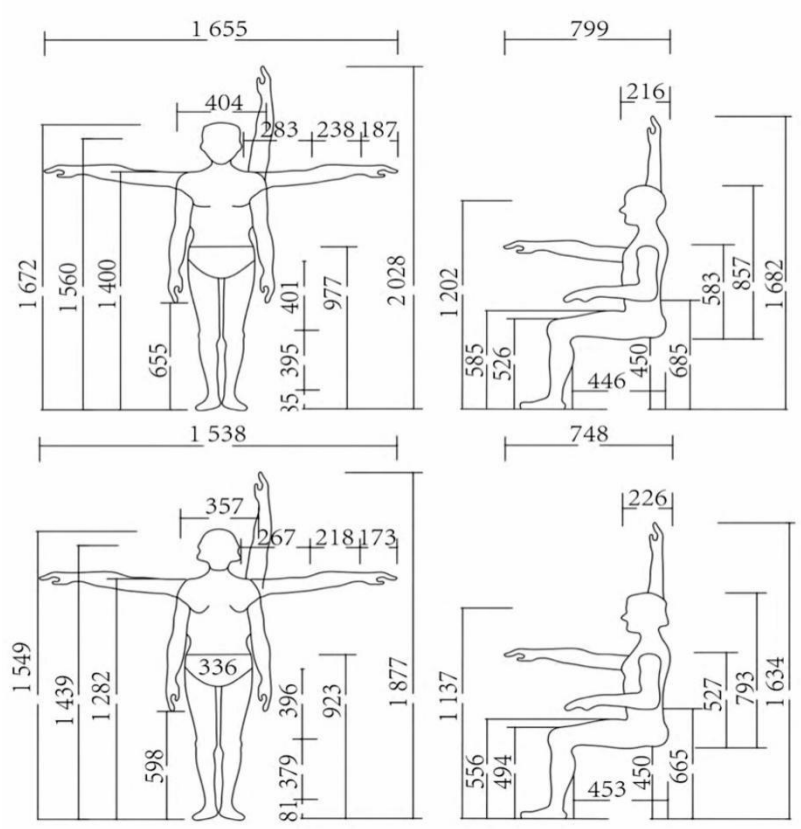
2.8.1 INTRODUCTION TO HUMAN-MACHINE ERGONOMICS

In the context of the rapidly advancing industrial sector of contemporary society, the design demands for machinery have been escalating, with an emphasis on accommodating both human and environmental needs. This has led to the proposition of human-machine ergonomics theory, which represents an interdisciplinary investigation into the "human-machine-environment" interface, focusing on the interactions among these elements. In everyday life, people's use of various products inevitably leads to issues of inconvenience and safety. The field of human-machine ergonomics addresses these concerns by analysing the interactions within the entire "human-machine-environment" system of a product, with the aim of enhancing the efficiency, comfort, and user-friendliness of human-machine systems. (Du, 2019)

2.8.2 ANALYSIS OF ELDERLY ANTHROPOMETRIC DIMENSIONS

Medical research indicates that the human body reaches its maximum height between the ages of 28 and 30, with a gradual decline thereafter. By the age of 70, the height of an individual may decrease by 2.5 to 3% compared to that of a younger person. Women may experience a greater degree of shrinkage, with a maximum reduction of up to 6%. A comprehensive and precise comprehension of the body dimensions of the elderly is essential for a more nuanced analysis of the ergonomic design of age-adapted assistive products. In order to more accurately study the body scale data of the elderly in China, the School of Architecture at Tsinghua University conducted a series of measurements and studies of the body size of the elderly, primarily in North China and some southern regions. The resulting data was used to create the human body scale measurement map of the elderly in China (Ma, 2016), as shown in Figure 12.

Figure 12 Anthropometric Measurements of the Elderly in China (Male & Female)



Note. (Ma, 2016)

The data indicates that the average height of 78-year-old elderly males is approximately 167 cm, with an arm length of approximately 521 mm, a trochanter height of 977 mm, and hip width of 342 mm. The sitting height is 450 mm, the knee height is 526 mm, the thigh length (horizontal) is 446 mm, the elbow height is 685 mm, and the sitting height to shoulder distance is 583 mm. The average height of an elderly female aged 78 is approximately 155 cm, with an arm length of around 475 mm, a trochanter height of 923 mm, and hip width of 336 mm. The sitting height is 450 mm, the knee height is 494 mm, the thigh length (horizontal) is 453 mm, the elbow height is 665 mm, and the sitting height to shoulder distance is 527 mm. The data will be employed and referenced in the study, providing a practical basis for the sizing proportions of the assistive devices described in this research.

2.8.3 ANALYSIS OF ELDERLY ASSISTIVE CHAIR DIMENSIONS

To ensure the comfort of the seating, it is essential to design assistive products for the elderly that facilitate sitting, standing, and moving based on the anthropometric data of the elderly illustrated above. Furthermore, the design process should consider the motions and steps involved in using the chair. This can be

achieved by conducting a product functional dimension analysis from the perspective of ergonomics, with the aim of achieving a harmonious human-machine-environment relationship.

(1) Seat Height: In order to provide a more comfortable sitting posture for the elderly, their lower legs tend to rest in front of the chair instead of being perpendicular to the ground. This indicates that the seat height should not be too high. However, if the seat height is too low, it could pose greater challenges for the elderly when attempting to stand up (Sun et al., 2020). Accordingly, based on the anthropometric measurements of the Chinese elderly in a seated position, which indicate a sitting height of 450mm for both male and female elderly individuals, the seat height of the product discussed in this paper is set to 450mm.

(2) Seat Depth: Seat depth refers to the front-to-back distance of the seating surface. It is important to ensure that the user's buttocks are fully supported without being excessively long, as too much length can cause the chair's front edge to press against the thighs of individuals with a shorter stature. When designing the seat depth, it should be slightly larger to avoid pressing the popliteal area (behind the knees) when the lower legs extend forward, and to increase the contact area between the buttocks and the seat. Nevertheless, an increase in seat depth should not result in discomfort to the lumbar spine's posterior curvature. Conversely, if the depth is excessive, it can present a challenge for the elderly when attempting to stand (Jia Limei, 2014). Based on the anthropometric measurements of the Chinese elderly in a seated position, elderly males have a distance of 446mm from the popliteal fossa to the buttocks when seated, while elderly females have a distance of 453mm. In accordance with the principle of preferring shallower to deeper seat depth, the seat depth for the product in this paper has been set at 440-460mm.

(3) Seat Width: The seat width should accommodate the width of the buttocks, allowing the user to adjust their sitting posture freely. A seat that is too narrow may force the user to squeeze in, while a seat that is too wide can create a feeling of instability. The seat width should be designed according to the large dimension principle (Jia, 2014). In consideration of anthropometric measurements, the seat width for Chinese elderly males is 342mm, while for females it is 336mm. In accordance with the large dimension principle and the seat width range of 370mm–420mm specified by GB/T 14774—1993, and with additional space for clothing and armrests in mind, the seat width for the product in this paper has been set at 400mm.

(4) Armrests: The provision of armrests on chairs allows the elderly to utilise their arms to support their body when sitting or standing, thereby reducing the burden on the shoulders. Additionally, the selection of an appropriate armrest height is crucial (Jia, 2014). The armrest height recommendation of 210mm–250mm by GB/T 14774—1993, in conjunction with the measured elbow height of 685mm for seated elderly males and 665mm for females with a sitting height of 450mm, leads to the conclusion that an armrest height of approximately 215-235mm is the most reasonable.

2.8.4 ANTHROPOMETRIC ANALYSIS OF ELDERLY ASSISTIVE ARMRESTS

The anthropometric data of Chinese elderly males indicates that the appropriate elbow height while seated is 685mm, while for elderly females, it is 655mm. Consequently, the optimal load-bearing height for armrests in assistive rising devices should be approximately 650-680mm. If the device is also intended to aid in walking, it is necessary to consider the standing stature measurements, where the distance from the foot sole to the iliac crest is 977mm for males and 923mm for females. Furthermore, the thickness of shoes must be accounted for in order to determine the optimal assistive armrest height. The armrest height should be designed in two parts. The first is the aforementioned rising support height of approximately 650-680mm, and the second part is the total height of the rising aid device, which is set between 950-1000mm.

2.8.5 SEATING POSTURE ANALYSIS FOR THE ELDERLY

The suitability of a seated posture for the elderly is contingent upon the dimensions, shape, and size of the chair design aligning with their fundamental physiological needs. A comprehensive comprehension of the essential dimensions of elderly seating can effectively inform the design of chairs that are optimally suited for their frequent use. In a seated position, it is of paramount importance to maintain a natural and comfortable physiological curvature, with the back in an optimal state and the legs free from pressure. When the seat is too high, the feet cannot reach the ground, impeding normal blood circulation in the legs. Conversely, when the seat is too low, it becomes difficult to stand up (Wang, 2022).

2.8.6 ANALYSIS OF MATERIALS FOR ASSISTIVE PRODUCTS

(1) Wood: Wood is a renewable resource with natural textures and warm colours, creating a comfortable and natural atmosphere. It can adapt to various decorative styles, from traditional to modern designs effortlessly. There are many types of wood to meet diverse customer needs. It is also easy to process, allowing for cutting, carving, and joining, which facilitates the creation of chairs in various shapes and designs. At the conclusion of its lifespan, wood is more readily recyclable and decomposable than metal or plastic, thereby causing less environmental harm. However, wood's lifespan may be diminished by weather and climate, necessitating regular maintenance.

(2) Bamboo: While wood is a renewable resource, bamboo regenerates at a much faster rate, making it a more sustainable option. It can mature in just a few years, whereas most trees take decades. Bamboo is lighter than most woods, which makes bamboo products easier to transport and move. Despite its lightness, bamboo offers similar rigidity and stability to many types of wood, with excellent tensile and

bending resistance, making it an excellent material for furniture. Like wood, bamboo has natural textures and warm colours that add a fresh and natural atmosphere to spaces. Its strong tensile and bending strengths make it easy to be crafted into various shapes, allowing for the production of uniquely designed products with perfect curves.

(3) Aluminium Alloy: Aluminium alloy is an optimal material for the fabrication of assistive chair frames due to its combination of lightness and durability. Its lightweight nature renders the chair easy to move and handle, which is particularly beneficial for elderly individuals who require frequent repositioning of their chairs. This material is widely available on the market due to its long-lasting use.

(4) Stainless Steel: Stainless steel is a material composed primarily of iron and chromium, with a minimum chromium content of 10.5% and a maximum carbon content of 1.2%. It is valued for its corrosion resistance and durability. The principal attributes of stainless steel include excellent corrosion resistance, heat resistance, strength, and formability (Liu et al., 2016).

(5) Non-slip Foot Pads: The undersurface of the product is typically furnished with rubber or other non-slip materials, which are typically manufactured from rubber or silicone. These materials offer good slip resistance and durability, effectively providing additional stability and safety to prevent walking aids from sliding or tipping over. Furthermore, some walking aids may utilise materials such as polyurethane or rubber foam for the purpose of providing enhanced cushioning and vibration reduction.

2.8.7 ASSISTIVE PRODUCT TECHNOLOGY

In 2023, Purwar et al. introduced a novel 6-bar sit-to-stand (STS) linkage mechanism integrated into a device. This mechanism follows the trajectory of hip movement and provides a comfortable orientation during motion. The device is positioned as a functional assistive tool, serving as both a support for sitting up and a walking therapy aid. Following testing, this device has commenced use across the United States, representing the latest technology for assisting in sitting up and walking (Purwar et al., 2023).

Additionally, there is another type of hydraulic spring, which typically consists of a hydraulic cylinder and a piston filled with incompressible hydraulic oil. When a user sits down, the piston compresses, pushing the hydraulic oil to the other side of the cylinder, storing energy. Upon the user's preparation to stand, the piston in the hydraulic spring mechanism releases the stored energy, allowing the hydraulic oil to flow back, thereby pushing the piston rod to extend. This action propels the chair's cushion and backrest forward and upward, assisting the user in standing. The valves in the hydraulic system regulate the flow rate of the hydraulic oil, thereby controlling the speed of the assisted standing process to ensure a smooth and safe experience. The hydraulic system converts a smaller force (the force exerted by the user on the chair

during standing) into a larger force (the force pushing the piston rod with hydraulic oil), thereby assisting the user in overcoming gravity and standing more easily. Assisted standing chairs usually come with safety mechanisms, such as locking devices, to prevent the accidental release of the hydraulic spring at inappropriate times, thus ensuring user safety. The hydraulic spring mechanism can be adjusted according to the strength and weight of different users, thus providing personalised assistance (Pan, 2023). Although hydraulic systems may necessitate periodic inspection and maintenance, they are typically designed to be straightforward and straightforward to maintain, thereby ensuring reliability over an extended period.

2.9 PREFERENCES OF ELDERLY USERS FOR ASSISTIVE DEVICES

As society continues to evolve, the development of age-friendly products has seen an increasing incorporation of smart technologies. However, due to generational shifts and age-related declines in memory and reaction times, elderly individuals tend to prefer assistive devices that are straightforward to operate and have clear functionalities. In terms of appearance, they may opt for products that are simple, have smooth lines, and are convenient to carry. Furthermore, given the diverse physical conditions and living environments among the elderly, they may prefer assistive devices that can be customised to meet their individual needs, thereby better addressing their personal requirements. However, some physically robust elderly individuals may deliberately reject assistive devices, viewing their use as a symbol of ageing, resulting in a lower acceptance rate among this group. The safety of all assistive products is of paramount importance and is a significant concern for the elderly, as high-safety devices can reduce and prevent many risks during use. Finally, economic considerations also influence the choices of seniors, who may prefer devices with a high cost-performance ratio (Sato & Iwata, 2015).

Furthermore, despite the prevailing trend towards the design of age-friendly products, numerous studies have found that older adults with diminished physical functions tend to resist smart products and favour simple, easy-to-use assistive devices. Smart products typically require the use of electronic gadgets, mobile phones, or applications for control and operation, which can present a technological hurdle for the older age group. They may be unfamiliar with or unaccustomed to these new technologies, leading to confusion and discomfort with smart products. Furthermore, smart products frequently comprise a plethora of functions and settings that can overwhelm those with impaired physical functions, who prefer straightforward and intuitive devices that do not necessitate complex setup or adjustments.

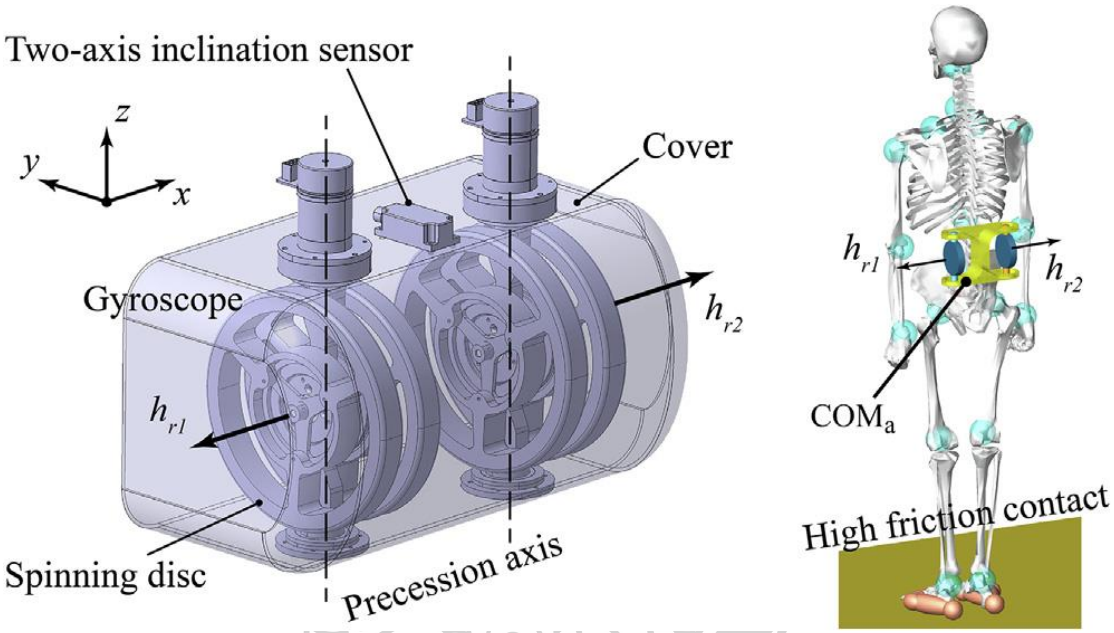
Additionally, older adults place greater emphasis on the reliability and stability of products. Smart devices may be susceptible to technical malfunctions, software glitches, or compatibility issues, prompting scepticism about their dependability. In contrast, simpler assistive products are generally more stable and trustworthy, hence more trusted and relied upon by the elderly. They are usually accustomed to

traditional assistive products that they have been using for years, with established habits and perceptions that these products meet their needs. Smart products may require them to change routines and learn new ways of operation, which can be challenging. Furthermore, they may face limitations in physical mobility, visual and auditory impairments, cognitive decline, and a desire for autonomy and independence. Consequently, when developing assistive products designed to meet the needs of an ageing population, it is essential to consider the physical and functional limitations of the elderly. The products should be easy to use, simple to operate and reliable, catering to the specific needs of the elderly and enhancing their quality of life (Zhao, 2023).

2.10 RELATED RESEARCH

In recent years, several studies have focused on assisting the elderly with sitting, standing, and walking. Each of these studies has emphasised different aspects. For example, Romtrairat et al. aimed to reduce the risk of falls due to excessive swaying by designing a wearable balance assistive device for the elderly (Figure 13). The device employs a scissor-type control moment gyroscope as a torque actuator and a dual-axis tilt sensor to detect the body's tilt angle, thereby calculating the swaying direction. The device weighs 8.2 kilograms and has dimensions of 32 cm in height, 40 cm in width, and 22 cm in depth. The device's balance recovery capability in any direction was verified through multi-segment model simulation tests, which also established the relationship between the effective initial angle and the detected tilt angle. The results indicated that the device can limit the swaying range caused by the elderly's imbalance (Romtrairat et al., 2019).

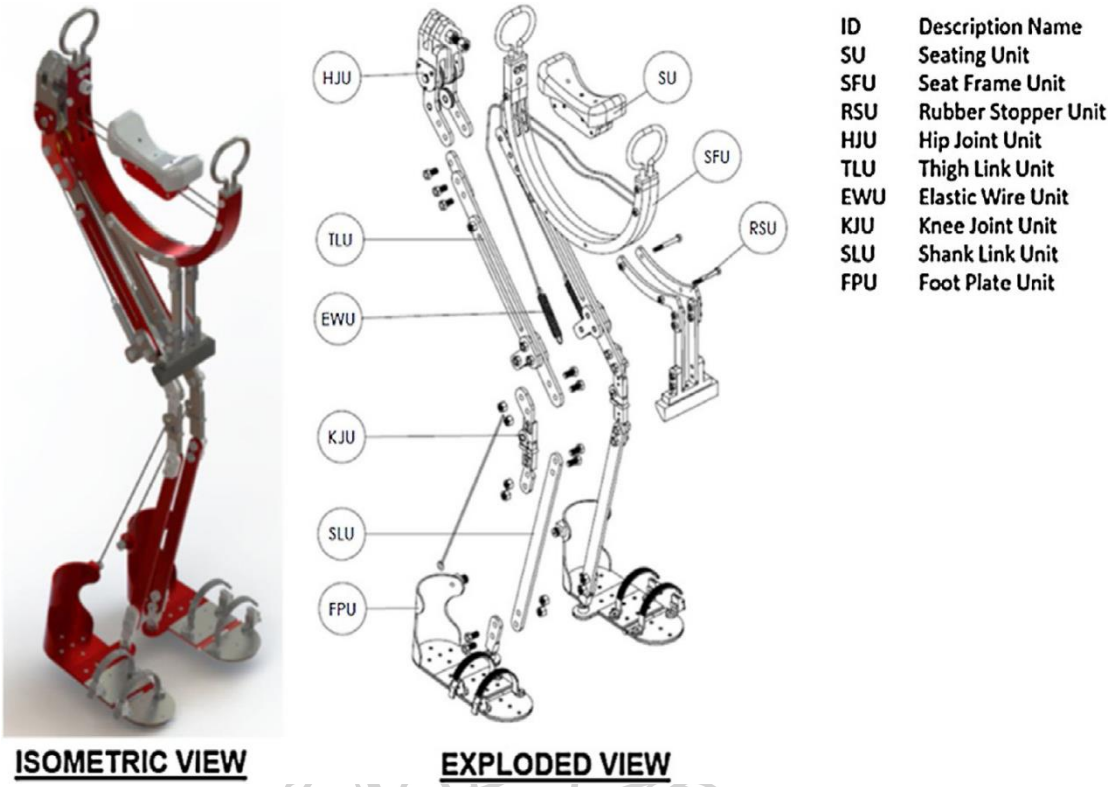
Figure 13 Wearable balance assistive device



Note. (Romtrairat et al., 2019)

Lovrenovic and Doumit from Canada proposed a passive walking assist exoskeleton (WAE) device with the objective of reducing the weight borne by users during standing and walking (Figure 14). The design exclusively utilises mechanical components, making it a simple, lightweight, and cost-effective mobility assistance system. The unique feature is the incorporation of a seat mechanism that applies an upward force on the user's pelvis without affecting gait stability. Two models were developed to simulate the mechanical behaviour of the exoskeleton in standing and walking scenarios. These models validated the proposed WAE design and calculated the assistive effects of the exoskeleton based on key operational variables (spring selection, spring extension, and seat displacement). Additionally, a human-scale model was created to accommodate the physical needs of the elderly. The final model employed affordable materials and conventional manufacturing techniques. Ultimately, the model successfully achieved the intended functions in standing and walking trials. The research results indicated that using stiffer springs could provide greater assistance but would reduce user comfort. For walking, the kinetic results showed that the device interfered with the user's gait and revealed some design issues that need to be addressed in future iterations of the WAE (Lovrenovic & Doumit, 2019).

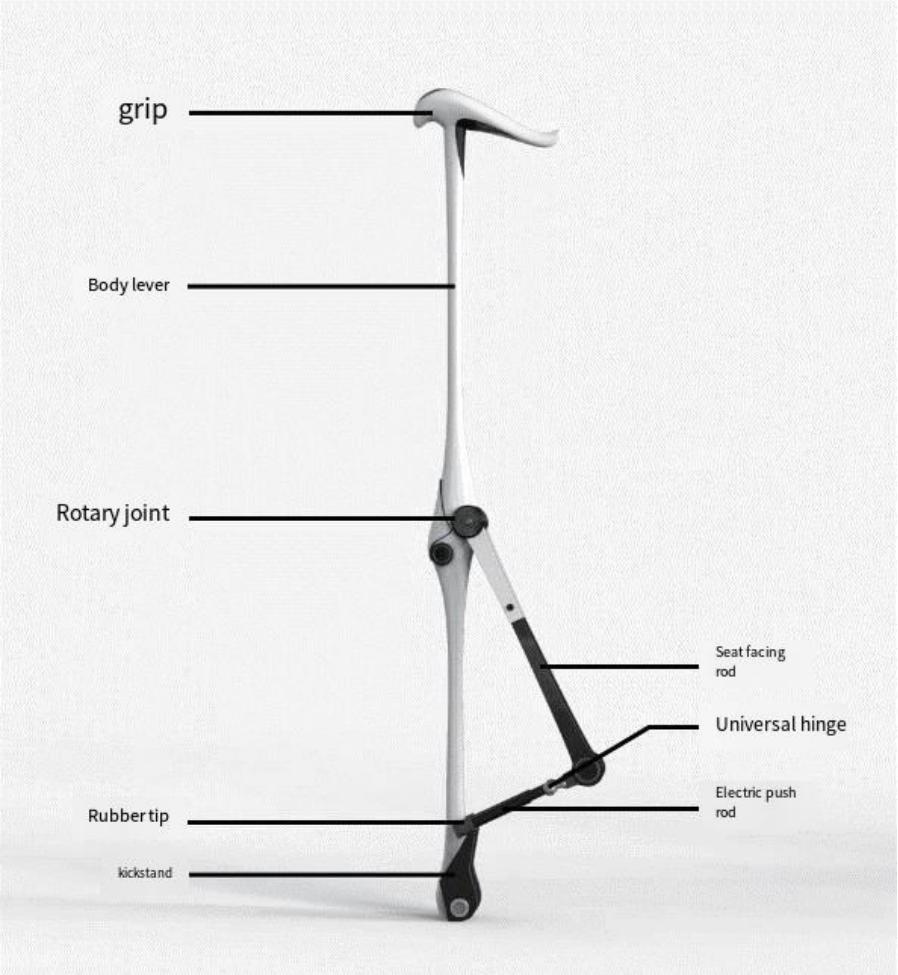
Figure 14 Walking Assistive Exoskeleton (WAE) Device



Note. (Lovrenovic & Doumit, 2019)

Chi et al. identified the necessity for equilibrium and brief repose during outdoor ambulation among the elderly, as well as the insufficient lower limb muscle strength that necessitates external assistance during the sitting-to-standing process (Figure 15). Consequently, in the design of the cane chair, this study concentrated on the physiological and psychological characteristics of the elderly population, adhering to the design principles of safety, usability, comfort, and emotional appeal. The study proposed a cane chair with the function of assisting the elderly in sitting and standing. The cane chair can achieve two main functions through the transformation of its folding structure: serving as a walking cane and as a seat for rest, providing external assistance during the sitting-to-standing process for the elderly (Chi et al., 2020).

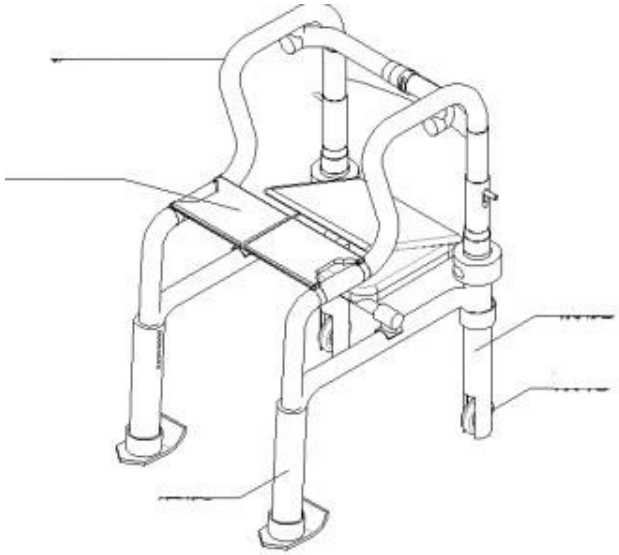
Figure 15 Crutch chair



Note. (Chi et al., 2020)

The objective of the study by Wang et al. was to address the inconvenience of mode switching and the single functionality of existing assistive walkers. The aim was to design a product that enables rapid mode switching and multi-functionality through a single-button operation (Figure 16). The study emphasised the functional requirements and design advantages of the product, including its rich functionality, simple and lightweight structure, and ease of installation, while considering the diverse living scenarios and mobility needs of the elderly. This design not only enhances the practicality and adaptability of walkers but also holds the potential to significantly improve the daily lives and rehabilitation training for the elderly (Wang et al., 2021).

Figure 16 Multifunctional walking Aid



Note. (Wang et al., 2021)

The study examines the behavioural characteristics, interactive methods, and psychological expressions of the elderly in different travel situations. It also analyses the variations of assistive walkers in indoor and outdoor environments and their interaction with users and surroundings (Figure 17). The design of assistive walkers can be enhanced through the method of situational construction, which improves the elderly's travel experience and interaction with the surrounding environment. This facilitates their independence in travel, completion of exercise rehabilitation plans, and increased communication and interaction with external elements (Yu & Ma, 2024).

Figure 17 Situational Scaffolding Device

Note. (Yu & Ma,2024)

In their investigation of the effects of intermittent walking exercise (IWE) using a wearable robot (Bot Fit) on the elderly, Shin et al. (Figure 18) recruited 22 individuals aged 65 and above and conducted an assessor-blinded, randomised controlled trial consisting of 22 experimental visits, including three assessments (pre-test, mid-test, and post-test) and 18 exercise sessions. The final results demonstrated significant improvements in pelvic movement and muscle strength among the elderly who underwent IWE exercise using the wearable robot Bot Fit. This intervention promoted correct posture and physical activity, ultimately enhancing the quality of life and serving the purpose of fall prevention and aging control (Shin et al., 2024).

Figure 18 Bot Fit

Note. (Shin et al.,2024)

2.11 RESEARCH DIRECTION

In conclusion, a review of the current state of research on furniture and products designed to assist the elderly with balance, an analysis of the design principles of related products, an examination of the ergonomics of assistive products for elderly sit-to-stand movements, and an understanding of the market offerings for aids that help seniors walk, stand, and sit, reveals that while there is substantial academic research on assistive devices for the elderly and some market products exist, many of these products suffer from issues such as single functionality, safety risks, and poor user experience. Aids that help seniors walk, stand, and sit can be used to discern that while there is substantial academic research on assistive devices for the elderly and some market products exist, many of these products suffer from issues such as single functionality, safety risks, and poor user experience. Moreover, there is a paucity of research on comprehensive products that assist with multiple activities, such as getting up from bed, walking, sitting, and standing. The objective of this research is to modify the structure of existing assistive products to create new ones that achieve multifunctional technology for assistance in standing, walking, and sitting, while addressing the difficulties seniors face in these activities. The goal is to enhance the autonomy of the elderly and reduce the burden on their families or caregivers.

CHAPTER 3

RESEARCH METHODOLOGY AND PROCESS

3.1 RESEARCH DESIGN METHOD

This study employs a mixed-methods framework that integrates qualitative and quantitative research strategies to comprehensively examine the core issues and challenges faced by elderly residents in caregiving institutions (Figure 19). It further assesses their use of and expectations for assistive sit-to-stand balance devices. The qualitative component will involve in-depth interviews with caregivers, elderly residents, and domain experts to uncover detailed and profound insights and perspectives. Concurrently, the quantitative component will comprise surveys designed to elicit opinions and feedback from older users. The empirical data collected will be used to inform a comprehensive analysis of their needs and to explore the current state and potential trends of assistive balance devices. This combined research approach will ensure the relevance and practical applicability of the study's direction.

Figure 19 Framework of Research Process

3.2 RESEARCH SUBJECTS (POPULATION AND SAMPLE)

3.2.1 ELDERLY INDIVIDUALS

The objective of this study is to examine in depth the specific needs of the elderly population aged 65 and above. To achieve this goal, the study employed an online questionnaire survey, which was supplemented by in-depth interviews with 20 elderly residents in three elderly care facilities in Dingxi City, Gansu Province. The choice of Gansu Province in China as the study site was based on two main considerations: Firstly, Gansu is situated in northwestern China, which has a relatively low level of socio-economic development. This helps to shed light on the problems and challenges that older people may encounter in elderly care services. Secondly, the researcher is from Gansu, China, and given that most of the elderly in the target group may not have the ability to communicate in Mandarin, communicating in the local dialect will be more conducive to building a trusting relationship, thus improving the

cooperation of the study participants and the authenticity of the data. It is therefore recommended that the local dialect be employed in order to facilitate the establishment of a trusting relationship, thereby improving the cooperation of the study participants and the authenticity of the data. In order to gain a comprehensive perspective on the needs of the elderly and the current state of nursing services, the study covered two large-scale nursing homes in Dingxi City and one smaller nursing home in Weiyuan County, which is part of the city.

3.2.2 CAREGIVERS

To delve into the needs and challenges faced by the elderly, this study selected six caregivers from three caregiving institutions as key informants. Through detailed understanding of these caregivers' daily responsibilities and the challenges they encounter in caring for the elderly, the study aims to uncover the core needs and difficulties of the elderly population. Additionally, these caregivers' insights on the needs for assistive products and their views on innovative product design provide valuable perspectives for the study's design concepts. This methodological approach not only facilitates a precise grasp of the elderly's actual needs but also proposes innovative design directions, enriching the research content of this paper.

3.2.3 EXPERTS

This study conducted in-depth interviews with three experts from the fields of product design, materials science, and furniture design to gain professional insights into the current state and future trends of assistive sit-to-stand products for the elderly. The objective of these interviews is to refine the understanding of the design principles and key considerations necessary for designing such products. In addition, the interviews explore the feasibility and cutting-edge guidance in technical practices and material innovations. The insights from these experts provide a solid theoretical foundation for the study and will guide the direction of future research on innovative product design, ensuring the practicality and forward-looking nature of the research outcomes.

3.3 RESEARCH TOOLS

3.3.1 RESEARCH INSTRUMENTS

The objective of this study is to design an innovative product that assists the elderly population with balancing, getting up, walking, sitting down, and standing. To achieve this goal, five research method tools were designed: First, a questionnaire survey targeting the population aged 65 and above was conducted, with an expectation of collecting 200 valid responses to gather extensive baseline data. Secondly, expert interviews were conducted with three experts from key areas of product design, furniture design, and material design. The aim of these interviews was

to gain an in-depth understanding of industry trends and design principles. The third research tool involved interviews with six caregivers from nursing homes. The objective of these interviews was to comprehend the practical support needs of the elderly in daily life. Fourthly, interviews were conducted with ten individuals aged 65 and above. The objective of these interviews was to delve into the personal needs and preferences of the users. Finally, a questionnaire survey was conducted on the product prototype to assess the practicality of the design and user acceptance. These comprehensive research tools will provide a solid theoretical and empirical foundation for the study, ensuring that the designed product effectively addresses the real-world needs of the elderly.

(1) The specific steps are as follows:

(2) Conduct fieldwork to identify the research problem.

(3) Define the research objectives based on the problem.

(4) Draft questions for research tools based on the objectives.

(5) Have the research tools reviewed by a mentor to ensure questions are appropriate and can achieve the research goals.

(6) Revise the research tools based on feedback from the mentor.

(7) Request an introductory letter from the school administration.

It is recommended that three experts review the research tools to assess their rationality and accuracy. The review criteria are as follows: "+1" indicates acceptance, "0" indicates uncertainty, and "-1" indicates rejection. The data analysis shows that all the research tools employed in this study demonstrate a high level of content validity (IOC). In particular, the IOC value for the questionnaire is 0.97, for the expert interview is 1, for the old people interview is 0.97, for the nursing worker interview is 0.9, and for the user test questions is 0.97. These high IOC values significantly indicate that all research tools possess good content validity, supporting their reliability as effective data collection instruments for this study. Consequently, these tools are deemed both theoretically and practically feasible, capable of providing high-quality data for this research.

The three experts are: Assistant Professor Dr.Donlaporn Srifar, Dr. Pitchaya Nilrungratana, Assistant Professor Dr.Prangthong Changtham. Figure 20 depicts the review session with the three experts, as detailed in the invitation letters referenced in Appendix 1.

Figure 20 IOC review by 3 experts

Note. Photographed by the researcher.

3.3.2 TOOLS FOR EVALUATING THE PROTOTYPE

In this study, data collection is conducted using three research tools: interviews, questionnaires, and testing. Each tool is designed to target different demographic groups and assessment objectives, ensuring comprehensive data on the prototype's efficacy from multiple dimensions is obtained. The interview tool is used to gain insight into participants' subjective experiences and personal insights, providing qualitative data that is critical for understanding user needs and the intrinsic motivations behind user-product interactions. The questionnaire tool collects user feedback in a quantified form through a standardised set of questions, offering efficiency and enabling comparative analysis across samples. Finally, the testing tool for the actual product prototype provides firsthand observations of user interactions with the prototype and vital information on the product's functions and design through simulated usage scenarios. The combined use of these three tools offers a comprehensive, multi-dimensional evaluation framework for assessing the effectiveness of the prototype.

(1) INTERVIEWS

Part 1: Interviews with the elderly are conducted to gain insight into their experiences and needs with regard to sitting and rising. These interviews primarily

consist of open-ended questions, allowing the elderly to freely express and share their needs.

Part 2: Interviews with nursing staff aim to uncover the challenges and challenges they face in caring for the elderly, as well as the extent to which existing assistive products help both the staff and the elderly. This provides a deeper understanding of the needs of the elderly.

Part 3: Interviews with experts in product design, material design, and age-friendly furniture design are conducted to gain insights into the development trends and design principles for the product in this study, providing a theoretical foundation.

(2) QUESTIONNAIRES

Part 1: A carefully designed questionnaire is administered to the elderly, aiming to gain in-depth understanding of their physical condition and the challenges they encounter in their elderly living. The questionnaire primarily consists of multiple-choice questions to facilitate the rapid and efficient collection of a large amount of data, providing solid and extensive data support for in-depth analysis in this study. By distributing 200 questionnaires, we aim to capture the common needs and specific issues faced by the elderly in daily life, providing key quantitative evidence for subsequent research and product design.

(3) TESTING

Part 1: In order to evaluate whether the developed assistive product in this study meets the predetermined research objectives and gain a deep understanding of the elderly users' usage experience and satisfaction, a product testing involving 10 elderly participants is organised. Through a series of rigorous testing procedures, qualitative feedback on product performance, user-friendliness, and overall satisfaction is collected. Furthermore, this study places particular emphasis on the incorporation of constructive feedback from elderly users, with the objective of providing invaluable user-centred insights for the continuous optimisation and iteration of the product. The data obtained from this testing stage will serve as a crucial empirical foundation to ensure that our product design is aligned with the actual needs of the elderly.

3.4 DATA COLLECTION METHODS

3.4.1 QUALITATIVE DATA COLLECTION

This study primarily employs two methods for qualitative data collection: interviews and participatory observations.

Firstly, I will personally visit elderly care facilities for on-site investigations and observe the daily lives of the elderly through direct interaction. During this process, I will document specific needs of the elderly in areas such as physical well-being (e.g., caregiving, medical services, and rehabilitation), psychological well-being (including

recreational activities and psychological support services), and daily living (e.g., clothing, food, shelter, and transportation).

Secondly, in-depth interviews will be conducted with elderly residents, healthcare professionals, and management staff at the care facilities. This will help gain a comprehensive understanding of the personalized needs and expectations of the elderly residents, professional suggestions on the efficacy of the product from healthcare professionals, and the analysis of existing elderly care products and prospects for future age-friendly products from management staff.

Furthermore, in order to gain a deeper insight into the social dynamics of the elderly care community, I will participate in group activities within the care facilities, such as choir singing, card games, and daily conversations. The participatory observation method will facilitate discussions among the elderly, enabling a more profound exploration and comprehension of their genuine needs and feedback. This methodological framework is designed to ensure the depth and breadth of research findings, providing a robust qualitative foundation for further product development and service design.

3.4.2 QUANTITATIVE DATA COLLECTION

In order to gather quantitative data, this study will employ two methods: questionnaire surveys and on-site observations. A carefully designed questionnaire will be distributed to elderly residents, nursing staff, and management staff at the care facilities. The aim of this is to systematically gather their expectations, preferences, and suggestions for age-friendly products. This will help quantify their needs and provide quantitative evidence for product design.

Concurrently, on-site observations will be conducted within the care facilities, focusing on the physical parameters of the environment, such as the scale of the space, the rationality of the layout, and the suitability of facilities and equipment. In-depth records of the usage conditions of existing age-friendly furniture will also be made, particularly noting any issues encountered during use. This information is crucial for evaluating the practicality of product design and proposing improvement strategies. The combination of questionnaire surveys and on-site observations will enable this study to comprehensively assess and optimise product designs for the elderly population.

3.5 DATA ANALYSIS METHODS

3.5.1 QUALITATIVE DATA ANALYSIS

This study employs content analysis as the primary method for qualitative data analysis. The data will be meticulously organised and transformed into a form that can be compared and analysed. This will be achieved by meticulously organising and transforming interview records with elderly residents and nursing staff, as well as

notes from on-site observations and group activity discussions. Through content analysis and theme identification, the actual needs and expectations of the elderly in care facilities will be identified. The objective of this process is to transform the extensive and intricate qualitative data into profound insights that elucidate the needs and expectations of the elderly. This will facilitate a comprehensive and in-depth comprehension of the requirements for future age-friendly product design.

3.5.2 QUANTITATIVE DATA ANALYSIS

The analysis of quantitative data in this study is primarily conducted through statistical analysis. Following the collection of questionnaire data, the first step is to clean the data and select valid questionnaires to ensure data accuracy and reliability. Then, detailed analyses are conducted using charting techniques to reveal the characteristics of the participants' needs for age-friendly products. These statistical results provide reliable data support for subsequent product design.

Furthermore, this study will employ a comparative analysis to understand the differences in the needs for age-friendly products among elderly residents of different age groups and health conditions. In particular, we will explore the unique needs of elderly individuals with different levels of self-care ability (independent and semi-independent). This multi-faceted, multi-dimensional analysis approach will facilitate a more profound and comprehensive comprehension of the needs of the elderly, thereby providing a robust foundation for the design of age-friendly products that align with their specific requirements.

3.6 CASE STUDY METHOD

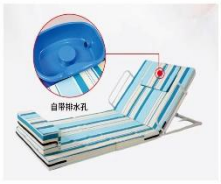
The case study method comprises several stages. Initially, the usage levels of age-friendly products in municipal and county-level care facilities will be evaluated. Based on this assessment, representative age-friendly products will be selected for subjective comparisons and analysis. These comparisons will be conducted from the following perspectives: functionality, materials, colours, and design. In-depth interviews with elderly residents, nursing staff, administrators, and designers will also be conducted to gain insight into their evaluations and expectations of existing products.

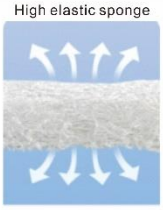
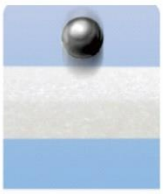
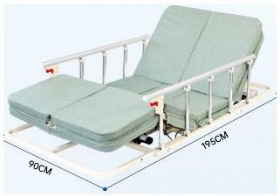
Secondly, based on the analysis of the products and the needs, evaluations, and expectations of the elderly residents, nursing staff, administrators, and designers, the strengths, problems, and areas for improvement of age-friendly products in care facilities will be summarised. This will provide insights and innovative ideas for my own design improvements.

Finally, the case study method allows for a better understanding of the current state of age-friendly products in care facilities. The results of the analysis will be presented in the form of charts, tables, or written descriptions, clearly depicting the characteristics and actual usage of age-friendly products in care facilities.

This study analysed six products and found that assistive products in the current market can be primarily divided into two categories: manual assistive products and electric assistive products (Table 1).

Table 1 Competitor Analysis

Product	Materials	Advantage	Weakness
	  Stainless steel paint PU foam	Compact appearance Portable Cheap Storage function High practicability	Low security There are restrictions on getting up Single function
	  Solid wood Stainless steel pipe	Size can be customized Easy to store cheap High practicability	There are restrictions on getting up Single function
	  sponge emulsion Eco-friendly coconut palm	Multiple functions Electric remote control to help High security	Not easy to move Remote control keys complex

Product	Materials	Advantage	Weakness
	High elastic sponge   	Smaller appearance Electric remote control to help Simple operation Cheap	Low security Not easy to move
	  Coconut hard cotton Coconut latex mat Air fiber mat	High security Variable shape Electric remote control Simple operation	Not easy to move The price is expensive (more than 3,000) Single user The bedpan will be uneven after you put it in
	  Leathaire leather Cotton pad	High security Variable shape Electric remote control Multiple functions	Not easy to move Expensive (more than 9,000) Too many remote buttons

3.7 LITERATURE REVIEW METHOD

Firstly, I collated a range of literature from various sources, including academic journals, conference papers, theses, and internet resources, on topics related to the current status of nursing homes, the design of age-friendly products, the needs of the elderly, ergonomics, elderly care, and the elderly perspectives on materials and colours.

Secondly, I categorised and organised the collected literature based on themes, including elderly needs, principles of age-friendly product design, and the development of nursing homes. Furthermore, I classified the literature based on research methods in order to gain insight into the approaches and tools employed by other researchers, learn about questionnaire design and interview protocols, and develop theoretical support and insights for my own research. This facilitates subsequent literature reviews and analysis.

Finally, I analysed the research methods, findings, and limitations of previous studies in order to identify gaps in the literature. This helps generate innovative ideas for my own research and provides a basis for evaluating the applicability and validity of previous conclusions. Furthermore, it enables me to establish connections between the existing literature and my own research, and to present my own perspectives and suggestions for improvement.

3.8 FIELD RESEARCH METHOD

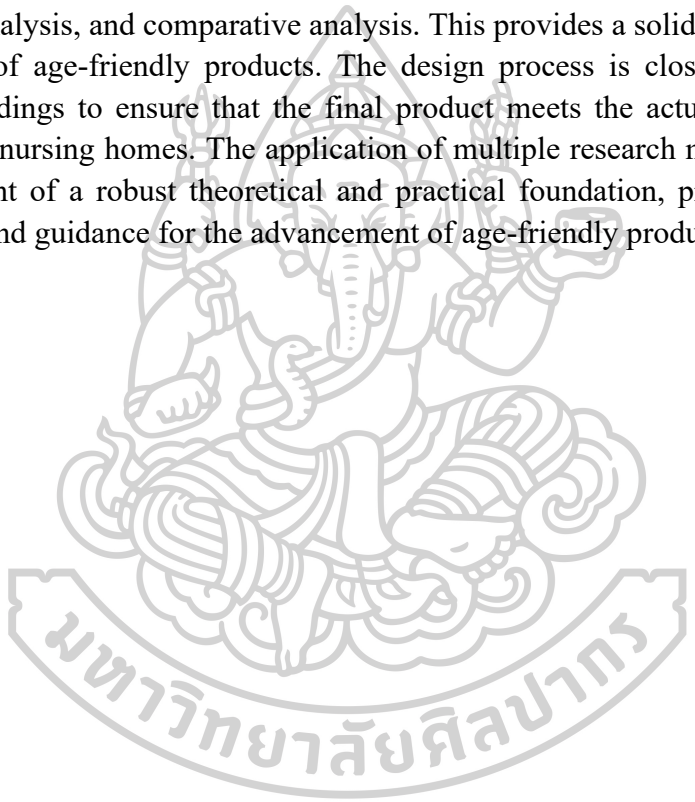
This study selected a number of elderly care facilities in Dingxi City, Gansu Province, China, with the aim of gaining insights into the accommodation status of elderly residents in the region, as well as their frequency of use of and satisfaction with activities and recreational facilities. The study focuses on how these factors affect the emotional needs of the elderly and the level of satisfaction they receive. In addition, the study also examined in detail the types and functions of age-friendly products in nursing homes, as well as the practicality of the interior layout of nursing homes. These data provide an important analytical basis for the subsequent development of age-friendly product sizes and design solutions. This series of in-depth research and analysis will facilitate the authors' more precise understanding of the elderly's living environment and assistive product design needs.

3.9 DESIGN PROCESS

In order to develop a practical and elderly-friendly product, the design process will include requirements analysis, conceptual design, sketching, 3D modelling, prototyping, and user testing. The design process will fully consider the needs and expectations of elderly residents in nursing homes, as well as the input and guidance from caregivers, doctors, administrators, and designers. This ensures that the product is both usable and safe, as well as comfortable for the elderly.

3.10 SUMMARY

This chapter provides a detailed explanation of the design framework and implementation process of this study. Adopting a mixed-method research strategy that combines qualitative and quantitative analysis, this study comprehensively explores the needs and expectations of nursing home residents. Qualitative data collection methods, such as observation, in-depth interviews, and group discussions, allow us to gain a deep understanding of user opinions and suggestions. Meanwhile, quantitative data is obtained through surveys and field observations, providing empirical data support for this study. During the data analysis stage, various methods are employed to deepen the understanding of the collected data, including content analysis, statistical analysis, and comparative analysis. This provides a solid data foundation for the design of age-friendly products. The design process is closely integrated with research findings to ensure that the final product meets the actual needs of elderly residents in nursing homes. The application of multiple research methods enables the establishment of a robust theoretical and practical foundation, providing invaluable references and guidance for the advancement of age-friendly product design.



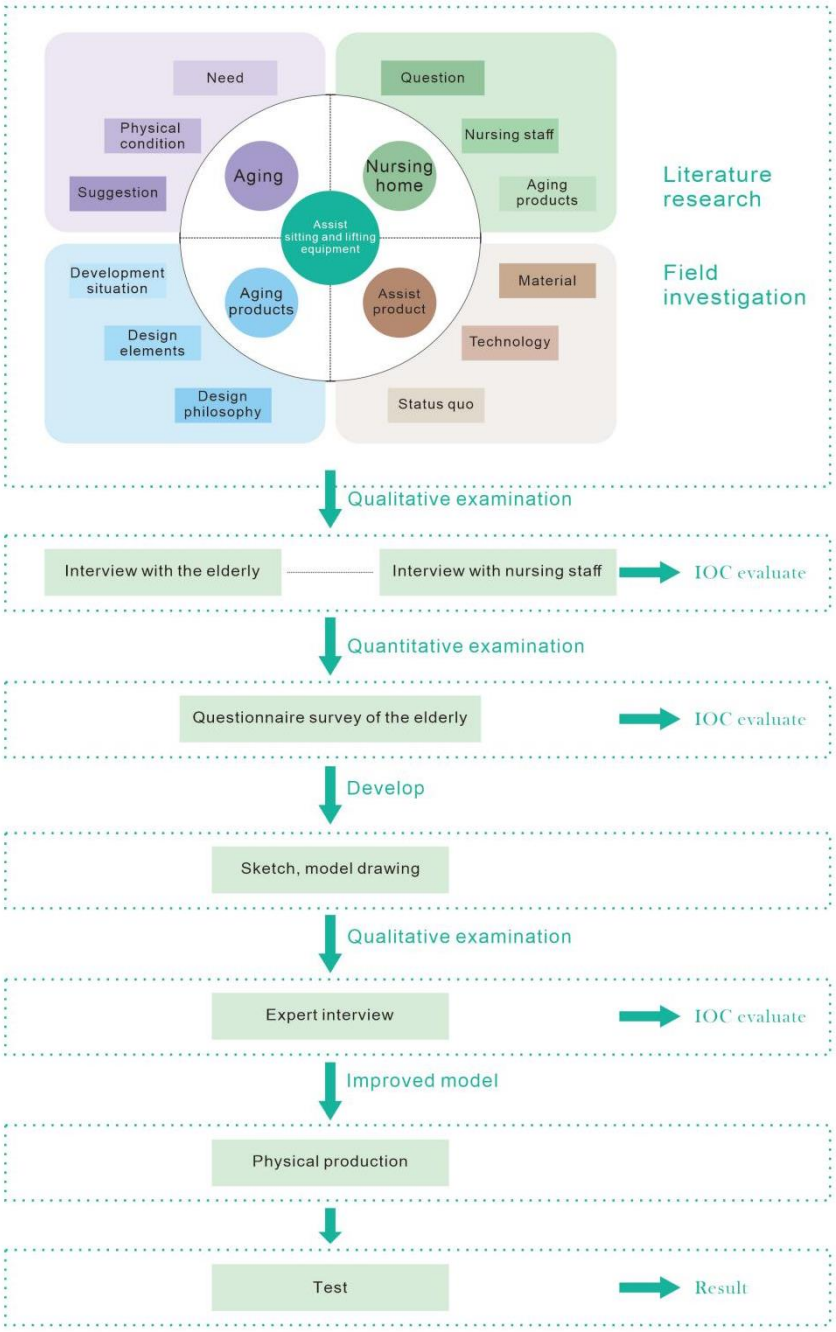
CHAPTER 4

RESEARCH AND DESIGN PROCESS

4.1 INTRODUCTION

The research process in product design is of paramount importance. In the early stages, conducting an in-depth literature review and theoretical research serves as a crucial step in establishing the necessary data support for design. Furthermore, conducting a comprehensive competitor analysis to identify strengths and weaknesses is essential in guiding product design and development. Prior to prototype production, it is effective to invite domain experts and experienced designers to review initial models and provide feedback, thereby mitigating risks in the later testing phase. Consequently, the design process in this study is explicitly divided into the following stages: data collection, data analysis, conceptual sketching, detailed model construction, expert consultation, prototype production, and testing (Figure 21). This figure illustrates the design process for developing assistive equipment for elderly individuals' sitting and standing needs. Initially, conducting literature research and field investigations helps to comprehend the needs of the elderly, requirements of nursing homes, existing assistive product materials, technologies, and design principles. Subsequently, qualitative research is conducted through interviews with elderly individuals and nursing staff to collect data, which is then evaluated using the Input-Output Control (IOC) method. Furthermore, quantitative research is conducted through surveys to gather additional data, which is also subjected to IOC evaluation. Subsequently, the development phase commences with the creation of sketches and models. Another round of qualitative research is conducted through expert interviews to refine the model, followed by another IOC evaluation. Finally, the improved model undergoes physical production and testing, leading to final results. Naturally, this process is adjusted and optimised based on the specific requirements of each project. The objective of this systematic research and design process is to ensure that the scientific, rational, and practical aspects of product design meet the demands of the target market.

Figure 21 The whole process of product design



4.2 RESEARCH AND ANALYSIS

The objective of this study is to address the common difficulty faced by the elderly in their daily lives, specifically the challenge of getting up from a seated position. The motivation for this research stems from the author's personal experience of seeing elderly family members frequently requiring external assistance to perform basic standing movements. This observation led to a deeper focus on the special needs

of the elderly population. Extensive research revealed that many elderly individuals encounter difficulties with basic actions such as sitting and standing, which became the core problem addressed in this research. Therefore, the objective of this study is to develop a multifunctional assistive device that enhances the sitting and standing balance of the elderly and solves the challenge of getting up from various positions. The design of this device not only aims to improve the quality of life for the elderly but also to enhance their ability to live independently. The design process was conducted in accordance with the principles of ergonomics, ensuring that the final product met the practical needs of the target users. This resulted in a substantial improvement in the daily lives of the elderly.

The study commenced with a comprehensive evaluation of existing assistive products for getting up from a seated position. This involved a thorough literature review and market analysis. The functional characteristics and limitations of these products were extensively explored. To gain further insight into user needs, a series of in-depth interviews were conducted, involving elderly individuals, caregivers, and interdisciplinary expert teams in fields such as product design, materials science, and furniture design. These interviews yielded valuable user feedback, revealing key challenges encountered in the practical use of assistive devices, such as usability, comfort, safety, and cost-effectiveness.

The data was used to establish key design indicators, including adjustability, stability, user-friendliness, portability, safety, and cost-effectiveness of the device. The design was iteratively optimised through multiple rounds of sketching, 3D modelling, and user testing. In the sketching phase, particular emphasis was placed on safety and ease of use, ensuring the design aligns with ergonomic principles. Furthermore, a meticulous selection process was conducted for the materials and manufacturing processes of the assistive device. Ultimately, a material with high hardness, durability, and ease of cleaning and maintenance was selected to ensure long-term performance and hygiene standards of the product.

During safety assessments, the weight-bearing capacity of the device underwent rigorous testing to ensure compliance with safety standards. Finally, a comprehensive clinical evaluation of the assistive device was conducted. A series of real-world tests were conducted in nursing homes to assess the device's performance in actual environments. This ensured that the device was effective in meeting the practical needs of the elderly and improved their quality of life.

4.3 QUESTIONNAIRE DATA ANALYSIS

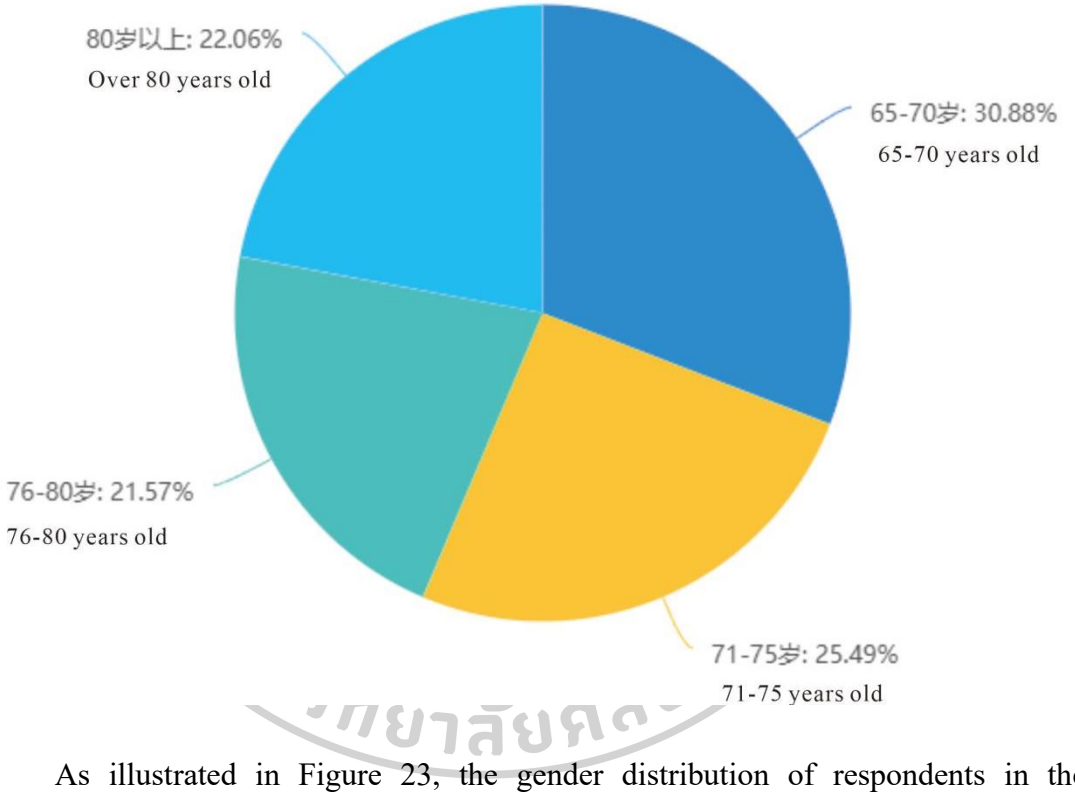
4.3.1 ONLINE QUANTITATIVE STUDY FOR THE ELDERLY

The purpose of this research tool is to understand the specific needs and challenges of the elderly in sitting and standing, as well as their usage and satisfaction with assistive devices. It aims to gather feedback from the elderly regarding their experiences with assistive products, including evaluations of functionality, comfort,

and ease of use, as well as their perceived main reasons for difficulty in sitting and standing. These objectives help ensure that the design and development of assistive devices truly address the issues faced by the elderly, improve their quality of life, and promote research and development in related fields.

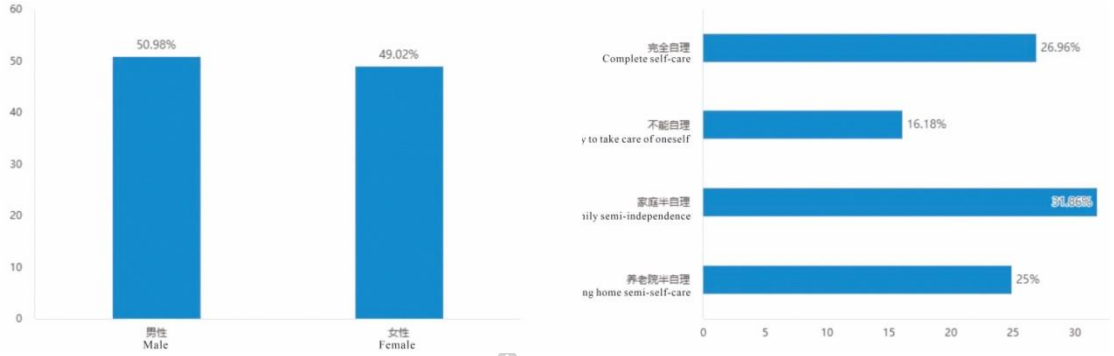
In this study, an online questionnaire was used to survey individuals aged 65 and above, and a total of 204 valid responses were collected. The data set revealed that participants aged between 65 and 70 accounted for 30% (Figure 22), which aligns with the target population criteria set for this study.

Figure 22 Age Composition of Survey Participants



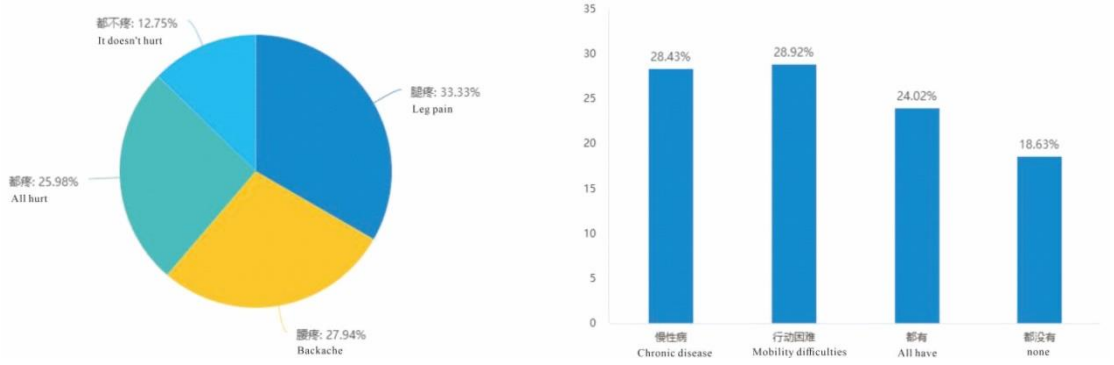
As illustrated in Figure 23, the gender distribution of respondents in the questionnaire survey of this study was 51% male and 49% female, ensuring a balanced representation and the comprehensiveness and representativeness of the data. Further analysis of the participants' self-care ability revealed that 32% of the respondents were in a semi-self-care state at home, while fully self-care and semi-self-care in nursing homes accounted for approximately 26% each. This distribution indicates that a significant proportion of the study population is in a semi-self-care state, which closely aligns with the characteristics of the elderly population that this study focuses on.

Figure 23 Proportion of Male and Female Participants and Percentages of Different Levels of Self-care



In response to the "Question 4: Do you often suffer from leg or back pain?" and "Question 5: Do you have any chronic diseases or mobility problems?", the survey results, as shown in Figure 24, indicate that among the 204 participants, approximately 30% reported experiencing leg pain, back pain, or both. Only 10% of the participants reported no pain at all. Leg pain and back pain were identified as the primary factors contributing to difficulty in sitting and standing. Furthermore, 83% of the elderly population reported having chronic diseases and mobility problems. These findings highlight the significance and necessity of this study.

Figure 24 Results of Participant Responses Regarding Physical Conditions



The survey results further demonstrate that only a small proportion of elderly individuals experience no difficulties in sitting or standing. Among the 204 participants, in response to "Question 6: Do you often find it uncomfortable or difficult to sit or get up?", the highest proportion reported difficulty in sitting (28%), followed by difficulty in getting up (26.5%). Approximately 25% of participants reported experiencing both leg and back pain (Figure 25).

Furthermore, when queried as to the primary cause of the difficulty in getting up and sitting, respondents provided a range of responses, including physical and environmental factors. The majority attributed leg pain as the primary reason for difficulty in sitting, indicating the necessity for the development of products designed

to assist elderly individuals in sitting or standing, with a focus on personalised design to address these specific needs (Figure 26).

Figure 25 Participant Responses on Difficulties in Standing or Sitting

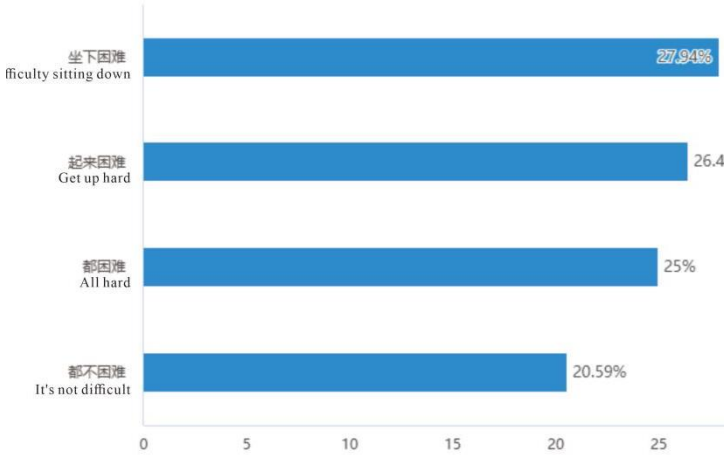


Figure 26 Reasons for Difficulties in Standing or Sitting as Reported by Participants

This study also addressed the risk of falls among elderly individuals. In response to "Question 8: Do you often fall?", the participants' answers are depicted in (Figure 27). The figure reveals that over 60% of the respondents have experienced falls, directly impacting the safety of the elderly. Additionally, in response to "Question 9: Have you ever used an assistive device to help you get out of bed?", the data indicates that over half of the elderly participants have utilized assistive products (Figure 28). This suggests that there is still considerable room for development in the market for assistive products. Based on the needs and issues identified among elderly individuals, this study will conduct further in-depth research on assistive products.

Figure 27 Participants' Responses on Frequency of Falls

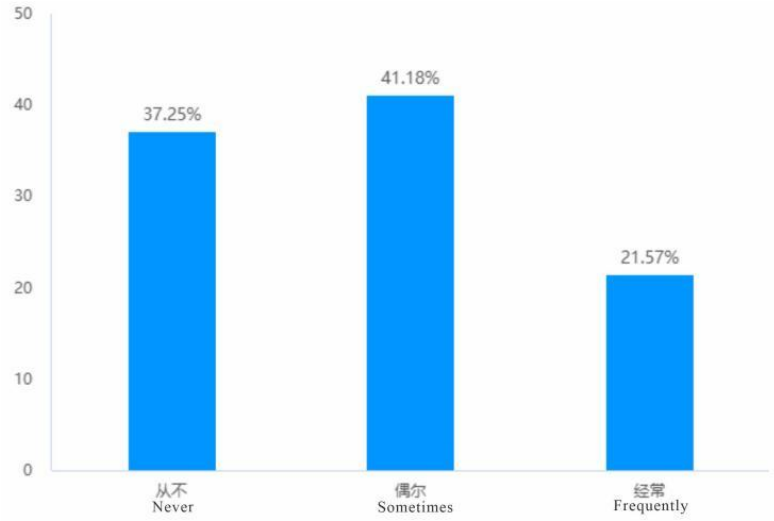
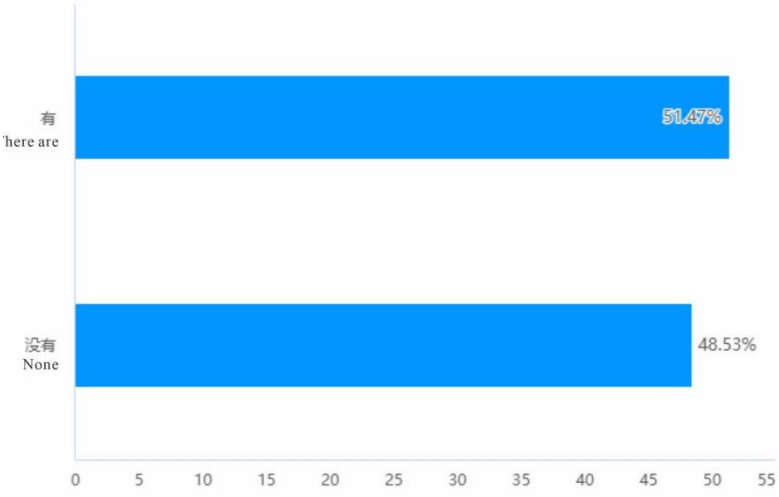


Figure 28 Participants' Responses on Using Assistive Products



The survey probed further into the elderly's specific requirements for assistive products with "Question 10: Are you interested in using assistive products to help you get up or sit down more safely?" and "Question 11: What do you want this product to do?" As depicted in Figures 29 and 30, a significant majority, over 60% of the elderly, showed interest in using assistive products and emphasized the need for essential features. The data revealed that ease of use and portability were the most highly prioritised features, aligning with the aversion to complex and intelligent systems that was mentioned in Chapter 2. Moreover, safety emerged as a paramount consideration, directly linked to the elderly's health and life.

Regarding smart technology, despite its extensive application in current assistive devices like massage chairs, beds, and rehabilitation equipment, the

complexity of these products' interfaces makes them less accessible to the elderly, who typically have lower adaptability to new and intelligent technologies. Furthermore, the incorporation of such technologies significantly elevates product costs. Consequently, our study's product design will not incorporate smart technologies, focusing instead on user-friendly and essential features that are critical to the elderly's needs.

Figure 29 Interest in Assistive Products Among Respondents

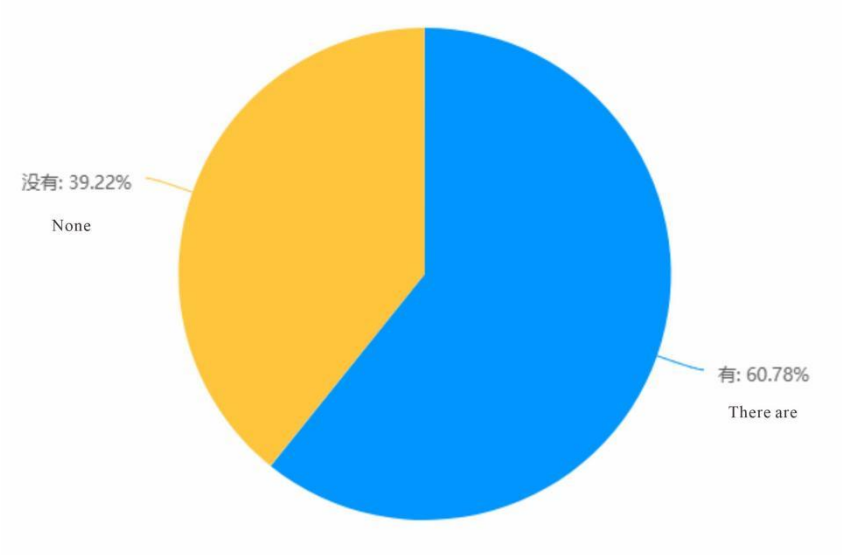
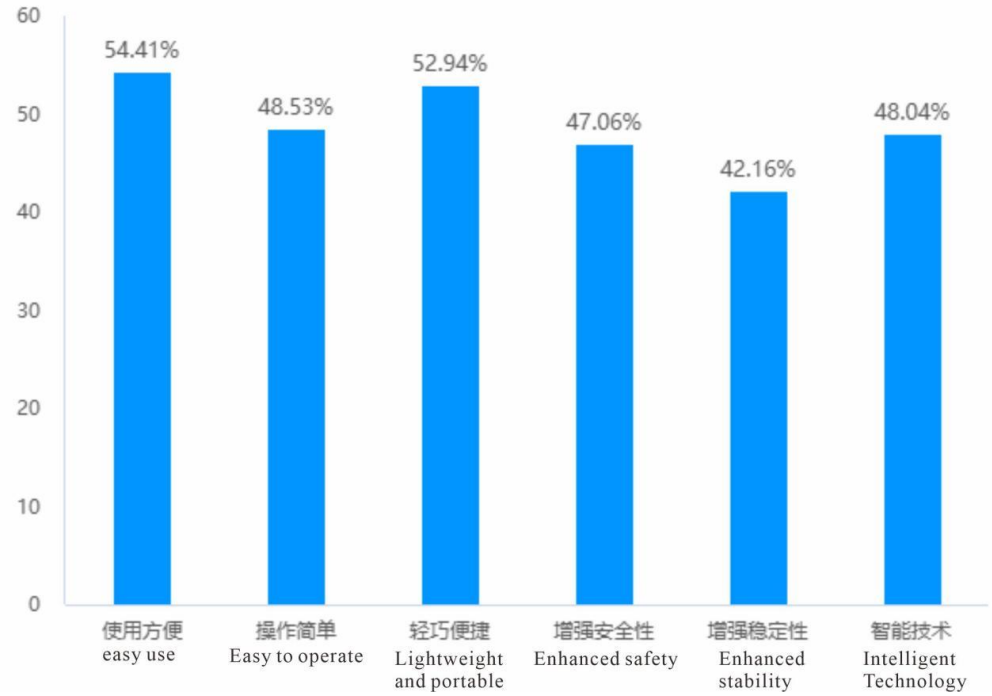


Figure 30 Desired Features in Assistive Products by Respondents



Figures 31 and 32 summarise the elderly's responses to "Question 12: When considering a new product, how concerned are you about the safety of that product?" and "Question 13: If there is a suitable product, would you like to use it?" Among the 204 participants, 80% expressed high concern for product safety, with 30% being extremely concerned. These individuals demonstrated a willingness to utilise appropriate assistive products to enhance their capacity to live independently, thereby underscoring the significance of this research.

Figure 31 Safety Concerns and Willingness to Adopt Suitable Products

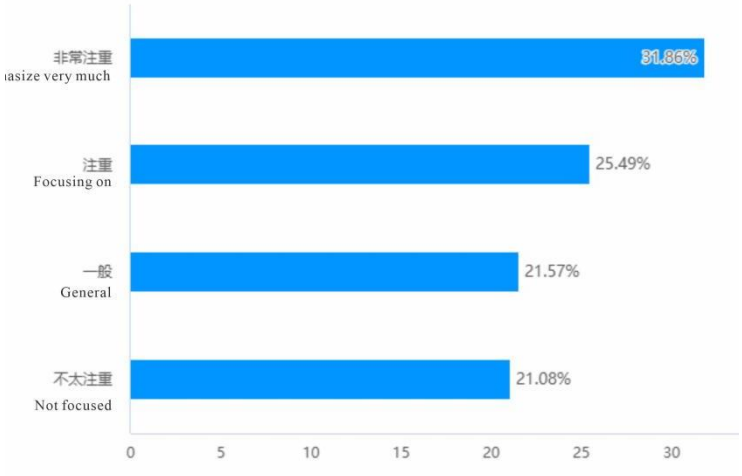


Figure 32 Willingness to Use Suitable Products Among Respondents

4.3.2 QUALITATIVE OFFLINE INTERVIEWS TARGETING THE ELDERLY

This research employed interviews with elderly individuals aimed at gaining an in-depth understanding of their specific needs and challenges regarding seating and standing balance. Through engaging with 10 elderly participants, feedback on the use of existing assistive devices was collected (Figure 33), encompassing evaluations of device functionality, comfort, and ease of use. Additionally, the interviews sought to

identify barriers encountered by the elderly in using assistive devices, such as technological acceptance, operational difficulty, and socio-psychological factors. This information is of great importance for ensuring that new or improved devices better meet users' specific needs. The findings will also assist researchers in assessing the practical effects of assistive devices on improving elderly individuals' balance, reducing fall risks, and enhancing quality of life. This evidence will provide a foundation for future technological innovations and policy formulation.

Figure 33 Interview for 10 Elderly Participants

Note. Photographed by the researcher.

To gain deeper insights into the difficulties faced by the elderly in their daily activities, this study initially conducted interviews with individuals aged 65 to 80 in Weiyuan County and Dingxi City, Gansu Province. The focus was particularly on the challenges they encounter while sitting down and standing up. According to the survey, 80% of respondents (8 out of 10) reported difficulties in performing these basic movements, primarily due to pain or weakness in the legs, back, and arms, as well as health conditions like rheumatism. This highlights the urgency of this study and the need to develop targeted assistive products.

Further research revealed that 70% of the interviewed elderly (7 out of 10) had attempted to use tools like tension bands and handrails to aid in standing up. However, these devices did not ensure balance and safety, and were inconvenient in terms of requiring side leaning or single-arm support, indicating a dire need for assistive products that offer both balance and safety.

Additionally, the study explored the elderly's functional and technological requirements for assistive products. All participants emphasized the importance of safety, with some also suggesting additional features such as adjustability, video playback, music playback, telecommunication, and medication reminders. Beyond safety, the ideal assistive product, as per the elderly's perspective, should also be

portable, easy to operate, mobile, and affordable. They expressed willingness to adopt a product meeting these criteria.

In summary, designing and developing assistive products for the elderly's daily activities must consider their specific difficulties and diverse needs. The design of targeted products should not only enhance the elderly's autonomy in movement but also ensure safety. This can be achieved by incorporating practical features and convenience, which will better integrate the product into the elderly's daily lives.

4.3.3 QUALITATIVE OFFLINE INTERVIEWS WITH CAREGIVERS

The principal instrument employed in this study was an offline interview with caregivers, which was conducted with the objective of gathering firsthand experiences, observations, and suggestions from frontline care personnel regarding the use of assistive products for elderly mobility. Through these on-site interviews, the researcher gained profound insights into the specific operational challenges caregivers face while assisting the elderly in sitting and standing, as well as their evaluations of the performance of existing assistive devices (Figure 34).

Firstly, this direct interaction enabled the researcher to effectively collect caregivers' intuitive observations and feedback on the needs for balance assistive devices for the elderly. This included understanding which types of assistive devices have proven effective in practical applications and collecting caregivers' experiences with these devices in daily nursing home operations. This information, encompassing both successful cases and encountered challenges, is useful in assessing the actual effectiveness of assistive devices in improving the elderly's balance during sitting and standing, and their impact on the elderly's daily life and mental health.

Secondly, the interviews sought to elucidate the obstacles encountered by caregivers when utilising assistive devices, encompassing matters such as the elderly's receptivity to such devices and the intricacies of their operation. Furthermore, the process gathered caregivers' suggestions for enhancing existing assistive devices and their requirements for novel types of assistive equipment. Through these feedbacks, the research can inform the generation of novel design concepts and innovative solutions, leading to products that better align with the needs of the elderly.

In conclusion, interviewing caregivers in nursing homes provides invaluable firsthand information, enabling researchers to gain a deeper understanding of the utilisation of assistive devices by the elderly in real-life settings. This, in turn, facilitates the design of more effective, user-friendly, and acceptable assistive devices. Furthermore, caregivers' insights on how to enhance devices to better align with the needs of the elderly are of significant value for the improvement of design and the optimisation of functionality. The interview results will provide practical guidance for the innovation of assistive products for mobility, enhancing their usability and the quality of life for the elderly.

Figure 34 Interviews with Frontline Caregivers in Nursing Homes

Note. Photographed by the researcher.

In this interview, five caregivers from Heyi Nursing Home in Dingxi City were questioned on a range of topics. The questions, which are detailed in Table 2, were designed to elicit information on the responsibilities of caregivers, their involvement in assisting elderly individuals with sitting and standing, and their understanding of relevant assistive tools.

Table 2 The Questions Regarding Caregivers

	The Questions Regarding Caregivers
1	How many years of work experience?
2	The name of the nursing home?
3	What exactly do you do when you take care of the elderly?
4	Do you often need to help the elderly get up at work?
5	What are your main challenges in helping older people get out of bed? (Physical strength, resistance, balance problems, product limitations, etc.)
6	What do you think are the main reasons why older people have trouble getting out of bed? (Such as muscle weakness, balance problems, fear of falling,
7	Do you think that using innovative products that assist in balancing can improve the safety of getting up for the elderly?
8	What characteristics do you think a good balanced innovative product should have?
9	Have you ever used a similar product? If so, please share your practical experience.

10	Do you think product safety is important for seniors and caregivers? Please describe.
11	Do you have any suggestions or comments on innovative products to help the elderly get out of bed?

The initial section of the interview comprised three inquiries pertaining to the duration of the caregivers' tenure, the names of the nursing homes they work for, and their specific responsibilities when caring for the elderly. Our findings revealed that their work experience ranged from one month to two years. They were required to assist with feeding, bathing, general movements, and daily life activities of the elderly. Consequently, they possess a profound understanding of the elderly's needs and the difficulties they face in life.

The subsequent questions, numbered 4, 5 and 6, constituted the focus of this study. These questions pertained to the issues that caregivers face when assisting the elderly with sitting and standing. The results of the interviews indicated that each caregiver frequently needed to assist with these two actions. Some elderly individuals exhibited resistance and defensiveness, necessitating significant effort from the caregivers to execute these tasks. The primary reasons for the difficulty in rising and sitting were identified by caregivers as poor balance, muscle weakness, and fear of falling among the elderly. Consequently, in the design of assistive products for "sitting" and "rising", it is essential to consider balance issues, minimise the space for elderly individuals to sway side to side, and potentially add armrests or barriers to prevent lateral tilting. This would allow the elderly to visually perceive the safety features of the product and reduce psychological concerns. Additionally, designing products according to ergonomic dimensions could practically enhance safety.

Questions 7 to 11 inquired about the understanding of caregivers regarding products designed to assist the elderly. The data revealed that all five caregivers concurred that innovative balance-assist products could enhance the safety of the elderly when getting out of bed. They posited that an optimal assistive device should possess practicality, stability, ease of use, and reasonable pricing. Additionally, they had previously utilized some assistive devices, which had resulted in fall-related safety incidents.

In response to the questions "Do you think product safety is important for seniors and caregivers? Please describe" and "Do you have any suggestions or comments on innovative products to help the elderly get out of bed?", the caregivers indicated that assistive products with high safety standards could enhance their efficiency and reduce safety incidents among the elderly. They also proposed that assistive devices should be affordable, innovative, practical, and easy to use. These insights provide a research direction and characteristics to be considered for this study.

In conclusion, this study gathered data on the assistance provided to the elderly in their daily lives through interviews with five caregivers from the Heyi

Nursing Home in Dingxi city. The interview questions encompassed the caregivers' work experience, job content, and their comprehension and utilisation of assistive devices. The caregivers' work experience ranged from one month to two years, with significant responsibilities to assist the elderly with a variety of daily tasks. The caregivers frequently assist with the elderly's sit-to-stand movements, which present challenges including balance issues, muscle weakness, and fear of falling. While the caregivers believe that innovative assistive products can enhance the safety of these movements, they also emphasise that product design should prioritise ease of use, stability, practicality, and affordability.

Additionally, the caregivers' feedback highlighted the complexity of sit-to-stand difficulties faced by the elderly, encompassing both physical and psychological factors. It is recommended that assistive products should combine safety, convenience, and affordability to improve work efficiency and reduce safety incidents. The study provides direction for designing assistive products for the elderly and emphasises key characteristics to consider during the design process. These insights will guide future product development to ensure that assistive devices meet the needs of the elderly and provide necessary support to caregivers.

4.3.4 QUALITATIVE RESEARCH THROUGH ONLINE INTERVIEWS WITH EXPERTS

Appendix 3 presents the outcomes of interviews with experts conducted online to gain an in-depth understanding of assistive products available on the market. These semi-structured interviews were conducted with design experts specializing in product, material, and furniture design. The participants included Associate Dean Wang Xibin, Lecturer Zeng Jiandan, and Lecturer Ji Fangyuan from the School of Fine Arts at Zhaoqing University in China. The interviews provided a comprehensive overview of assistive products for the elderly from a variety of expert perspectives. They delved into the specific needs of the elderly regarding sitting and standing balance, how design can meet these needs, and discussed the integration of ergonomics, aesthetics, and functionality in the design of assistive products.

From the perspective of furniture design experts, the discussion centred on the potential for seating to be combined with assistive products in order to provide enhanced support and comfort. Material research experts examined the properties of different materials, including durability, comfort, ease of cleaning, and cost-effectiveness, and their impact on the performance and user experience of the devices. Product design experts engaged in discourse pertaining to technical and structural considerations, including the design of assistive products that ensure safety and stability during use, the potential incorporation of sensor technology and smart technologies to enhance functionality and interactivity, and the design of adjustable and customisable assistive devices to suit the physical conditions and preferences of different elderly individuals. Additionally, the discussions encompassed expert views

on current market trends, future directions in assistive device design, and the principles and standards that should be adhered to in designing assistive products. The insights gained from interviewing experts from different fields provided a comprehensive and in-depth understanding of the design of assistive products for the elderly. This understanding will inform the development of more effective, safer, and user-friendly assistive products.

Interviews with three experts revealed that the assistive products for getting out of bed currently on the market are often expensive, complex to operate, lack sufficient functional differentiation, and emotional care. This study aims to address these issues through design considerations. Based on recommendations from a materials expert, the use of stainless steel and aluminium alloys is advised for their strength, stability, and moderate weight, supplemented by natural materials like wood, bamboo, and softer materials such as rubber, plastic, and fabric.

The product design must adhere to ergonomic principles to ensure comfort, safety, reliability, human-centredness, aesthetics, data-driven attributes, standardisation, and adaptability. The experts proposed several design principles for the study's product, emphasising ease of use, adjustability, stability, and portability. These principles are considered fundamental to the development of assistive products for the elderly.

Furthermore, the experts proposed the incorporation of interactive design elements, the optimisation of user interfaces to ensure that controls and indicators are understandable and operable, and the catering to the elderly with diminished sight and hearing. The emotional care of the elderly can be addressed by the integration of simple smart technologies for real-time monitoring of vital signs such as heart rate, blood pressure, and blood sugar, which will promote health from the ground up. Finally, the principles of personalised customisation should be considered from a humanistic standpoint, offering customisable features to cater to the diverse physical conditions and lifestyle habits of the elderly.

4.4 SKETCHING AND SELECTION

The preliminary sketching phase plays a pivotal role in this study, providing a foundation for the innovative design of assistive devices. At the outset of this phase, researchers employed brainstorming to generate a range of potential designs. Following a period of creative ideation, over 30 design concepts were proposed, with 24 deemed to have practical design value. At this stage, the primary objective was to ensure a broad and diverse range of design ideas, with feasibility considerations secondary.

Following a comprehensive discussion and analysis with mentors, 15 high-potential design concepts were selected for further development. Based on mentor recommendations, these ideas were refined and enhanced, addressing the basic shape, structure, and anticipated materials and colour schemes of the devices. This

phase also examined the multifunctional features of the assistive devices, including electric lifting mechanisms, smart sensor integration, and emergency braking systems. In addition, the core components, such as armrests, seating, and support structures, were detailed to ensure that the design conforms to the elderly's physicality and usage habits.

It is of significant importance to note that during the sketching stage, researchers concentrated on the potential of product design to effectively assist the elderly with sitting and standing movements. This was done with the aim of alleviating physical strain and significantly enhancing safety and comfort during use. This stage laid a solid foundation for subsequent prototype fabrication and functionality development.

In summary, as a key step in the design process, sketching not only facilitated the optimization of design solutions but also provided vital visual references for prototype creation and user testing. Through these efforts, researchers ensured that the final assistive devices developed would truly meet the practical needs of the elderly in sitting and standing balance, while offering a comfortable, safe, and easy-to-use experience (Figure 35).

Figure 35 Sketching of Product Design

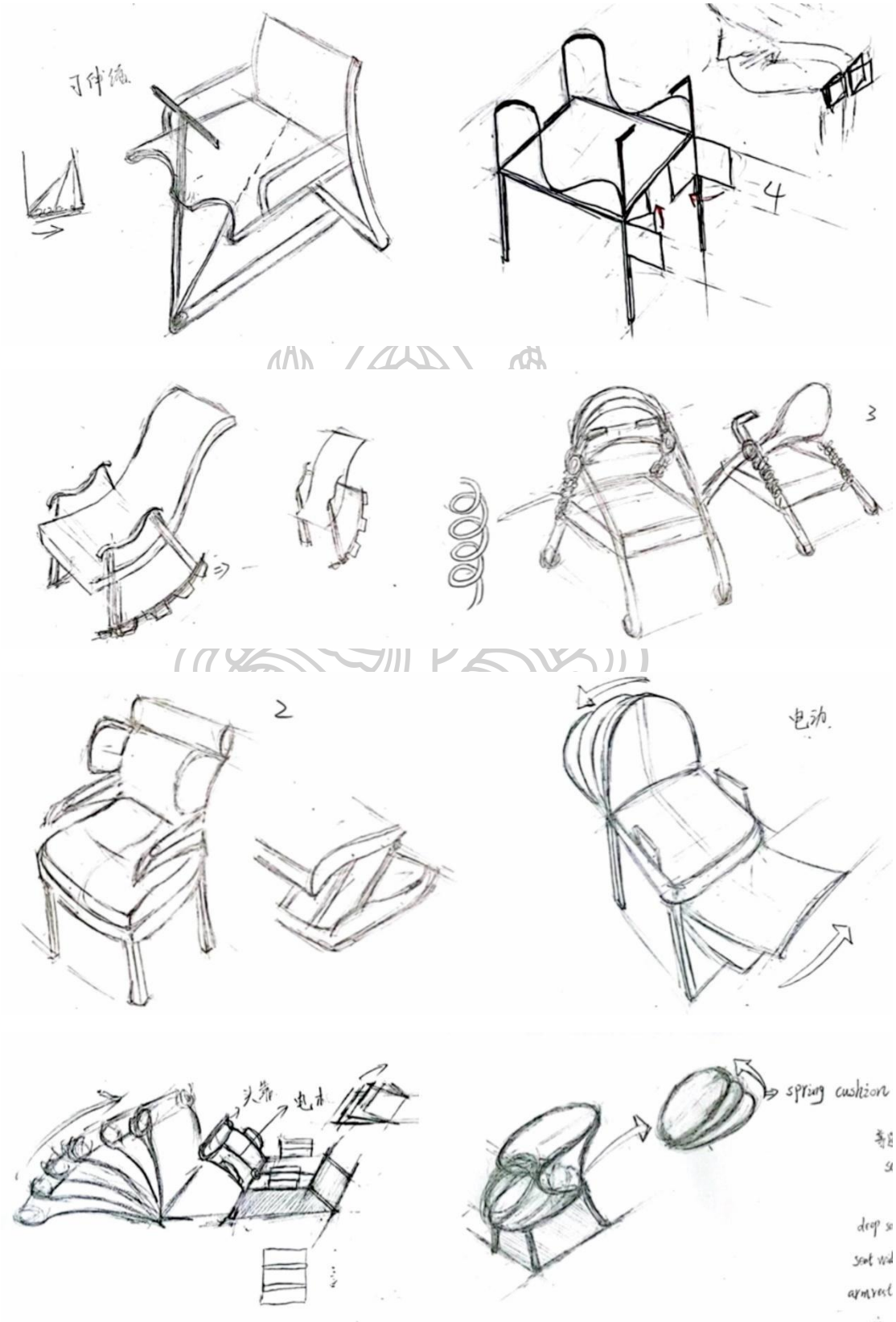


Figure 35-1 Sketching of Product Design

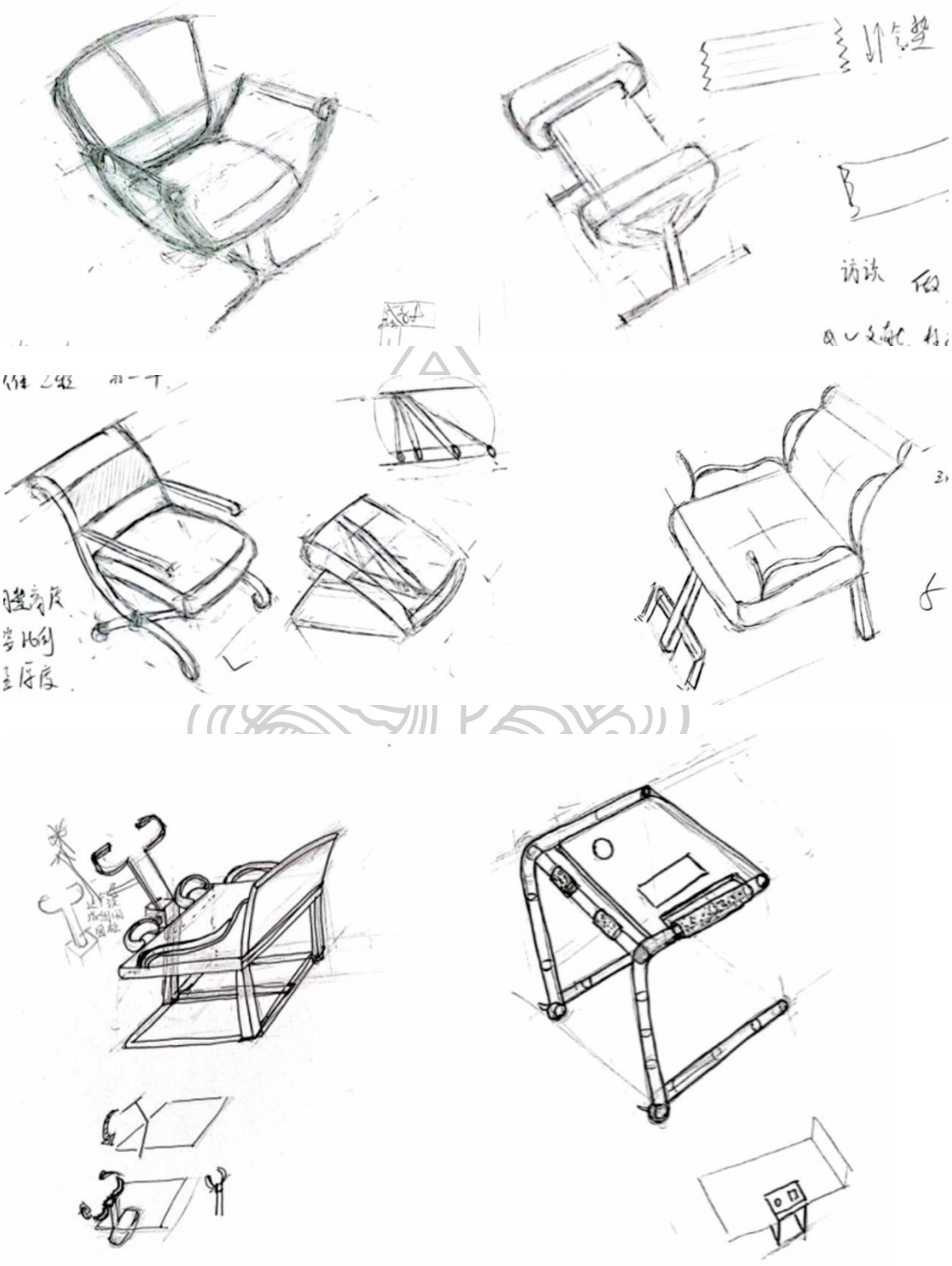


Figure 35-2 Sketching of Product Design

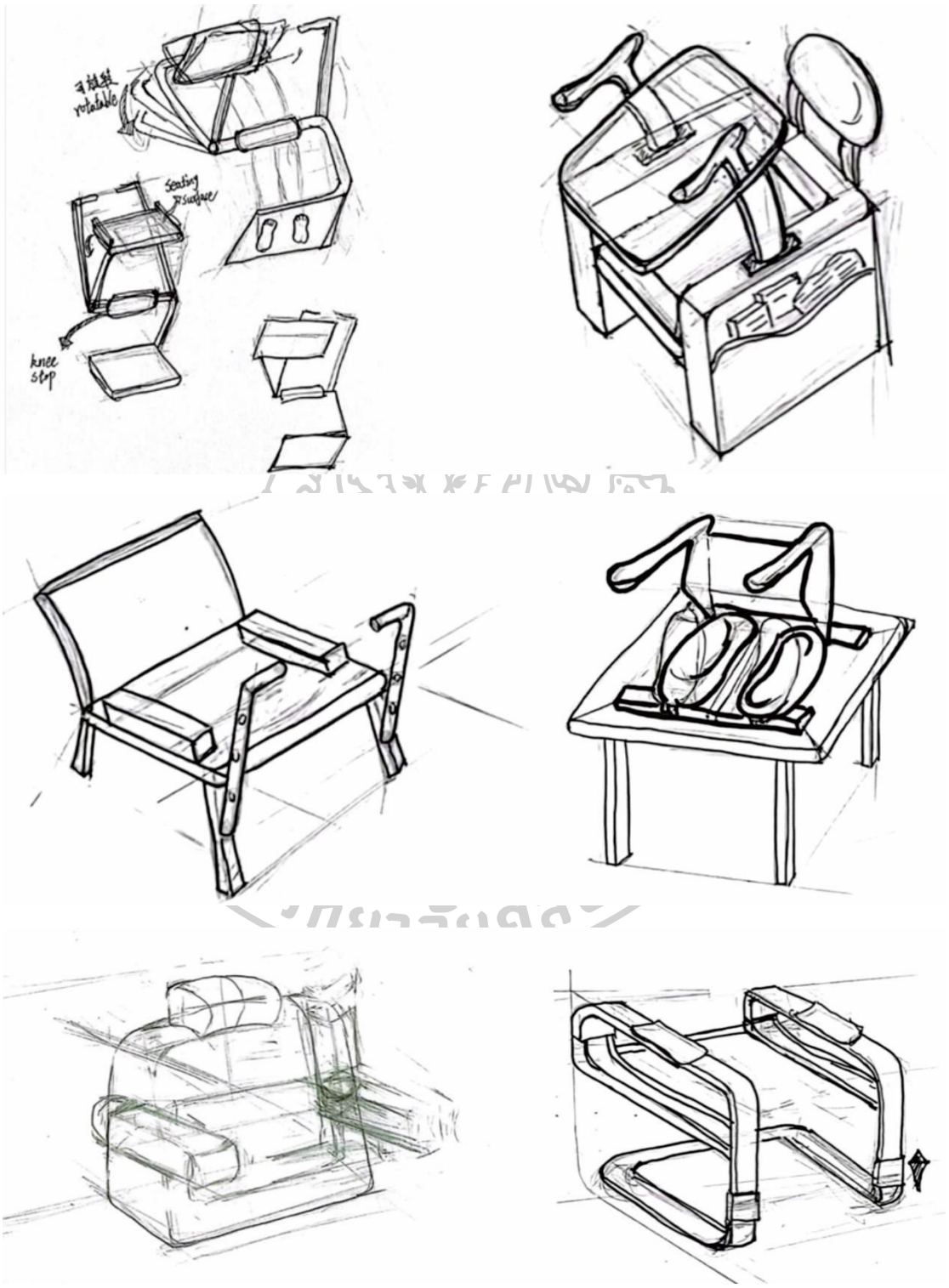


Figure 35-3 Sketching of Product Design

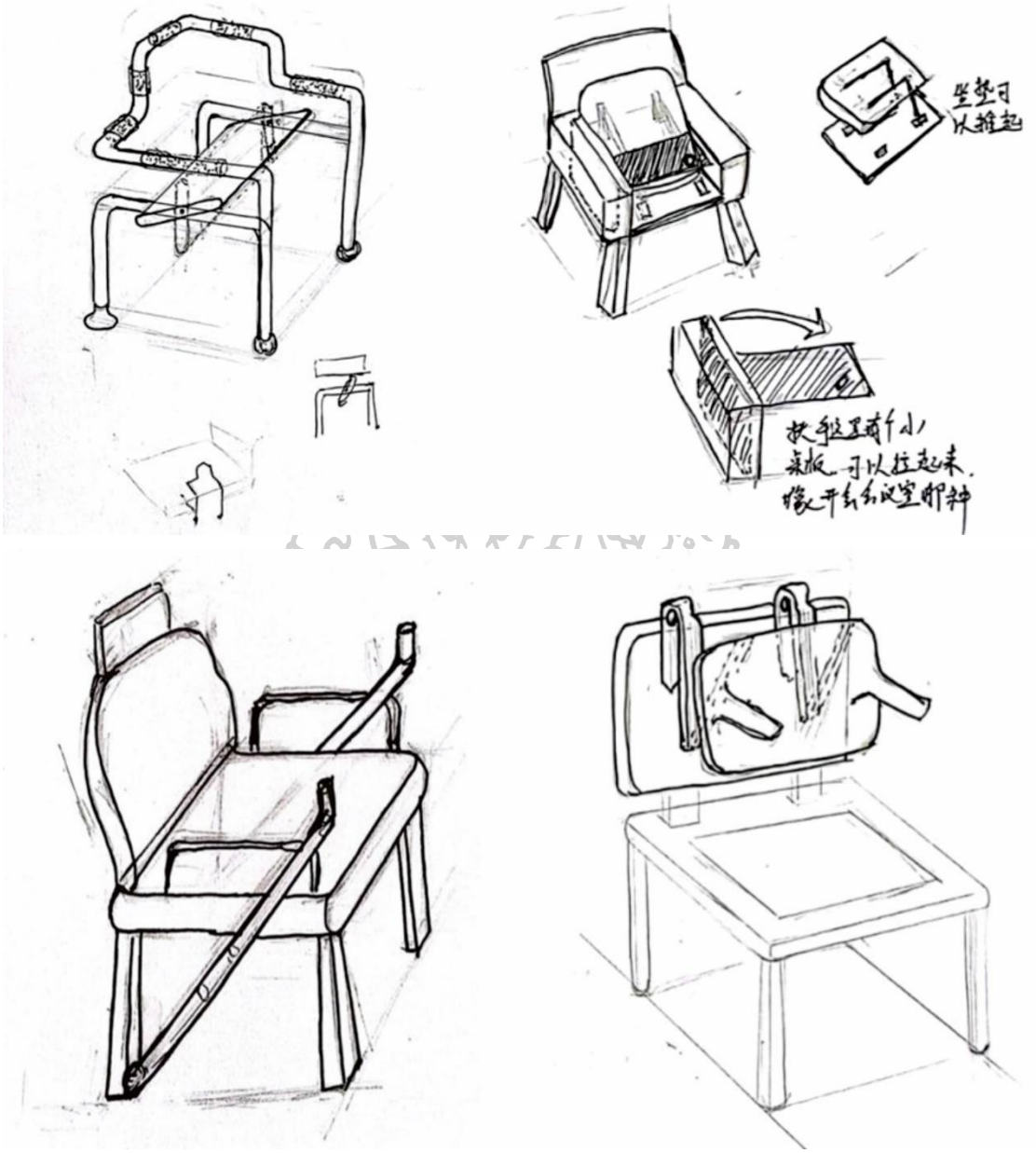
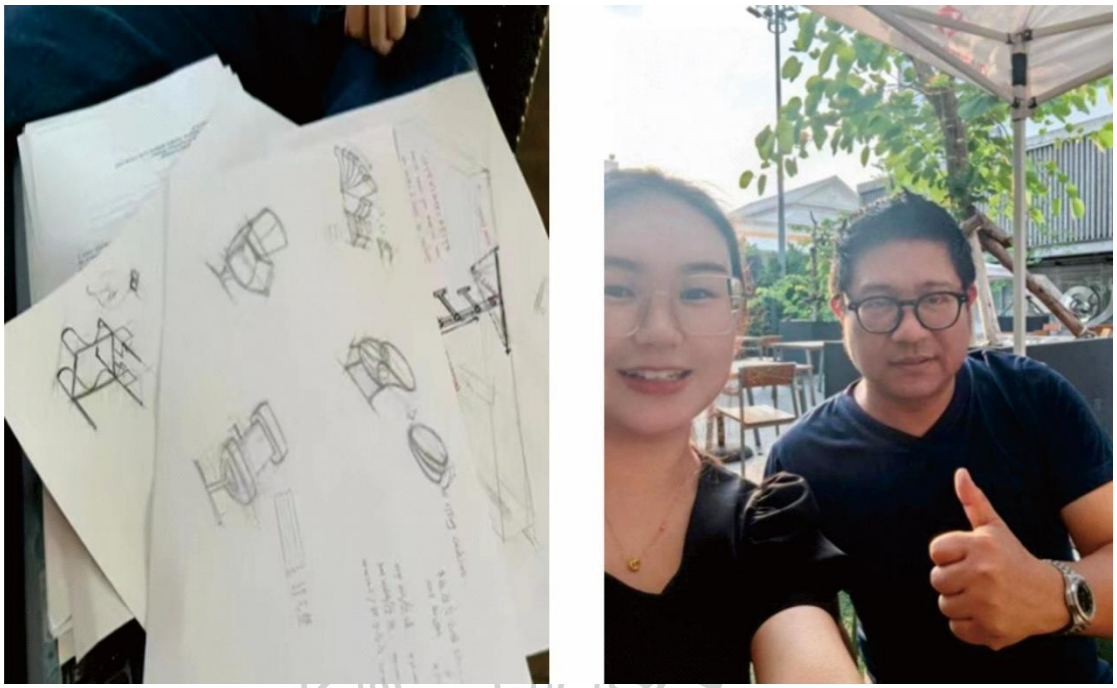


Figure 35-4 Sketching of Product Design



Note. Painted by the author

Following the completion of the sketches, the design phase proceeded to the meticulous detailing stage. The author, in collaboration with the advisor, refined the most promising sketch designs into detailed engineering plans. This entailed a comprehensive evaluation of various factors, including safety, cost, adjustability, comfort, portability, weight, user-friendliness, independent use, and versatility. A total of fifteen sketches were selected for further investigation, with the objective of identifying the most promising designs in terms of performance metrics. This involved a detailed examination of specific aspects, including materials, dimensions, functionality, and colour options, prior to commencing the three-dimensional modelling process (Figure 36).

Through analysis, the top 15 products selected for their highest scores and safety were models 1, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 16, 17, 23, and 24.

Figure 36 Evaluation of the Merits and Demerits of Different Sketch Proposals

Advanta / Product	High security	Cheap	Adjustable	comfort	Portable	Light and handy	Easy to operate	Independent use	versatility	Score
	√		√	√			√	√	√	6
		√			√	√	√	√	√	6
		√	√		√	√	√	√		6
	√		√	√			√	√	√	6
	√	√	√				√	√		5
	√		√	√		√	√	√	√	6
	√		√		√	√	√	√		6
	√			√	√					3
	√	√		√	√	√	√	√	√	8
	√	√		√			√	√	√	6
	√	√				√	√	√		5
	√		√		√	√	√	√		6
	√	√		√		√	√	√		6
		√	√		√	√	√	√		6
		√		√		√	√	√		5
	√	√	√	√			√	√		6
	√			√		√	√	√		5
							√	√		2
	√			√			√	√		4
	√			√		√	√	√		5
	√		√	√			√	√		5
		√				√	√	√		4
	√		√	√		√	√	√		6
	√	√		√		√	√	√		6

Note. Compiled and analyzed by the researcher.

4.5 3D MODEL DESIGN AND SELECTION

The creation of three-dimensional (3D) models represents a pivotal stage in the design of consumer products. These models serve to transform conceptual designs into visual and interactive digital representations, thereby providing precise guidance for subsequent prototype production and product development. Following the initial sketch design phase, the author employed the professional 3D modelling software Rhino to commence the construction of the 3D models of the assistive products, based on the selected design proposals. This involved the detailed geometric modelling of design elements from the sketches, including various components, connections, and technical structures of the devices. The initial objective was to accurately create the geometric shapes of each part, ensuring that dimensions and proportions conformed to the design specifications (Figure 37).

Subsequently, by applying appropriate material properties and textures, the visual and functional characteristics of the models were further refined. These characteristics included surface finishes, colours, materials, and technical elements of the products. In the 3D models, particular attention was given to the dynamic features of the products, such as the lifting mechanism of the seat cushions, the folding function of the tabletops, and the disassembly technology of the walking sticks. In the

later stages of 3D modelling, rendering techniques were used to generate realistic visual effects, serving not only to showcase the final appearance of the design but also to facilitate communication of design intent with non-professional stakeholders. The completion of the 3D models marked the transition from the conceptual stage to prototype production and testing. Through 3D modelling, the author was able to comprehensively verify the design's functionality, form, and user experience, laying a solid foundation for developing practical assistive products that meet the needs of the elderly.

Figure 37 3D Model Rendering

Figure 37-1 3D Model Rendering

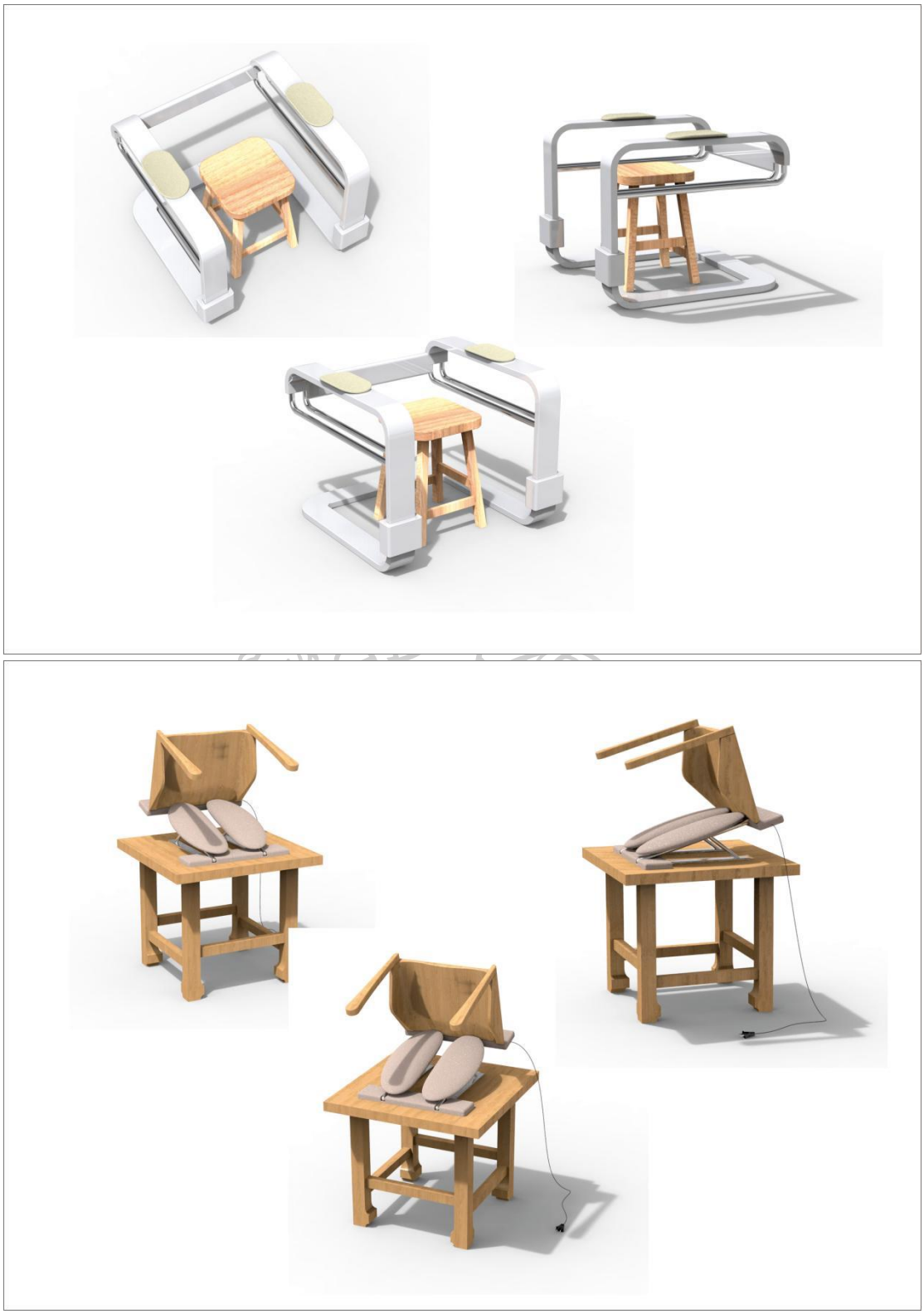


Figure 37-2 3D Model Rendering

Figure 37-3 3D Model Rendering

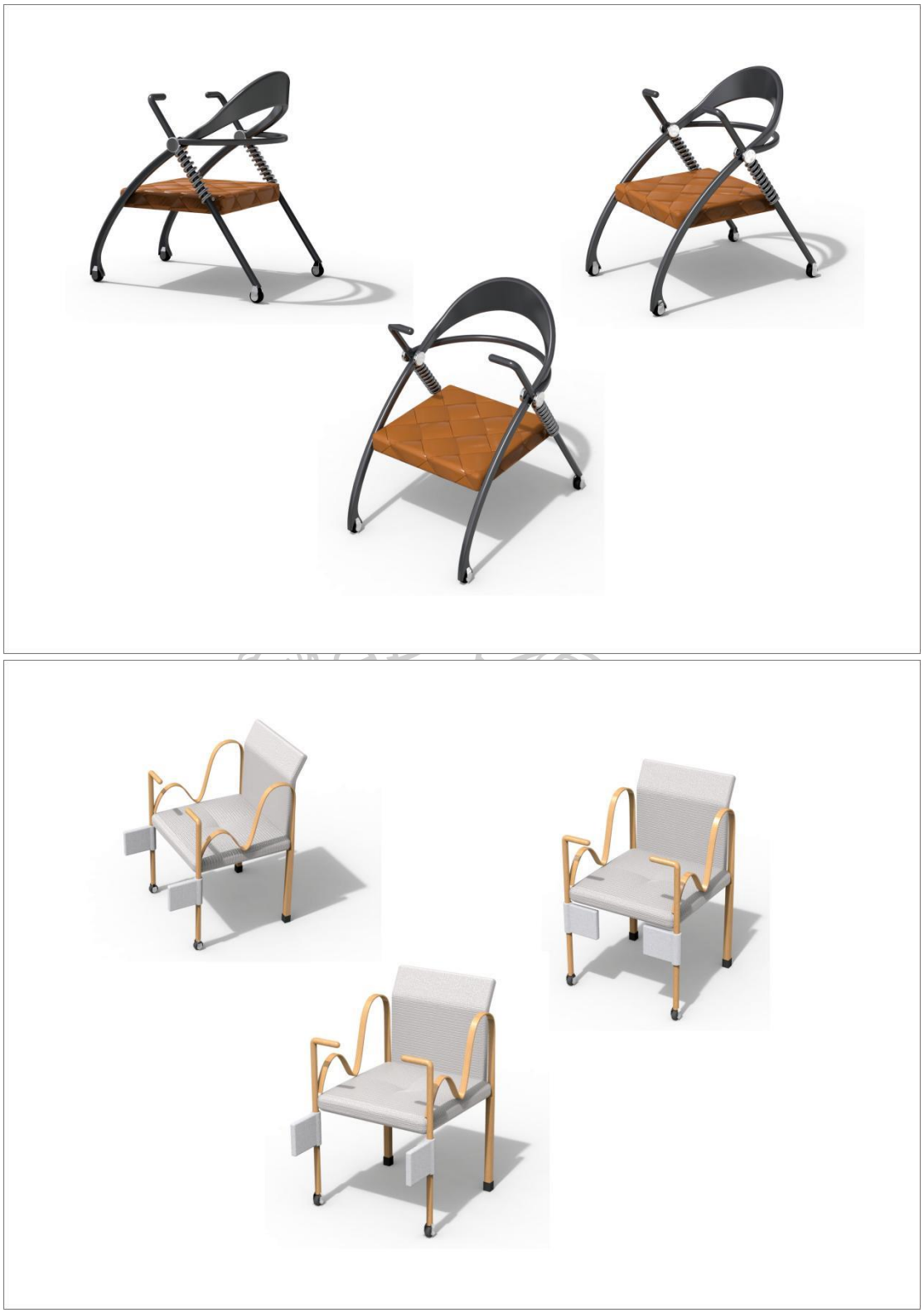
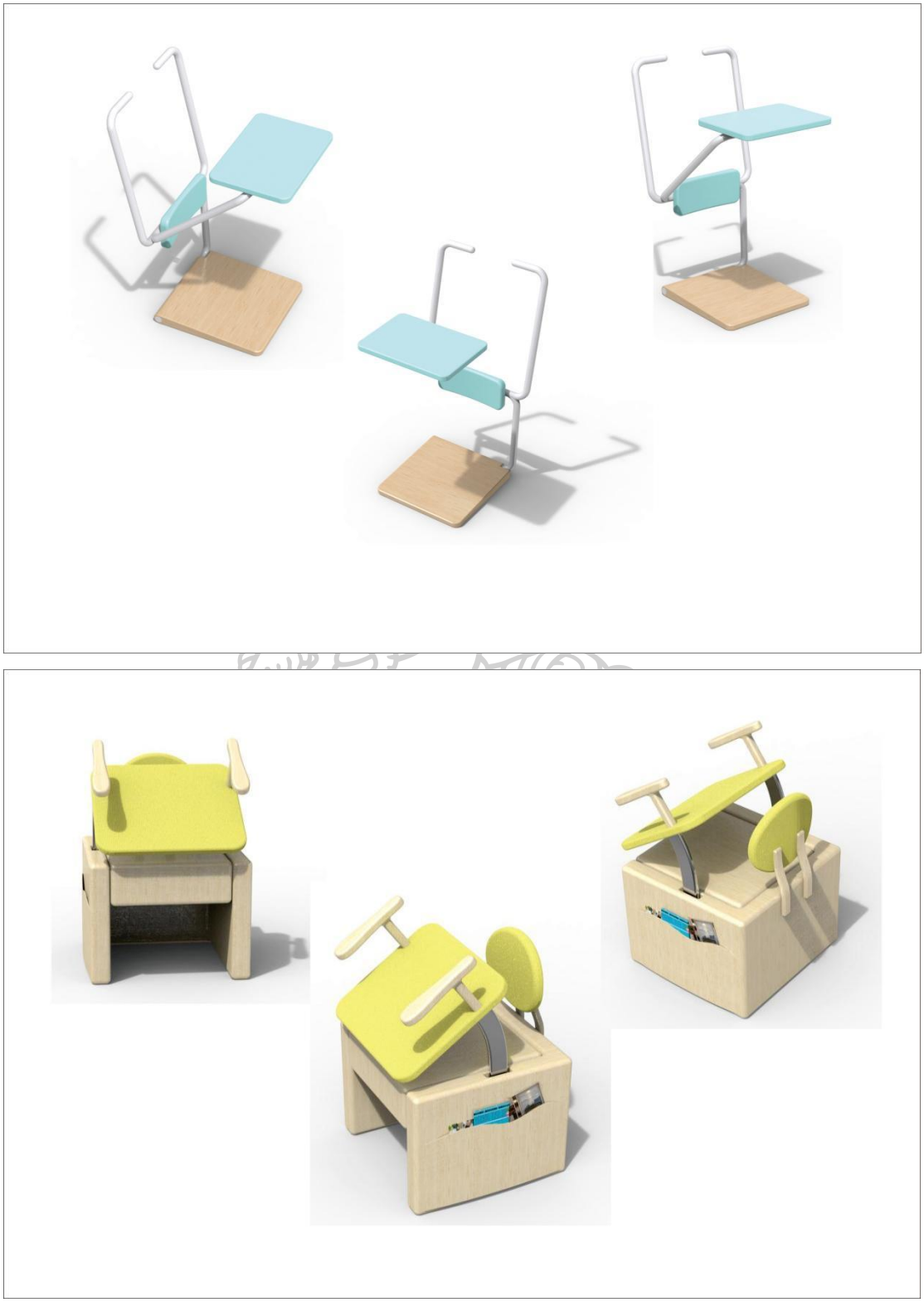


Figure 37-4 3D Model Rendering

Figure 37-5 3D Model Rendering

Figure 37-6 3D Model Rendering



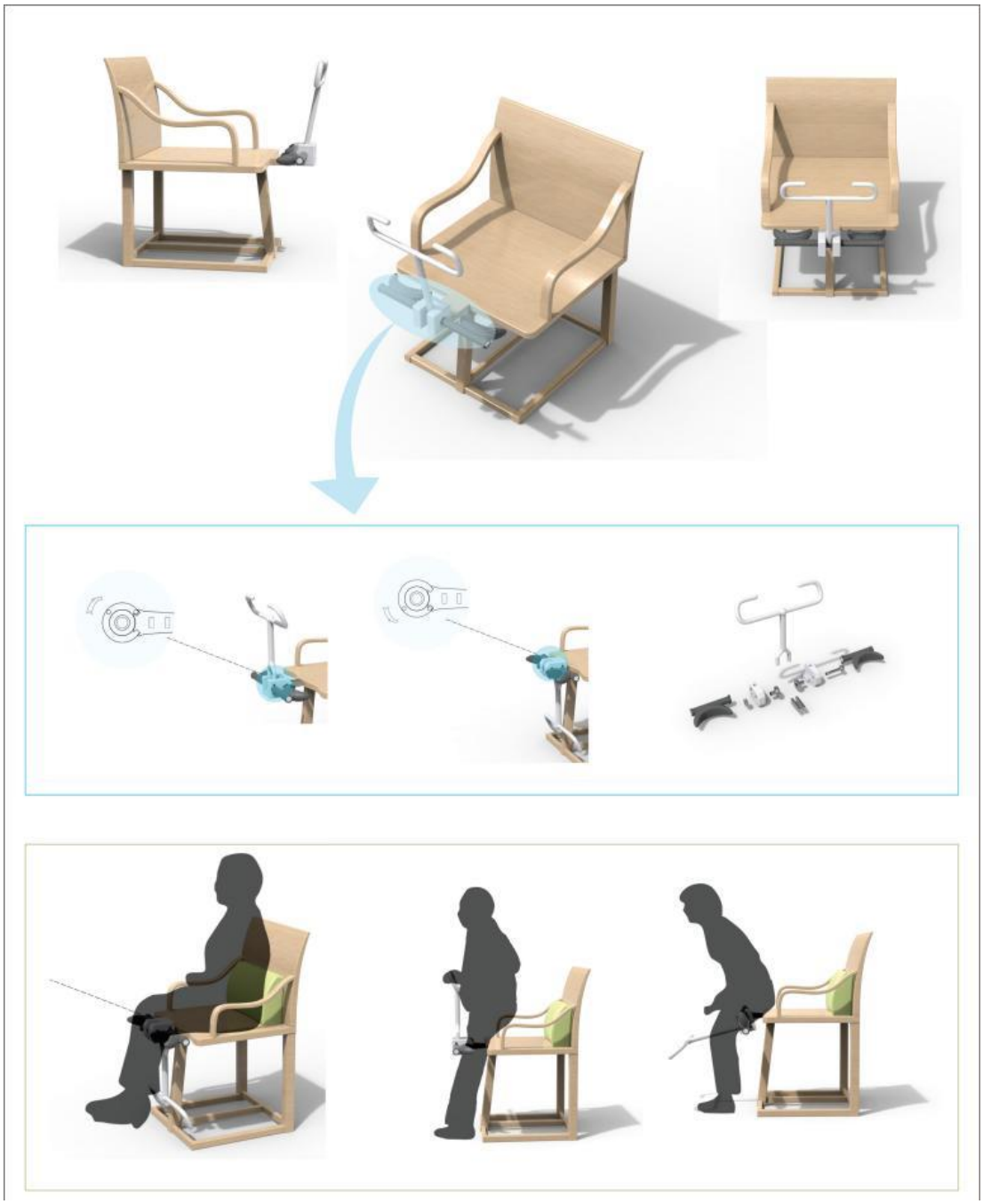
Note. Painted by the author

Upon completion of the 3D modelling phase, comprehensive evaluations were conducted on 13 models in collaboration with the Advisor. The evaluation criteria were designed to cover several key dimensions, including safety, cost-effectiveness, adjustability, comfort, portability, lightweight design, ease of operation, independent usability, and versatility. Through a rigorous selection process and in-depth discussions, eight outstanding design proposals were ultimately identified. These selected designs demonstrated significant advantages across multiple evaluation dimensions, reflecting high practicality and innovation. Subsequently, the eight designs were subjected to further refinement and optimisation in order to ensure that they met the actual needs of the elderly, while also performing optimally and providing an excellent user experience in practical applications.

This process not only strengthened the practical feasibility of the design proposals but also laid a solid foundation for subsequent product development and market promotion. Through this systematic evaluation and optimisation process, the researcher ensured that the final product's quality and functionality would meet or exceed expectations, providing strong technical support for enhancing the quality of life for the elderly. A detailed explanation of each design will be provided in a subsequent section.

Design Description for the First Model: Research revealed that most elderly individuals struggle to stand up due to insufficient leg strength. This product has been specifically designed for this group, featuring an additional armrest and a knee-locking groove in front of the chair. The user can stand up by securing the knees and pulling on the armrest. After standing, releasing the armrest allows it to retract slowly and automatically under the chair. This design leverages arm strength, making it particularly suitable for elderly individuals with weak legs (Figure 38).

Figure 38 3D Model of the First Design



Note. Painted by the author

A description of the design of the second model is provided below. This is a multifunctional aid designed to assist the elderly in activities such as getting up from bed, walking, and resting while seated. A review of existing products designed to assist the elderly revealed that current bed-rise aids are limited to various types of bedside handrails that require the user to turn on their side and use the elbow joint of the other hand to pull themselves up. This design effectively addresses the issue of

rising from a lying position by enabling the elderly to do so in a manner that ensures better balance and safety. Additionally, the device is lightweight and includes adjustable features to accommodate beds of varying heights (Figure 39).

Figure 39 3D Model of the Second Design

Note. Painted by the author

The third model of the assistive device employs electric hydraulic lifting technology, a mechanical motion that utilises a hydraulic system for raising and lowering objects. The device is constructed mainly from natural materials, such as wood, in order to provide a warmer appearance which is favoured by the elderly. The structure is designed to be square-shaped in order to enhance safety (Figure 40).

Figure 40 3D Model of the Third Design

Note. Painted by the author

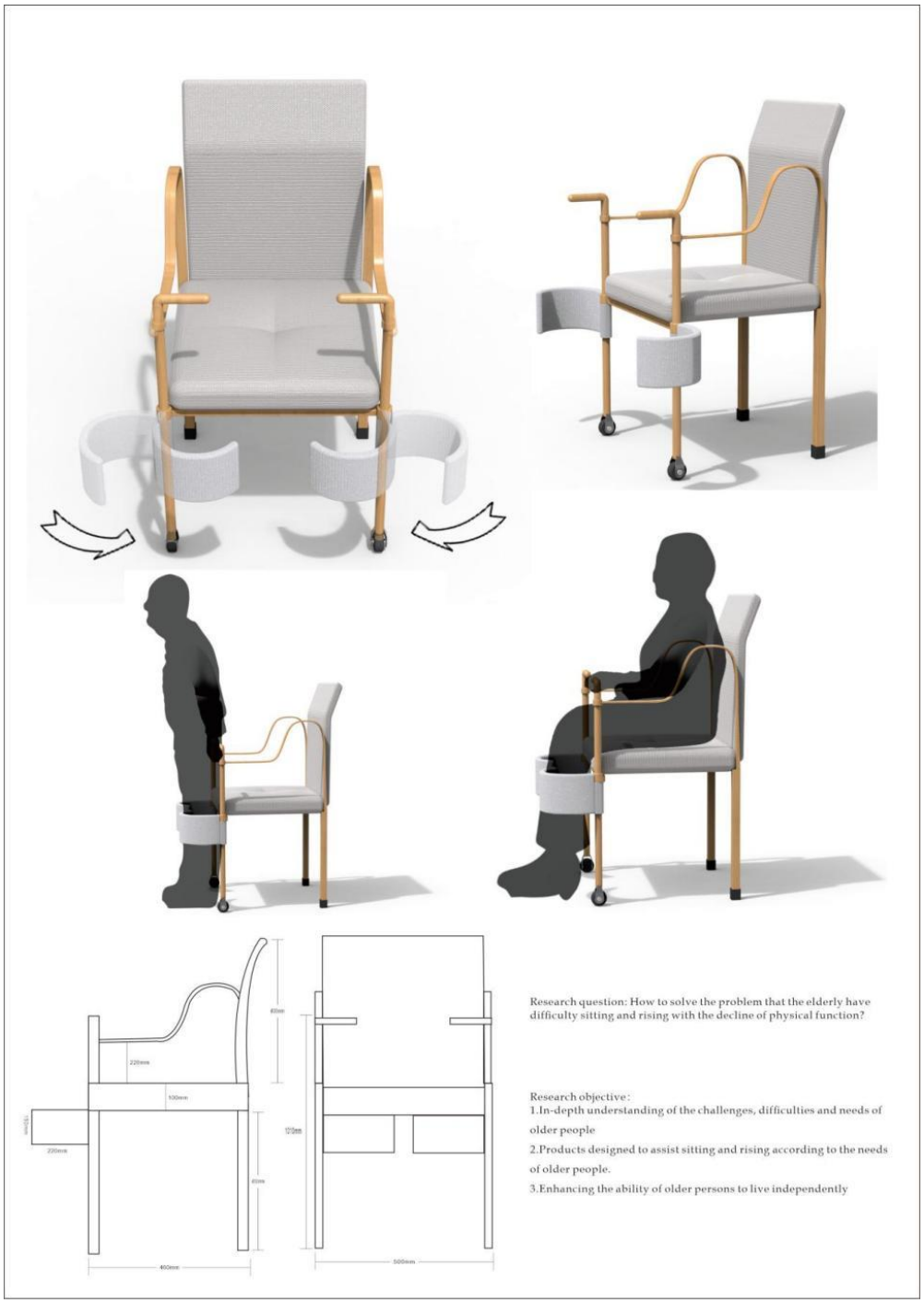
Design Description for the Fourth Model: This product incorporates hydraulic lifting and sensor technologies, not relying on electric power. When the elderly attempt to stand up by slightly lifting their hips, the hydraulic system detects this force, prompting the hydraulic pump to push oil into the cylinder, causing the piston rod to elevate the seat cushion. Additionally, its design features strong enclosure for increased safety and includes a small table for added functionality. The materials chosen are soft fabric and natural wood (Figure 41).

Figure 41 3D Model of the Fourth Design

Note. Painted by the author

Design Description for the Fifth Model: This product is tailored for elderly individuals with weak leg muscles. When the user intends to stand, the knee guard wraps around the knees, and with the aid of the handrails and arm strength, the user is assisted to a standing position. Additionally, two wheels are incorporated to facilitate walking, allowing for easy maneuvering of the product. (Figure 42)

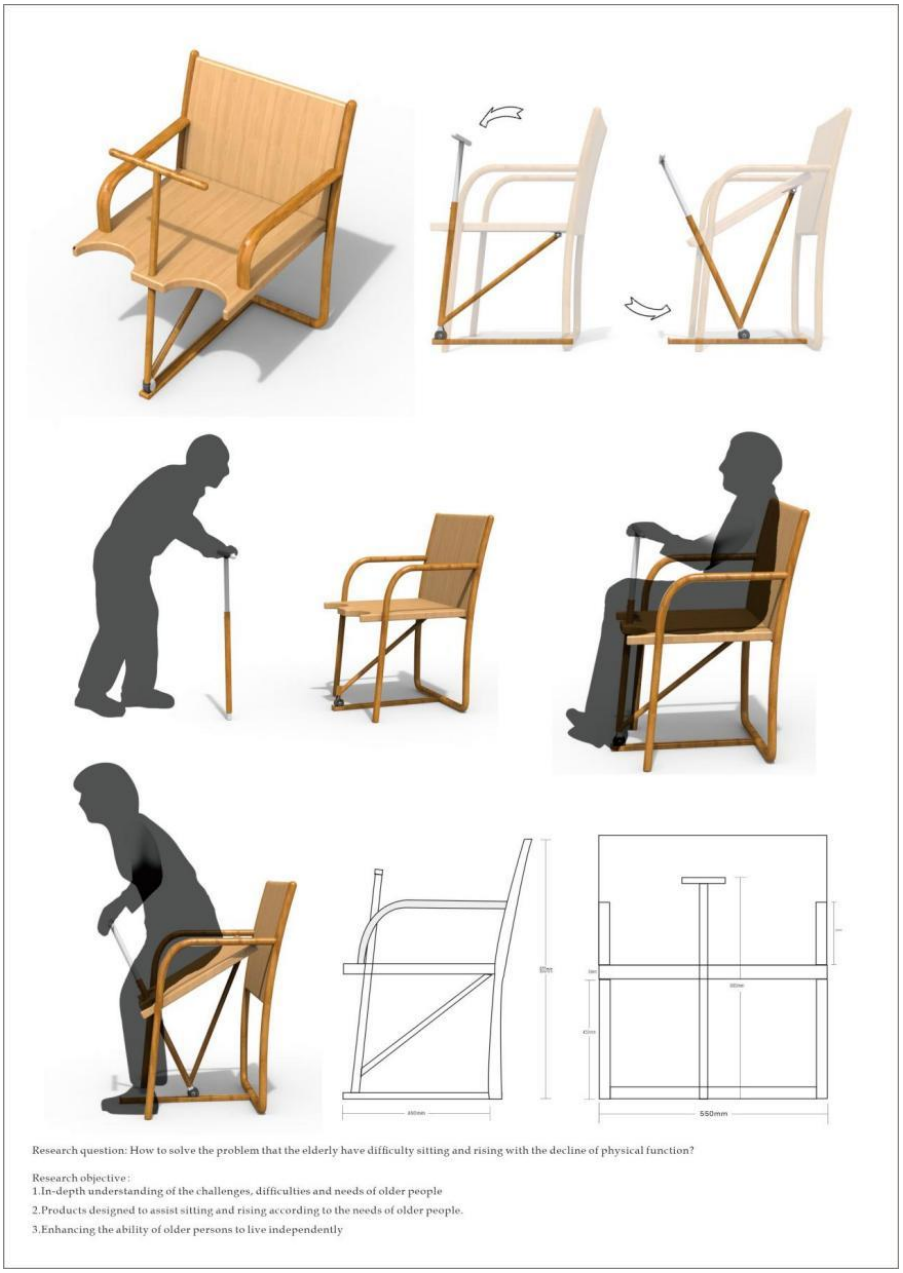
Figure 42 3D Model of the Fifth Design



Note. Painted by the author

A design description for the sixth model is provided below. It should be noted that, in addition to assisting users in standing, the product also provides support while walking. This is achieved through the inclusion of detachable handrails that can be used as canes. The design draws inspiration from a fitness equipment structure known as the "Health Rider," which incorporates slide rail technology. As the user pushes on the handrails, the wheels begin to move, and the connecting rods push the seat upward, aiding in standing. Once the user has stood, the handrails can be detached and used as canes. The primary material used is wood (Figure 43).

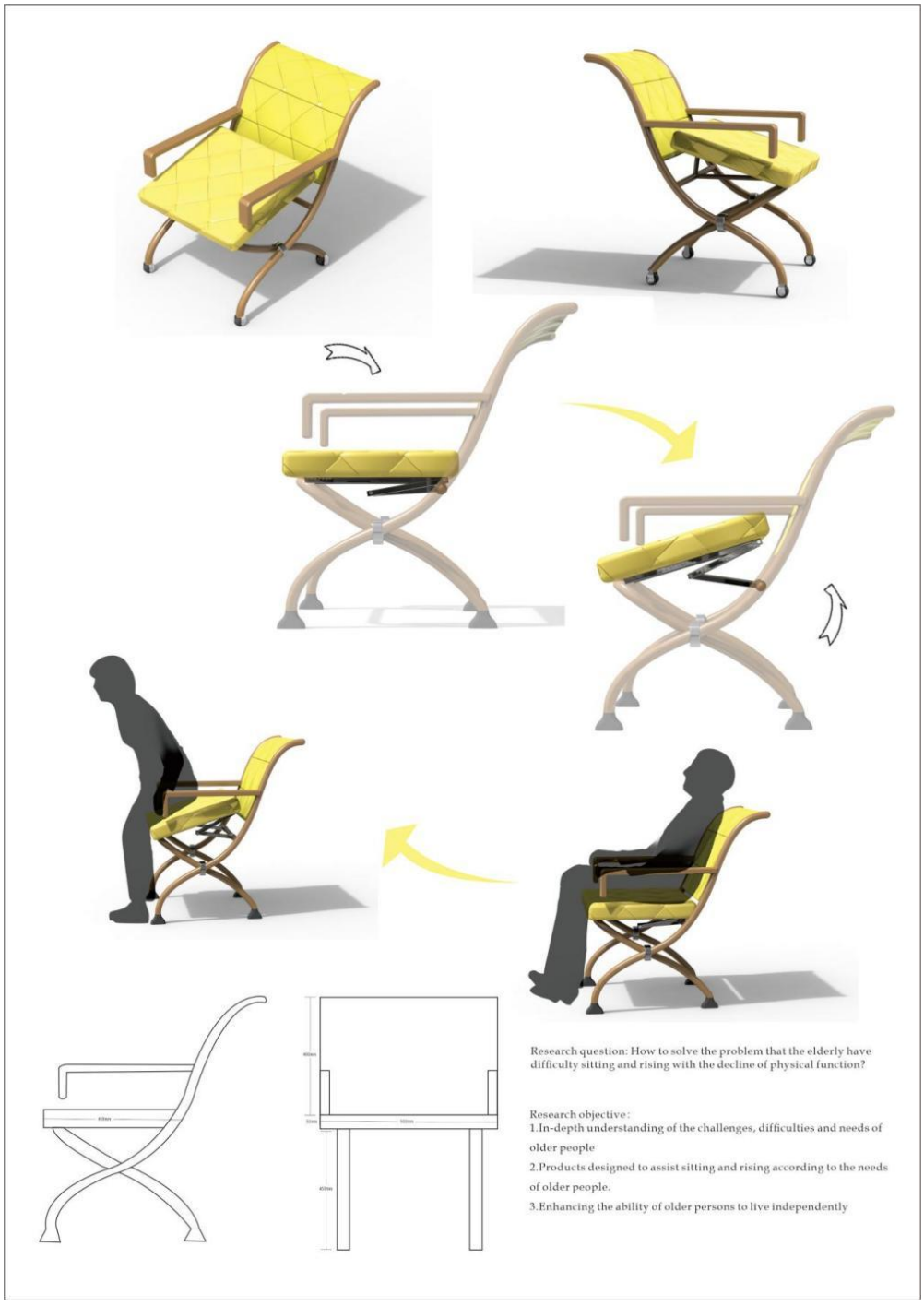
Figure 43 3D Model of the Sixth Design



Note. Painted by the author

Design Description for the Seventh Model: This model also employs hydraulic lift technology and is constructed with a durable stainless steel frame and a leather cushioned seat. The backrest is ergonomically designed with a curvature to fit the human body (Figure 44).

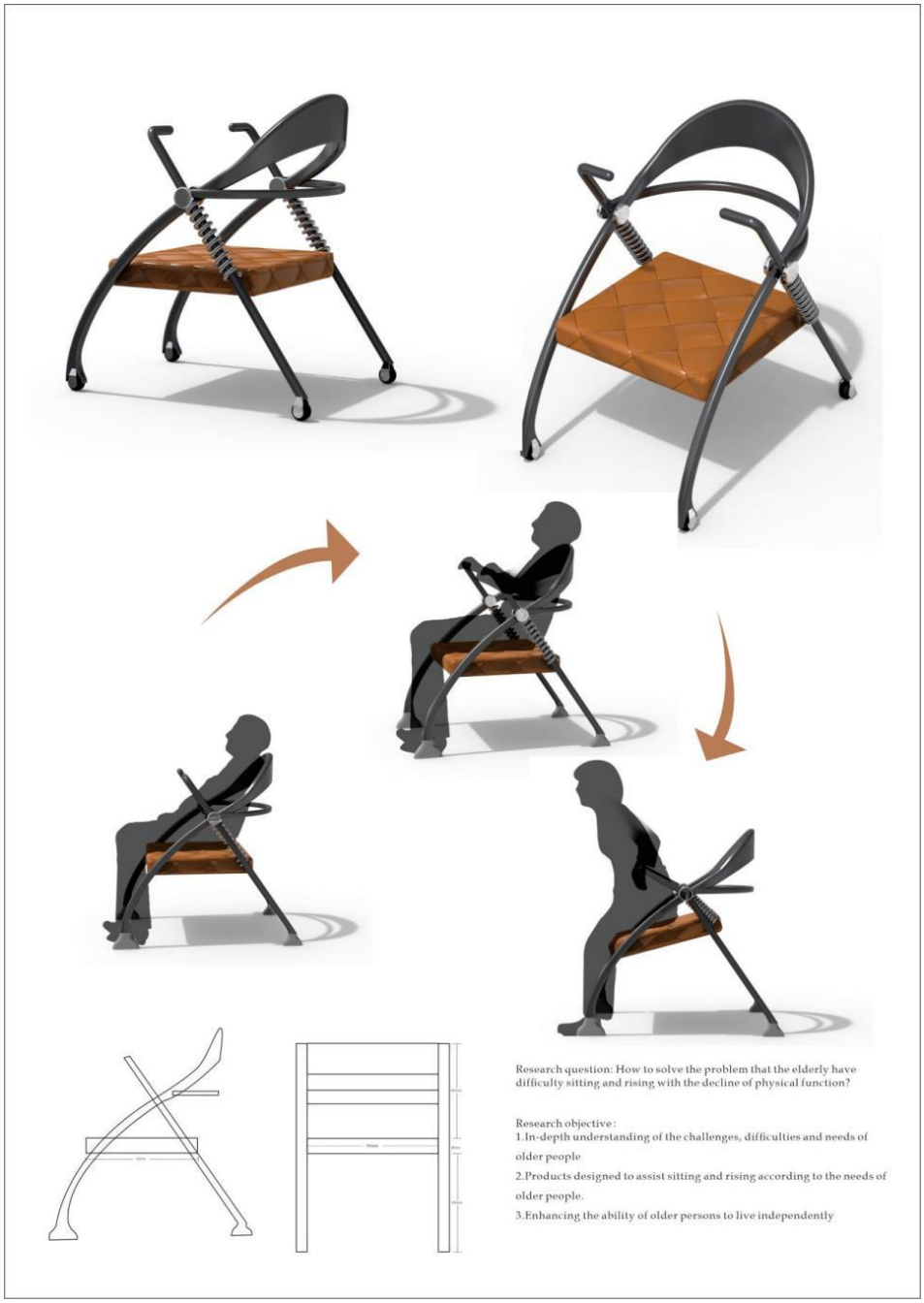
Figure 44 3D Model of the Seventh Design



Note. Painted by the author

The eighth model is designed to utilise spring tension in order to assist the user in maintaining an upright position. The seat base is connected to the spring mechanism, and when pressure is applied to the handrails, the spring tension raises the seat. After standing, releasing the handrails allows the spring to reset, lowering the seat. The frame is constructed from stainless steel, with a leather-cushioned seat and an ergonomically curved backrest (Figure 45).

Figure 45 3D Model of the Eighth Design

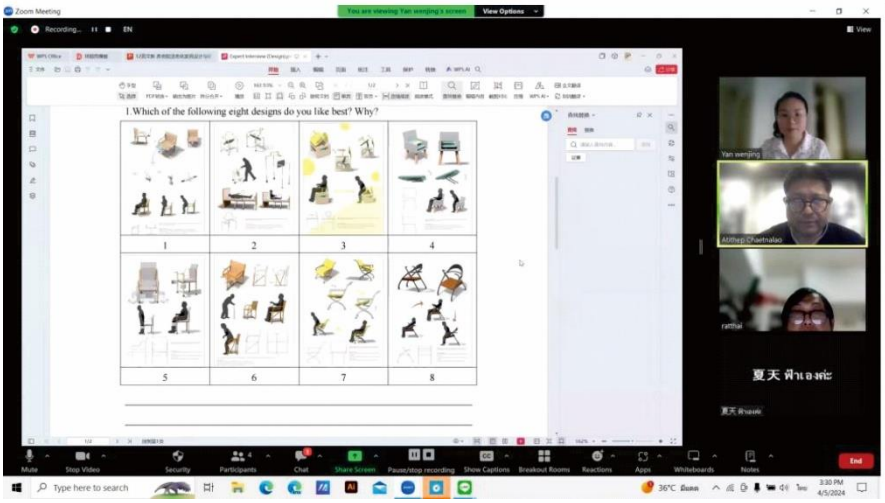


Note. Painted by the author

Following the completion of the in-depth modelling work, this study invited three domain experts to participate in a detailed review of the eight product proposals. One expert participated in the review through offline communication, while the other two joined the discussion online, ensuring the breadth and diversity of the review process (Figure 46, please refer to (4) (5) (6) letters in Appendix 1 for detailed expert invitation letters).

During the review, the experts conducted in-depth analysis and discussion on each product proposal from various dimensions, including but not limited to technical feasibility and user experience. The expert review at this stage played a crucial role in identifying potential issues in the proposals, enhancing the targeted design objectives, and optimising the products. Furthermore, the feedback and suggestions provided by the experts offered valuable third-party perspectives, which served to guide the refinement and improvement of the product proposals and to establish a solid foundation for the successful development and deployment of the final products.

Figure 46 Online and Offline Interviews with Three Experts



Note. Photographed by the researcher.

Following comprehensive interviews with three domain experts, a meticulous and systematic analysis and summary of their opinions was conducted, leading to further refinement and detailed revisions of the proposals. After a thorough review of the provided 3D model diagrams, the experts conducted a comprehensive system evaluation for each product, offering professional feedback (Table 3). The experts acknowledged the comprehensiveness and innovation in certain model designs and noted that the diagrams clearly displayed the structural layout and usage of assistive devices, providing an intuitive and easy-to-understand operational guide for elderly users.

The experts paid particular attention to the application of ergonomics. They highlighted that while ensuring visual friendliness, the design must also adapt to the physiological characteristics and movement requirements of the elderly in practice. This user experience-focused design philosophy ensures the practicality and comfort of the device, while also enhancing the overall quality and market competitiveness of the product.

Table 3 Summary of expert advice

Product	Expert1	Expert2	Expert3
		When the handrail part is closed, you need to bend over, and it will be dizzy, which is not very good for the elderly.	
	1.Teachers like it best. 2.Adjustable part spacing 5cm. 3.Add a cushion to increase the function of "sitting". 4.Strengthen the adjustable position because the bed is different in height 5.Enhance security	1.Does not fit the theme (helps function). 2. More diversity Tip1:Put 3 wheels (like airport luggage cart technology). Tip2:Press the wheel to go, lock the wheel when you let go. Tip3:You can sit directly without going around the other side of the product.	1.Safety of wheels 2.The price is relatively affordable

		1. Teachers like it best 2. The safest and most stable 3. Do not need to use machinery, can be replaced by elastic power	
	Afraid of not having enough or too much power	1. This stretch booster can be used for other chairs 2. Low cost	The storage problem of small table
	Low security		
			1. Experts like it best, because most elderly people who need help standing up also need help walking. 2. Tip: Pull your crutches back instead of forward when you get up.

	Unsteady	It's unstable on wheels	
		Spring unsafe	
Remark	Option 2-1-4	If you need electronic technology, you need to design more in-depth, the teacher suggested not to use electronic technology	Option 6-2-4

Note. Compiled and analyzed by the researcher.

For example, Expert 1 highly praised the second design, considering it to have significant development potential and research value, and listed it among their favourite products. However, Expert 1 noted that the fourth product might lack in strength performance, while the fifth and seventh designs had safety flaws. Based on these assessments, Expert 1 recommended further refinement of the first, second, and fourth designs.

Expert 2 expressed concerns regarding the safety of the first product, particularly in relation to potential dizziness issues for elderly users during operation after standing up. With regard to the second product, Expert 2 considered it to be the most multifunctional, but suggested improvements to the emergency braking function of the wheels, the addition of a braking system, and the optimisation of the seat adjustment mechanism. Expert 2 particularly favoured the third design due to its excellent stability and recommended the replacement of the electric hydraulic technology with a spring-assisted system. Furthermore, Expert 2 identified potential in the hydraulic lifting technology of the fourth design, but identified safety concerns

in the wheel and spring designs of the seventh and eighth products. Ultimately, Expert 2 selected the second, third, seventh, and eighth designs for further improvement.

Expert 3 expressed some concerns about the wheel safety of the second design but found it more cost-effective. Expert 3 most appreciated the sixth design, which comprehensively considered assistive functions for standing and walking, meeting the practical needs of many elderly individuals. However, Expert 3 also pointed out issues with the push-pull structure of the sixth design, suggesting adjustments to the force direction to eliminate safety hazards. Ultimately, Expert 3 recommended improvements to the second, fourth, and sixth designs.

The integration of the opinions of all three experts has revealed that each design possesses distinctive strengths and areas for improvement. The valuable insights from the experts have been fully incorporated into the product design, providing crucial guidance and decision support for subsequent development. This process has significantly enhanced the maturity of the design proposals and ensured that the final products meet the actual needs and expectations of the target user group (Figure 47).

Figure 47 Comparative Analysis of Strengths and Weaknesses for Eight Products

advanta / product	High security	cheap	adjustable	comfort	portable	Light and handy	Easy to operate	Independent use	versatility
	√	√		√		√	√	√	
	√	√	√	√	√	√	√	√	√
	√			√			√	√	√
	√	√		√		√	√	√	√
		√				√	√	√	
	√	√	√	√	√	√	√	√	√
	√	√		√		√	√	√	
	√	√		√		√	√	√	

Note. Compiled and analyzed by the researcher.

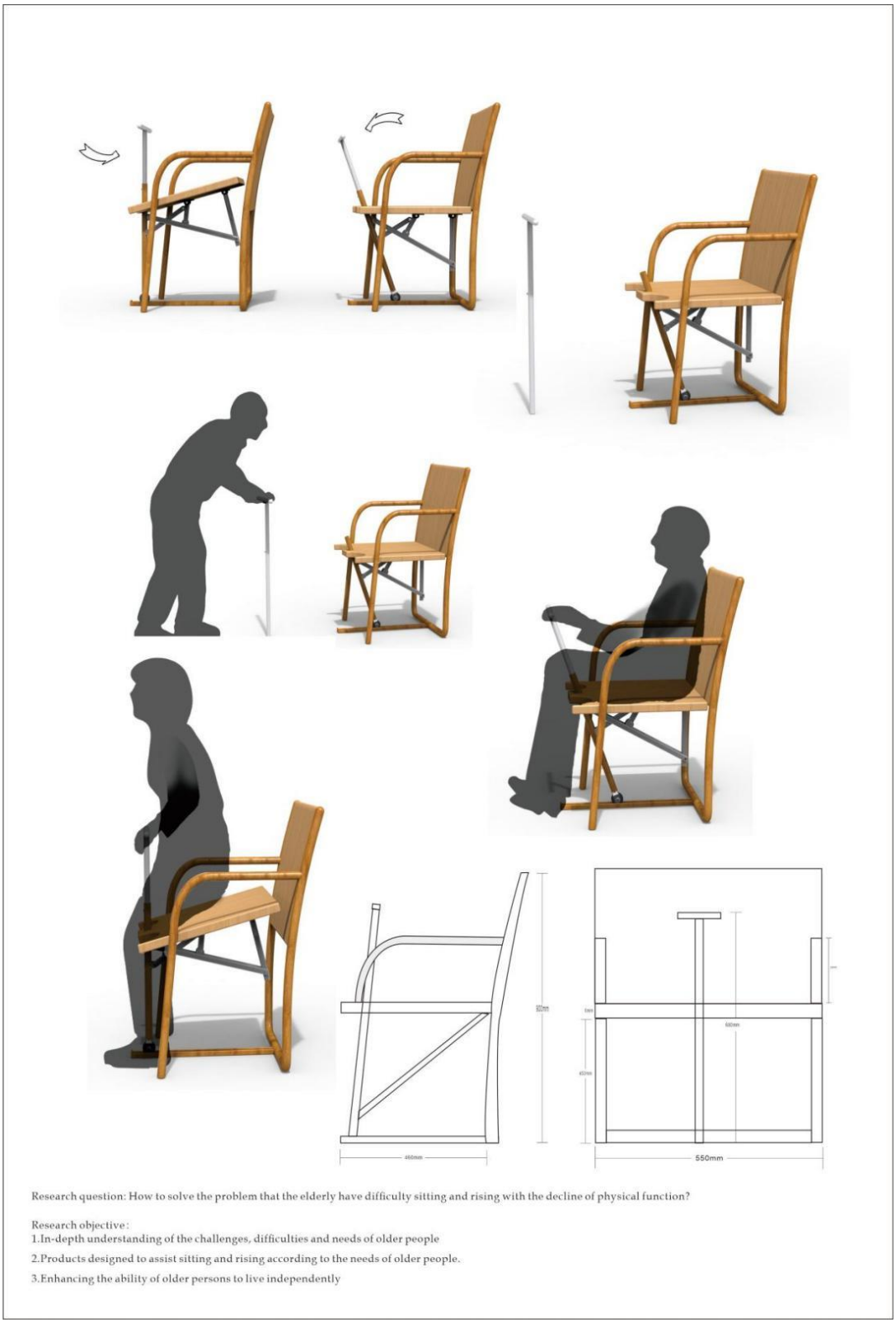
Furthermore, in accordance with the recommendations of the experts, I have replaced the electric hydraulic system in the third product with a non-electric hydraulic spring technology. Additionally, following the advice of Expert 3, I have improved the push-pull direction of the sixth product, changing it from a push-out to a

pull-back mechanism, adopting a structure similar to a rowing machine, which effectively assists with the standing-up function (Figure 48 & 49).

Figure 48 Non-Electric Hydraulic Assist Chair

Note. Painted by the author

Figure 49 Multifunctional Assist Chair with Cane



Note. Painted by the author

4.5 PRODUCT MANUFACTURING PROCESS

During the initial preparation phase of product manufacturing, I collaborated with factory designers for an in-depth discussion on the product structure (Figure 50 & 51). A key issue identified was that the existing design had only two load-bearing points on the seat, which did not meet the basic requirements of structural mechanics. Further analysis also revealed that the seat height exceeded the ergonomic sitting requirements for most elderly individuals.

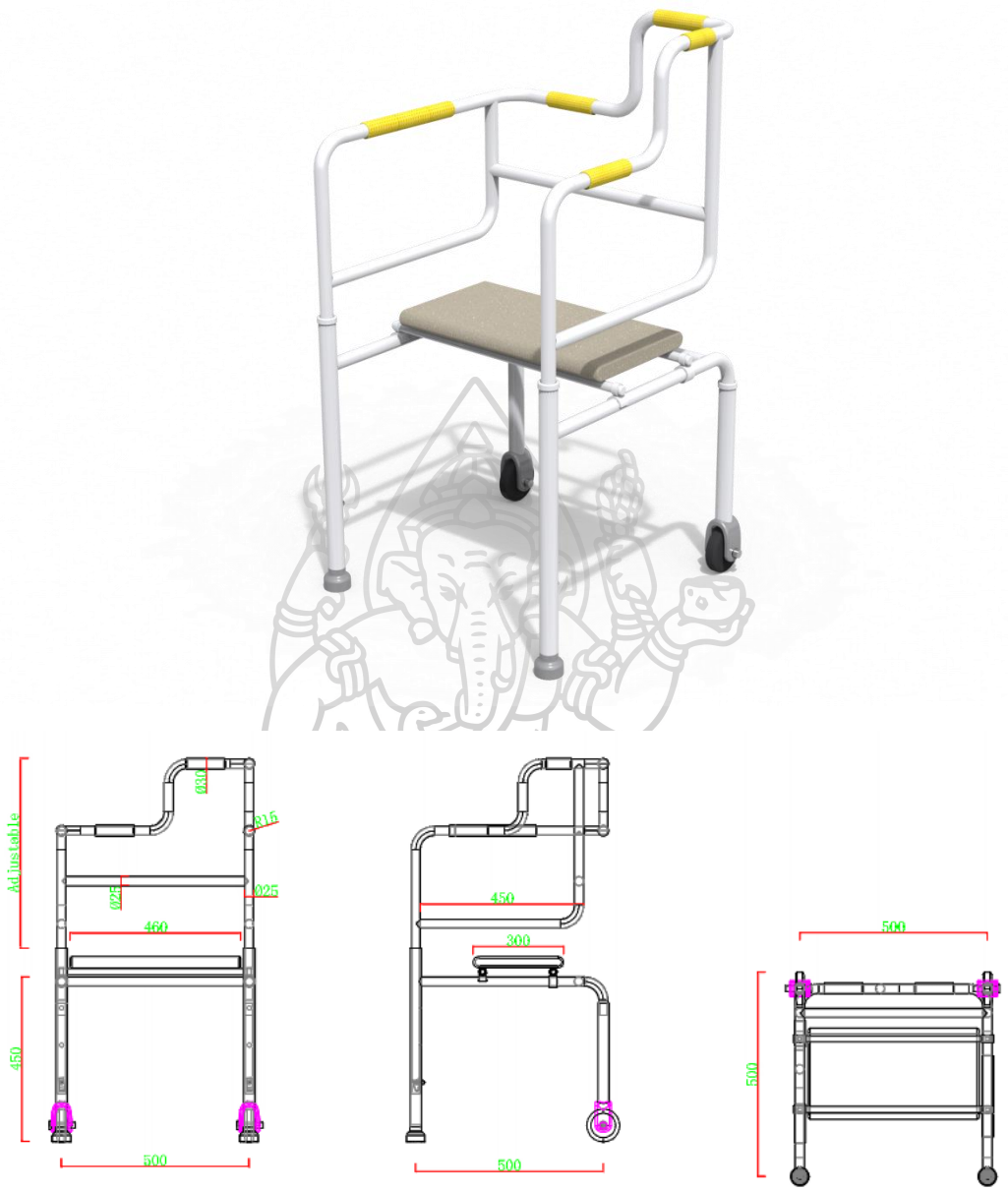
To address these issues, modifications were made to the design, lowering the seat structure and expanding from two to four load-bearing points to comply with engineering mechanics standards. In terms of dimensional adjustments, based on a detailed study on ergonomics presented in Chapter 2, the seat dimensions were set at a height of 430mm and a width of 500mm, with an overall maximum height of 1150mm. This height represents the maximum dimension of the product, while the overall height can be adjusted at 100mm intervals to accommodate beds ranging from a minimum height of 450mm to a maximum of 730mm.

This rigorous design modification process ensured that the product not only meets engineering requirements theoretically but also serves the target group—elderly individuals—better in practice, providing them with a safer, more comfortable, and ergonomically sound user experience.

Figure 50 Discussion with Factory Designers

Note. Photographed by the author

Figure 51 The latest design diagram



Note. Painted by the author

Once the product model and dimensions had been finalised, further research was conducted on the selection and application of materials. The most commonly used materials in the market for such devices are presented in Table 4.

(1) Stainless Steel: This material is renowned for its excellent corrosion resistance, strength, and ease of cleaning. It is therefore a popular choice for walkers, as it can withstand the rigours of daily use and damp conditions, ensuring a long lifespan.

(2) Aluminium Alloy: Due to its lightweight and robust nature, aluminium alloy is a commonly used material in walker manufacturing. Its use not only reduces the

weight of the walker for easy portability and operation, but also maintains sufficient stability and durability.

(3) Plastic and Nylon: These materials are often used for components like seats, backrests, and storage spaces in walkers. Lightweight, wrinkle-resistant, and abrasion-resistant, plastic and nylon can also bear a certain weight, providing a comfortable user experience.

(4) Iron and Steel: Although less prevalent than stainless steel and aluminium alloys, iron or steel may be employed in instances requiring enhanced stability and load-bearing capacity.

(5) Ultimately, stainless steel was selected for the principal structure due to its low cost, robust load-bearing capacity, and straightforward processing.

Table 4 Product Material Composition

Material	
	1.2mm stainless steel tube 1. The thickness of the pipe wall is not easy to deform, and it is more Use safety 2. Lightweight stainless steel, save effort and not tired 3. Stronger load-bearing capacity 4. Easy to process 5. Affordable
	Soft PVCgrip 1.Comfortable and durable 2.With non-slip texture

	Soft leather cushion 1. Waterproof, soft and comfortable 2. No tools are required for installation
	Non-slip foot mat 1.The bottom 3 rings are anti-slip 2.Built-in reinforced steel sheet, more wear-resistant
	Wheel Rubber wheels have good elasticity and grip, can provide good stability and cushioning effect, suitable for a variety of ground.

Following the meticulous selection of materials, the product was officially entered into the production phase. The initial stage involved procuring an ample quantity of stainless steel tubing, which was then pressed to the specified dimensions using the factory's specialized machinery to create the main framework of the product. This was followed by the application of advanced welding techniques to join the formed steel tubes, ensuring strong and stable connections between components and constructing a complete framework. These precise operations ensured the structural strength and durability of the product, while also enhancing its overall quality and reliability (Figure 52).

Figure 52 Main Framework of the Product after Welding

Once the welding of the stainless steel tubing framework was complete, the next stage was the painting process. Initially, the welded frame was sanded and cleaned thoroughly to ensure a smooth surface free of oil and impurities, thus allowing for even paint adhesion. The colour chosen was matte white, which enhanced the product's sleek appearance while reducing glare and improving overall aesthetics. After painting, the framework was left to dry under the sun for two days to allow the paint to cure fully. This meticulous process not only enhanced the aesthetic appeal of the stainless steel frame but also endowed it with exemplary corrosion resistance and wear properties, thereby guaranteeing dependable functionality in subsequent applications (Figure 53).

Figure 53 Painting Proces

Following the painting process, the stainless steel frame underwent further processing. Initially, high-precision drilling equipment was used to create holes at designated locations on the frame. Each hole was meticulously designed and drilled with rigorous measurement and calibration to ensure accuracy and consistency, facilitating perfect alignment with subsequent installed components. After drilling, we proceeded to install adjustable spring catches, a critical component that allows for height adjustments based on usage requirements. During the installation process, technicians conducted a meticulous inspection of the placement and firmness of each spring catch to ensure stable and reliable operation. Post-installation, multiple tests and adjustments were conducted to confirm the normal functioning, smooth adjustment, and overall structural stability of the spring catches, in alignment with the design specifications (Figure 54).

Figure 54 Drilling

Once all frame processing and the installation of internal adjustable spring catches had been completed, we proceeded to the final assembly stage. Initially, components were installed sequentially in accordance with the design drawings and production process. A comfortable and durable cushion was provided to ensure optimal comfort for users. Subsequently, handles were installed, which not only adhered to ergonomic design for a good grip but also featured anti-slip treatment for enhanced safety. Subsequently, high-strength wheels were mounted onto the frame, ensuring product stability, smooth mobility, and offering some shock absorption. Finally, anti-slip devices were installed to provide effective traction on various surfaces. Each component underwent rigorous quality checks and testing to ensure perfect integration and proper functionality within the product. The assembly and adjustment process was conducted with great care and attention to detail, resulting in the creation of a high-quality product that is comfortable, affordable, portable, practical, and safe. This product offers users an optimal experience (Figure 55 & 56).

Figure 55 Component Installation

Figure 56 Finished Product of Multifunctional Assistive Device for Elderly Rising

Due to budgetary and temporal limitations, the third and sixth models were presented in 3D printed form (Figure 57). The third model primarily employs hydraulic technology to facilitate the ascent, whereas the sixth model employs the structural principle of the biker to achieve the same objective.

Figure 57 3D printing model

4.6 PRODUCT TESTING

Upon completion of the manufacturing phase, we proceeded to the critical testing phase with the objective of verifying whether the product's functions and overall performance met the established design specifications and user expectations. To ensure safety during the testing process, we initially selected five young volunteers for preliminary testing of basic functions to assess product performance in a risk-free environment. These volunteers tested the product's assistance features for sitting, walking, and rising from the bed. The tests confirmed the product effectively assisted with sitting and walking. Nevertheless, during the test of the rising assistance feature, it was discovered that the adjustable height was unable to accommodate certain beds (Figure 58).

Figure 58 Five Young Volunteers Testing the Product

Following initial testing that confirmed the product's safety and absence of any anomalies, a more comprehensive evaluation was conducted with five elderly participants at a nursing home (Figure 59). The results indicated that the product fell short in meeting the needs of the elderly for assistance in rising from bed, due to issues with securing the product to the bed and its adjustable range not being suitable

for all bed types. However, it effectively supported the elderly with walking and sitting, enhancing their mobility and ability to sit independently.

Figure 59 Elderly Individuals Testing the Product

The aforementioned issues were identified through my observations. To verify the objectivity and authenticity of the results, interviews with 10 individuals were conducted after the testing phase. The interviews consisted of seven questions and a rating scale, as detailed in Table 5.

Table 5 Questions from the tester

	Questions from the tester
1	What was your experience with this balanced product?
2	Do you find this product easy to operate?
3	When using this product, do you feel that there is enough stability and security?
4	Does this balance aid help you get out of bed?
5	What do you think of the materials used to make this product?
6	Does the current functionality of this product meet your needs?
7	What aspects of this product do you think could be improved?

When asked, "Question 1: What was your experience with this balanced product?" the responses indicated that eight out of the ten individuals reported a positive experience, with only two finding it average. Thus, 80% of the participants had a positive experience.

Regarding "Question 2: Do you find this product easy to operate?" all participants found the product straightforward and user-friendly, accounting for 100%. This fulfills one of the design principles for assistive products for the elderly: simplicity and ease of use.

In evaluating the product's stability and safety, an in-depth survey was conducted with participants. The specific question asked was: "Question 3: When using this product, do you feel that there is enough stability and security?" The findings indicated that among the ten elderly participants, eight (80%) felt a sufficient level of safety, one (10%) did not feel secure, and another (10%) was unsure. Overall, a significant majority of participants (80%) affirmed the product's safety and stability, aligning with the core principles of assistive product design for the elderly — ensuring safety and stability.

With regard to the efficacy of the product in assisting the elderly with getting out of bed independently, there was a notable divergence in tester opinions. When addressing "Question 4: Does this balance aid help you get out of bed?" among the ten elderly participants, four reported no discernible effect in assisting with getting up, while the other six found the product helpful, leading to some controversy. In light of the aforementioned observations, a preliminary conclusion can be drawn: while the product does provide some assistance in getting up, it still has shortcomings in this function. Consequently, future research will focus on exploring and optimising the product's assistance in getting up. Through detailed analysis of the current design and identification of potential improvements, efforts will be made to address existing issues and make corresponding adjustments and enhancements to the product. The objective is to enhance the overall efficacy of the product, ensuring it better meets the needs of elderly users by providing a safer and more convenient solution for getting out of bed.

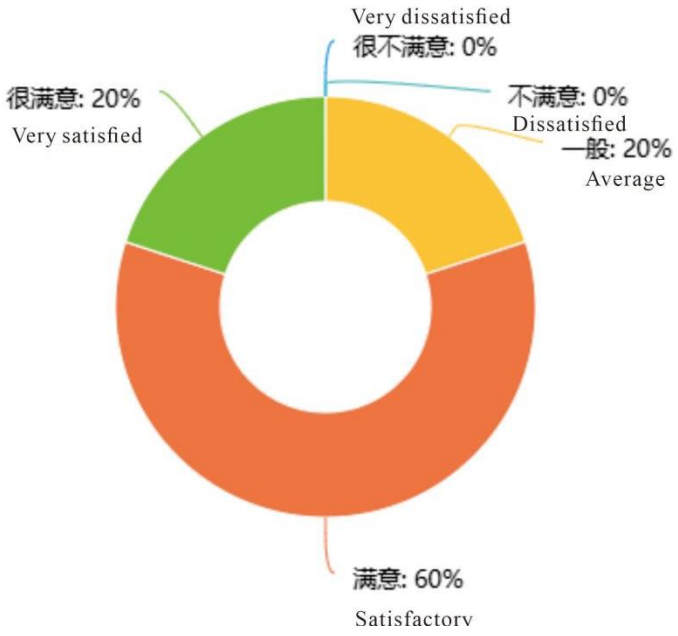
Question 5: How do you rate the materials used in this product? The responses indicate that the 10 testers are generally satisfied with the stainless steel material used in the product. They find it lightweight, with good load-bearing capacity, and easy to work with.

The main focus of this study is to examine whether the product meets the assistance needs of the elderly. In response to the question, "Does the current functionality of this product meet your needs?," five of the ten testers indicated that it did, while the remaining five stated that it did not meet their specific needs for assistance in getting out of bed, although it did meet their needs for walking and sitting.

In order to further optimise the product, a seventh question was posed to the testers: "What aspects of this product do you think could be improved?" The questionnaire results indicate that the product requires improvement and further development in terms of adjustable functionality, secure attachment to the bed, and assistance in getting out of bed. These findings align with the observations made by the researcher during the testing phase.

Finally, the testers were asked to rate the product on a scale of 1 to 5, with 1 representing very dissatisfaction and 5 representing very satisfaction. The survey results indicated that 60% of the participants were satisfied with the product, 20% were very satisfied, and another 20% rated it as average. Overall, these 10 testers expressed satisfaction with the product (Figure 60).

Figure 60 Satisfaction levels of the testers regarding the product



The comprehensive testing of the product and the data analysis obtained through the questionnaire interviews have confirmed that the design of this product adheres to

the basic design principles of assistive products for the elderly and largely meets the basic mobility needs of the elderly. However, the test results have also indicated shortcomings in the product's bed-assist function. This finding suggests the need for more research resources and continuous iterative testing for this feature.

Future research will concentrate on further optimising the bed-assist function of the product in order to address the difficulties encountered by the elderly in practical use. Based on feedback from testers and additional users, adjustments will be made to the product design, and the latest research findings in ergonomics will be integrated. A scientific research and development process will be employed to ensure that the product not only meets the theoretical needs of the elderly but also provides safe and effective support in practical applications. Ultimately, this will contribute to an improvement in the quality of life for the elderly.

4.7 EXPERT RECOMMENDATIONS

Following the completion of tests at the nursing home, I invited experts from our university to evaluate my research and product (Figure 61). Four experts provided their suggestions:

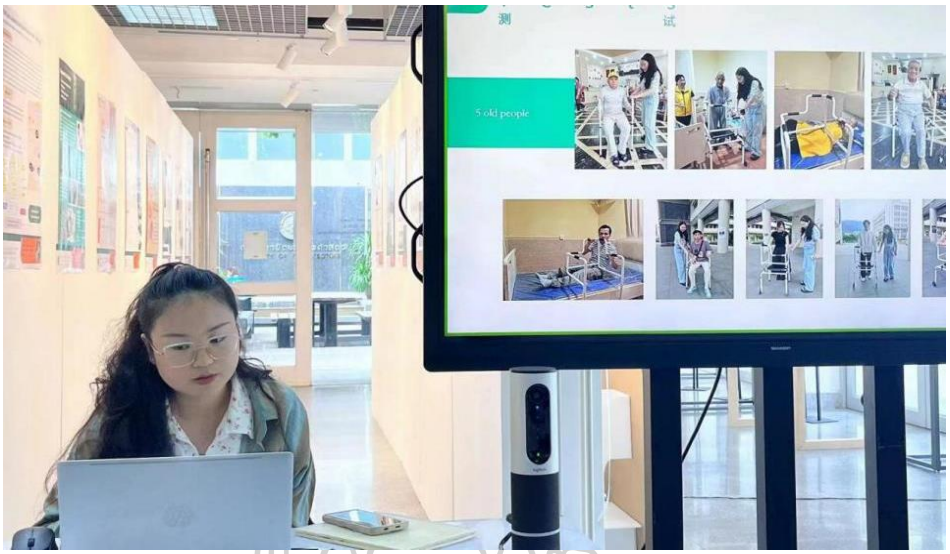
Expert 1: Professor Goesh Karnchanapayap believes that the research process is reasonable, but that the final product requires improvement in terms of aesthetics.

Expert 2: Professor Isarachai Buranaut considers that the product lacks aesthetics and requires further explanation regarding its load-bearing capacity.

Expert 3: Professor Khajornsak Nakpan proposes that the design of the product should commence with an investigation into the dimensions of the bed. This would ensure compliance with size requirements while also allowing for aesthetic considerations. Furthermore, the wheel design should be made rotatable by 180°, enabling elderly users to alter their walking direction as required.

Expert 4, Professor Atithep Chaetnalao, builds upon the previous expert's suggestion of wheels that can rotate by 180° to propose the addition of a braking system to ensure product safety.

Figure 61 Review Session



Following the incorporation of valuable feedback from experts, an in-depth investigation was conducted into the existing market of walking aids. The research yielded an important finding: there are currently no walking aids on the market that utilise 180° rotating wheels. Further analysis indicated that the implementation of 180° rotating wheels in walking aids could potentially compromise the overall stability of the product, posing potential safety risks. Furthermore, a detailed investigation revealed that the majority of walking aids currently available on the market have similar wheel structures to the proposed product, with only a few having a brake system. The walking aids with a brake system have more complex structures and are priced significantly higher than those without.

Given the characteristics of slow mobility in the elderly population and their preference for simplicity and affordability, further investigation and research should be conducted before considering the integration of a brake system into the walking aid.

With regard to the aesthetic considerations inherent to product design, it is acknowledged that there is scope for enhancement in the integration of appearance and functionality. Consequently, the objective of future research is to investigate the potential for the seamless integration of aesthetic design with the functionality of the product, thereby meeting the visual and practical needs of users. It is believed that through the continuous development of innovative and improved walking aids, it is possible to create products that are both aesthetically pleasing and practical, thereby better serving the elderly population and enhancing their quality of life (Figure 62).

Figure 62 Solution for rotatable wheels and braking system

CHAPTER 5

CONCLUSION, DISCUSSION AND RECOMMENDATION

5.1 CONCLUSIONS

Given the rapid global ageing population, it is crucial to address the mobility challenges faced by the elderly. This research aimed to delve into the numerous challenges encountered by the elderly in their daily activities, particularly focusing on balance issues related to sitting, standing, and walking. As individuals age, they often experience a gradual decline in physical function, leading to significant difficulties in activities like getting up from a seated position, standing, and walking. These challenges not only severely restrict the elderly's independence but also significantly increase the risk of falls, which represents a major threat to their health and quality of life.

This study is dedicated to the design and development of an assistive device to enhance the abilities of the elderly in getting up from bed, walking with support, and safely sitting down and standing up. Extensive research was conducted to explore the challenges faced by the elderly in performing these basic activities, and a device solution was proposed to address these challenges. The development of this solution was based on a series of field investigations and a comprehensive analysis of qualitative and quantitative data collected through surveys and in-depth interviews. This data was integrated with the actual needs of the elderly and the challenges they face in their daily lives.

To ensure the practicality and effectiveness of the designed device, this research focused on the usability, safety, comfort, and ease of operation for users, taking into account the physical and cognitive limitations of the elderly. The ultimate design outcome of this assistive product is expected to significantly enhance the autonomy and independence of the elderly. By reducing inconvenience and risks in daily activities, it can contribute to improving their quality of life and maintaining their dignity and self-esteem.

Furthermore, the assistive device developed through this research also aims to provide important support tools for families and professional caregivers, alleviating their pressure and workload in caring for the elderly. Additionally, the outcomes of this research are expected to provide enduring and robust support for long-term healthcare and welfare of the elderly, contributing new perspectives and strategies to the field of research and practice.

In order to better meet the needs of the elderly, this research extensively explored the specific problems they encounter in daily activities and their actual requirements for assistive products through field investigations, surveys, and interviews. By collecting and analysing this data, a specialized assistive device addressing the sitting and standing issues of the elderly can be designed. This device not only considers

convenience and safety in use but also takes into account the elderly's demands for comfort and ease of operation. The ultimate goal of this research is to improve the quality of life for the elderly, reduce inconvenience and risks in daily activities, and achieve greater independence and self-esteem. Furthermore, it is hoped that the development and application of assistive products will provide effective tools to family caregivers and healthcare professionals to alleviate their burdens in caring for the elderly. After one year of research and practice, this study has successfully achieved the three research objectives stated in Chapter 1.

5.1.1 ENHANCED COMPREHENSION OF THE DIFFICULTIES AND REQUIREMENTS ENCOUNTERED BY THE ELDERLY

This study was conducted through comprehensive research and investigation, which enabled the researchers to gain an in-depth understanding of the challenges, difficulties, and needs faced by the elderly. The most prominent challenge for the elderly is the gradual decline in physical function. With age, muscle strength, flexibility, and balance capabilities decrease. This change requires them to exert more effort in sitting down and standing up, increasing the risk of falls. Statistical evidence indicates that falls are a significant cause of injury among the elderly, with the potential for fractures or other life-threatening injuries. Furthermore, many elderly individuals suffer from chronic diseases such as arthritis, diabetes, hypertension, and heart disease. These conditions not only directly impact their mobility and daily activities but can also result in fatigue, pain, and other complications, leading to additional difficulties in their daily lives. Additionally, a decline in cognitive abilities is another significant challenge faced by the elderly. As individuals age, they may experience a decline in cognitive abilities, including memory loss, decreased attention, and slower reaction times. These impairments can affect their ability to comprehend and operate complex devices or perform daily tasks, further increasing the challenges they face in their daily lives.

The common issues that affect the elderly, such as muscle weakness and joint stiffness, can have a significant impact on their daily activities. These activities include getting up, sitting down, standing, walking, and bathing. Without the necessary strength and mobility, the elderly may require external assistance or the help of others to perform these activities. This can not only affect their autonomy but can also lead to feelings of frustration and dependence. It can also result in reduced social engagement, which in turn impacts their mental well-being and further decreases their quality of life. Consequently, the elderly population has a high demand for safety and stability. They require well-designed and safe assistive devices to help them accomplish their daily activities. These devices should have good stability and ease of use to reduce the risk of falls and injuries. Additionally, assistive devices should not only be safe but also consider comfort and convenience. The elderly population has sensitive skin, and prolonged use of uncomfortable devices may cause

skin damage. The design of assistive devices should be straightforward, comprehensible, and straightforward to operate, taking into account the cognitive abilities and usage habits of the elderly. Furthermore, the elderly population is heterogeneous, with each individual having different physical conditions and needs. Therefore, the design of assistive devices must consider personalised requirements. Through adjustable design, this study better meets the needs of different elderly individuals, improving their quality of life.

In conclusion, this study has conducted a comprehensive investigation and in-depth analysis of the mobility challenges faced by the elderly in their daily lives. It has employed both qualitative and quantitative research methods to accurately identify their specific needs for assistive devices. This comprehensive needs analysis provides a solid theoretical foundation and practical guidance for the subsequent design and development of assistive devices in this study, and also offers data support and a new perspective for other research in the field of elderly assistive devices.

5.1.2 THE DESIGNED ASSISTIVE PRODUCT FOR SITTING AND STANDING THAT MEET THE NEEDS OF THE ELDERLY

A review of pertinent literature, an examination of existing products on the market, the design of solutions tailored to the mobility needs of the elderly, the conduct of field investigations, interviews, and data collection, the analysis of the data, the creation of over 22 conceptual sketches, consultations with experts, the construction of 3D models, the production of prototypes, and the conduct of physical tests have enabled the design of a product that assists the elderly in getting up from bed, supports them in walking, and facilitates sitting down and standing up at any time. This product adheres to the design principles of assistive products for the elderly, which include:

(1) Safety: Safety is the primary consideration in designing assistive products for the elderly. The product must ensure no tilting, slipping, or other hazards during use. It needs to be made of sturdy materials with anti-slip properties and a strong and stable structure to ensure stability under various usage conditions. The comfort of the product is of paramount importance to the elderly user, as it affects their willingness and experience of using it. Therefore, the seating area is made of soft padding and incorporates ergonomic design to provide maximum comfort.

(3) Convenience: The product should be designed to be simple and easy to use, enabling the elderly to operate it independently. For example, lightweight materials and easy-to-grip handrails can assist the elderly in operating the product more easily.

(4) Adjustability: In order to meet the personalised needs of the elderly, the product in this study is designed to be adjustable to accommodate different bed heights and the height of the elderly individuals.

(5) Affordability: Based on expert opinions and market research, this study selected cost-effective, durable stainless steel with good load-bearing capacity as the primary material for the product.

These design principles ensure that the assistive product for the elderly meets their specific needs and provides them with enhanced mobility and independence. Visibly, this study successfully developed an assistive device that combines usability, safety, comfort, and affordability. This device helps mobility-impaired elderly individuals to independently get out of bed, walk, and sit down to rest. The design of this device considers not only the physiological limitations and cognitive characteristics of the elderly, but also emphasises adjustability and personalised needs. This represents a significant innovation in the field of elderly assistive product design. It is expected that this achievement will drive updates in related product design standards and increase product diversity.

5.1.3 THE DESIGNED ASSISTIVE PRODUCT ENHANCE THE ELDERLY'S CAPACITY FOR INDEPENDENT LIVING

The overarching objective of this study is to significantly enhance the independent living capability of the elderly through the innovative design of assistive devices. The design of this device adheres to a comprehensive research process and principles previously outlined, ensuring that it fully meets the actual needs of the elderly in their daily activities. The research results demonstrate that this assistive device has shown significant effectiveness in improving the mobility and autonomy of the elderly.

Specifically, the assistive product developed in this study enables the elderly to move more freely within the nursing home and to participate actively in social and leisure activities. In particular, when they require rest, they can easily sit down and support themselves comfortably with the assistance of handrails when getting up, thus eliminating the need for the help of caregivers or others. This improvement not only enhances the self-esteem of the elderly but also significantly enhances their independence in daily life.

Furthermore, the assistive device has been specifically designed with the function of assisting in getting up. This effectively helps the elderly to maintain a balanced position when getting up, significantly reducing the risks associated with traditional side-lying methods such as exertion and twisting. Its adjustable design further expands its applicability to different bed types, ensuring its wide applicability and practicality. The assistive device significantly enhances the mobility quality and autonomy of the elderly, demonstrating good effects in promoting their daily activity capabilities and social engagement. Furthermore, the device serves as an effective support tool for family caregivers and professional care teams, alleviating their burden in caring for the elderly. This has important practical significance in improving the quality of elderly care services.

In conclusion, this study provides theoretical support for the design and development of elderly assistive devices at the academic level. The developed device not only represents a technological innovation but also significantly enhances the quality of life and autonomy of the elderly in practical applications. Furthermore, on a social service level, it offers feasible solutions to improve the quality of life and independence of the elderly, as well as to optimise elderly care services. These achievements have a profound impact on advancing technological progress and practical innovation in the field of elderly care.

5.2 DISCUSSIONS

This study, through comprehensive and detailed research, has developed a multifunctional assistive device for elderly mobility, aimed at enhancing their independent living capabilities. By comparing the outcomes of this study with existing research and market products, we observe notable similarities and differences.

Firstly, compared to current market products, the assistive device designed in this study demonstrates significant advantages in functionality and customisation. A number of existing assistive devices, including the 24 initially conceived products, provide basic support functions such as assistance with sitting, standing, or walking. However, some lack adjustable and personalised designs tailored to individual elderly needs, and others have relatively single functions that fail to meet the multifunctional needs of the elderly, particularly the need for assistance in getting up or lying down in bed. This study, through in-depth demand analysis and user research, ensures that the product design meets the diverse specific needs of different elderly individuals, especially in assisting with bed mobility. This significantly enhances the applicability and user satisfaction of the product. This is a crucial reason why many experts selected this product among the 24 options.

Secondly, this study also places emphasis on the user experience and safety aspects during the product development process, in comparison to related research. Many studies propose innovative design concepts, yet often fail to consider the usability and safety of the product in practical applications. This study employs a continuous optimisation process through field testing and user feedback, ensuring that the product provides assistance functions while ensuring user safety and comfort. Additionally, this study places particular focus on the economic aspect of elderly assistive devices. In the current healthcare system, cost-effectiveness is a critical factor, as most nursing homes are privately owned and are very cost-conscious. Although some assistive products, like smart devices, have excellent functionality, nursing homes or cost-conscious elderly individuals prefer cheaper products. This study employs the use of affordable yet high-quality materials, such as stainless steel, which not only reduces production costs but also makes the assistive device more

affordable for more nursing homes and elderly individuals, thereby expanding its social impact.

However, this study also faces challenges and limitations. For instance, although the product design considers various needs of the elderly, further optimisation may be required in practical applications to meet the special needs of extreme individuals.

The study successfully developed an assistive device that significantly enhances the independent living capabilities of the elderly. This was achieved through innovative design and rigorous user testing. The device not only breaks through in functionality but also provides new perspectives and solutions for the practice of elderly care. Future research can further explore how to refine this assistive device through technological improvements and market strategies to better meet the needs of assisting elderly individuals with mobility.

5.3 SUGGESTIONS

(1) The results of the research demonstrate that the assistive device developed in this study effectively addresses mobility challenges and significantly enhances the independence of the elderly in activities such as walking, sitting, getting up, and getting out of bed. However, limitations were identified during testing. The device was not securely fixed on beds when performing the assistive getting up function, and it is currently only compatible with beds that have a minimum height of 450mm. Some nursing home beds have heights below 450mm, rendering the device unsuitable. Future research should investigate the heights and thicknesses of beds in more nursing homes and further explore adjustable sizing to increase the adjustable height range of the seat.

(2) Due to the scarcity of factories producing such products and their reluctance to create molds for individual products unless produced in batches, the cost of producing a single unit of the assistive device in this study is very high. It was a considerable challenge to identify a factory willing to produce the device, resulting in tight production deadlines and inadequate attention to certain details, which led to a lack of aesthetic appeal. It is recommended that future researchers, while fully meeting the product needs of the elderly, should continue to optimise the appearance of the products by integrating knowledge from ergonomics, aesthetics, and psychology. The objective of this approach is to enhance the aesthetic appeal of assistive products for the elderly, while simultaneously ensuring their comfort and safety during use.

(3) Future researchers, including myself, will be able to continue studying the heights of different nursing home beds, including the height of the bed frame itself and the height with the addition of a mattress. Once the adjustable seat height range of the device is sufficient and the seat can be securely wedged between the bed frame and mattress, the device can be effectively fixed, allowing elderly individuals to safely and slowly get up and lie down with the assistance of the device.

(4) Extensive market analysis revealed that the wheel structure of current walking aids aligns with the product design in this study, while walking aids with braking systems are relatively scarce in the market. Such products with braking systems are often more expensive due to their more complex structure. Given that elderly individuals typically prefer simple, user-friendly, and affordable assistive devices, it is recommended to conduct deeper market research and user needs analysis in future studies. This will assist in the assessment of the feasibility of introducing braking systems to enhance the safety of walking aids while maintaining ease of use and price competitiveness. The ultimate goal is to enhance the functionality and safety of the product without compromising user convenience, thereby better serving the elderly user group.

(5) In terms of product testing, it is essential to conduct durability assessments of the product materials to ensure long-term usage without any malfunctions or damages. This will enhance the product's reliability and durability. Additionally, improvements in the handle's material by selecting higher quality materials can enhance the product's tactile feel and visual appearance. Similarly, replacing the seat material with a softer and more comfortable option can enhance the product's comfortability and user experience. Such enhancements can further increase the product's value proposition, leading to higher sales prices and improved market competitiveness, ultimately achieving better commercial benefits.

(6) For another auxiliary product, the Electric Hydraulic Lift Chair (Figure 48), incorporating a design with an elastic seat can augment its flexibility and adaptability. This design approach enables the product to be compatible with various chair types, providing users with more options and convenience.

(7) It is recommended that copyright protection be promptly applied for once the product has undergone thorough testing and meets the expected standards. Copyright protection ensures the safeguarding of intellectual property rights for the product, providing legal protection and a competitive advantage for designers and companies. By obtaining copyright, designers and companies can establish their unique brand image and reputation in the market, thereby better protecting their innovative achievements and commercial interests.

REFERENCES

Chen, W. (2022). Research on Furniture Design Integrating Ming-Style Furniture Modeling Elements and Image Sensor Data: Taking Suitable Old Furniture as an Example. JOURNAL OF SENSORS, 2022, 5306491. https://doi.org/10.1155/2022/5306491

Chi, C., Cui, H., Ji, H., & Ma, M. (2020). Design study of a cane chair for the elderly with assisted sitting-to-standing function. Technology Innovation Herald, (17), 74-76. doi:10.16660/j.cnki.1674-098X.2020.17.074

Cui, Y. (2021). Research on aging-friendly furniture design based on behavior assistance mode (Master's thesis, Shandong University of Art and Design). Retrieved from https://link.cnki.net/doi/10.27789/d.cnki.gsdgy.2021.000003.

Dai, H. (2016). Study on the correlation between knee strength and lower limb functional activities in the elderly (Master's thesis, Beijing Sport University). Retrieved from https://kns.cnki.net/kcms2/article/abstract?v=WVDzDAe5jxaafjaQDNiGucEvmPU06SDKgF7USEZB3W_TOAr_R2aGZl43auZMpAiTZuB8LdqEJNLuPpat0riL1DCCCW93dCkznQsbMSrqSjv9GIjtPwKlgEm2ALqVayCxQuyz3AKWZVrcMtmPpgO7PA==uniplatform=NZKPTlanguage=CHS

Dai, Y., Zhang, Z., Chen, N., & Tang, L. (2022). Research on home aging-friendly chair design based on AHP, QFD, and AD. Packaging Engineering, (20), 228-236. doi:10.19554/j.cnki.1001-3563.2022.20.025.

Di Nicolantonio, M., Rossi, E., Deli, A., & Marano, A. (2020). The human centric lighting approach for the design of Age-Friendly products. THEORETICAL ISSUES IN ERGONOMICS SCIENCE, 21(6), 753–772. https://doi.org/10.1080/1463922X.2020.1742400

Du, J.Y. (2019). Design of displacement machine for the elderly based on ergonomics (Master's thesis, Xi'an Technological University). Xi'an Technological University. https://link.cnki.net/doi/10.27391/d.cnki.gxagu.2019.000277doi:10.27391/d.cnki.gxagu.2019.000277.

Fabisiak, B., Jankowska, A., Klos, R., Knudsen, J., Gillsjo, C., Kuprienko, I., Vidiasova, L., Poberznik, A., & Kreigere, V. (2021). Preferences of seniors living in selected Baltic Sea region countries towards the use of indoor public space furniture. PLoS ONE, 16(12), e0258676. https://doi.org/10.1371/journal.pone.0258676

Feddersen, E. (2019). Global Manual of Design for Senior Living [M]. CITIC Publishing House.

Fei, W. (2022). Research on smart furniture design method based on the lifestyle of the elderly (Master's thesis, Dalian University of Technology). Retrieved from https://link.cnki.net/doi/10.26991/d.cnki.gdllu.2022.000932.

Feng, X., Ma, Y., & Wu, Z. (2020). The influence and enlightenment of Japanese aging-friendly furniture on Chinese aging-friendly furniture design. Furniture and Interior Decoration, (05), 26-27. doi:10.16771/j.cn43-1247/ts.2020.05.007.

Fu, F.G. (2022). Research on elderly-friendly furniture design based on the concept of empathy (Master's thesis, Qingdao University of Technology). Qingdao University of Technology. https://link.cnki.net/doi/10.27263/d.cnki.gqudc.2022.000107doi:10.27263/d.cnki.gqudc.2022.000107.

Han, Y. B. (2021). Furniture design based on the living behaviors of the elderly (Master's thesis, Hebei University of Science and Technology). https://link.cnki.net/doi/10.27107/d.cnki.ghbku.2021.000533

Hu, H., & Wu, Y. (2023). Research on aging-friendly design of public seats for the elderly based on the flourishing experience model. Design, (18), 128-131. doi:10.20055/j.cnki.1003-0069.001153.

Jia, L. M. (2014). Analysis of human factors in seating. Light Industry Science and Technology, 10, 101-102.

Kamnik, R., & Bajd, T. (2004). Standing-up robot: An assistive rehabilitative device for training and assessment. Journal of Medical Engineering & Technology, 28(2), 74–80. https://doi.org/10.1080/03091900320001123 06

Khan, M. R., Patnaik, B., & Patel, S. (2017). Design and Development of a Novel Sit-to-Stand and Mobility Assistive Device for Ambulation and Elderly. In A. Chakrabarti & D. Chakrabarti (Eds.), Research into Design for Communities, Volume 1 (5 📊; pp. 801–811). Springer. https://doi.org/10.1007/978-981-10-3518-0_69

Lei, Z., Fu, J., Zhou, C., & Wang, Z. (2018). Study on the safety of elderly assistive standing chairs. Software, (10), 121-125.

Li, J.Z. (2023). Analysis of the main ingredients and health claims of functional foods for osteoarticular health at home and abroad. Modern Food, (13), 117-124. doi:10.16736/j.cnki.cn41-1434/ts.2023.13.029

Li, Y. R. (2016). Design strategies for renovated elderly care facilities (Master's thesis, Xi'an University of Architecture and Technology). https://kns.cnki.net/kcms2/article/abstract?v=SeVhTfopIAZXNNXAIpefRNf4R0ACWZ6009-d5XsH6okrWMOyC2yl2KHExWToPFZJdtBPjEKN24-n6ETDG38xzsy-hLpJPIgumCriDTAxeDzHFvD-c0YCVywmvzRIRyqkrKbhV711r9DiuSUNSb2EZA==uniplatform=NZKPTlanguage=CHS

Li, Y., & Zhou, C. (2023). Analysis of scientific research hotspots on aging-friendly furniture assisting standing design. Furniture, (01), 55-59. doi:10.16610/j.cnki.jiaju.2023.01.012.

Liu, R. X. (2020). Design research of nursing care products for nursing homes based on service platforms (Master's thesis, Hubei University of Technology). https://doi.org/10.27131/d.cnki.ghugc.2020.000712

Liu, Y., & Wang, W. (2022). Research on Quality Evaluation of Product Interactive Aging Design Based on Kano Model. COMPUTATIONAL INTELLIGENCE AND NEUROSCIENCE, 2022, 3869087. https://doi.org/10.1155/2022/3869087

Liu, Y.P., Niu, Z.B., Zhou, H.F., Shi, K.X., & Shi, K. (2016). Modern stainless steel materials: Structure, performance, characteristics, and applications. Magnetic Materials and Devices, (01), 72-77+80.

Lovrenovic, Z., & Doumit, M. (2019). Development and testing of a passive walking assist exoskeleton. Biocybernetics and Biomedical Engineering, 39(4), 992-1004.

Luo, L. (2021). Intelligent furniture design based on the lifestyle of the elderly (Master's thesis, Central South University of Forestry and Technology). https://doi.org/10.27662/d.cnki.gznlc.2021.000163

Luo, Q. (2020). Research on furniture design to prevent falls among elderly living alone based on situational construction (Master's thesis, China University of Mining and Technology). Retrieved from https://link.cnki.net/doi/10.27623/d.cnki.gzkyu.2020.001173.

Luo, Y. (2014). Analysis of the current situation and prospects of the elderly furniture market. China Business and Trade, (33), 118-120.

Lutz, W., Sanderson, W., & Scherbov, S. (2008). The coming acceleration of global population ageing. Nature, 451(7179). https://doi.org/10.1038/nature06516

Ma, X. X. (2016). Research on age-friendly furniture design under the home-based elderly care model (Master's thesis, Beijing Forestry University). Retrieved from https://kns.cnki.net/kcms2/article/abstract?v=SeVhTfopIAbDdX-VI7IuvMJWE5OZGF0-NZLNvx64xjz0x4NENfWkNq3IM71kwuG2kc_3B0Kg0RoyFCK--SHRHzPAz32JX8eVX4L6EtWfFgAbp3Rr40zNMP0prOpMqLagbN0fFGk2wAZUVOeDyT_z6g==

Mu, R. (2021). Research on humanized design of elderly furniture. Packaging Engineering, (10), 282-285. doi:10.19554/j.cnki.1001-3563.2021.10.040.

National Bureau of Statistics of China. (2021, May 12). Bulletin of the Seventh National Census~([1])(No. 5). China Information News, 002. doi:10.38309/n.cnki.nzgxx.2021.000487.

Nguyen, L. P., Saleh, M., & Le Bouquin Jeannès, R. (2018). An Efficient Design of a Machine Learning-Based Elderly Fall Detector. In M. U. Ahmed, S. Begum, & J.-B. Fasquel (Eds.), Internet of Things (IoT) Technologies for HealthCare (Vol. 225, pp. 34–41). Springer International Publishing. https://doi.org/10.1007/978-3-319-76213-5_5

Norton, V., Lignou, S., & Methven, L. (2022). Promoting Protein Intake in an Ageing Population: Product Design Implications for Protein Fortification. NUTRIENTS, 14(23), 5083. https://doi.org/10.3390/nu14235083

Orozco, J., Santos, R., Ochoa, S., Ordinez, L., Messeguer, R., & Baloian, N. (2014). A Clinically Assisted Collaborative System Architecture for Preventing Falls in Elderly People. In L. Pecchia, L. L. Chen, C. Nugent, & J. Bravo (Eds.), Ambient Assisted Living and Daily Activities (Vol. 8868, pp. 111–114). Springer International Publishing. https://doi.org/10.1007/978-3-319-13105-4_17

Pan, Y. (2023). Research on intelligent furniture design for the elderly's bedroom (Master's thesis, Nanjing Forestry University). https://link.cnki.net/doi/10.27242/d.cnki.gnjlu.2023.000854doi:10.27242/d.cnki.gnjlu.2023.000854.

Purwar, A., Bhargava, K., & Behan, E. (2023). A multi-functional mobility assist device for sit-to-stand motion. International Journal of Industrial Ergonomics, 93, 103396.

Rasche, P., Mertens, A., Broehl, C., Theis, S., Seinsch, T., Wille, M., Pape, H.-C., & Knobe, M. (2017). The “Aachen fall prevention App”—A Smartphone application app for the self-assessment of elderly patients at risk for ground level falls. PATIENT SAFETY IN SURGERY, 11, 14. https://doi.org/10.1186/s13037-017-0130-4

Romtrairat, P., Virulsri, C., & Tangpornprasert, P. (2019). An application of scissored-pair control moment gyroscopes in a design of wearable balance assistance device for the elderly. Journal of Biomechanics, 87, 183-188.

Sato, R., & Iwata, M. (2015). The effectiveness of assistive devices for elderly people in preventing falls: A systematic review. Journal of Physical Therapy Science, 27(2), 499-506.

Shen, D., & Wang, J. (2020). Elderly furniture design from the perspective of safety. Packaging Engineering, (14), 351-354. doi:10.19554/j.cnki.1001-3563.2020.14.055.

Shi, X. A., & Zhang, F. (2023). Research on the design of home age-friendly furniture products based on "behavior-centered" approach. Furniture and Interior Design, 30(2), 44–49. https://doi.org/10.16771/j.cn43-1247/ts.2023.02.008

Shin, J. H., Byeon, N., Yu, H., Yun, G., Kim, H., Park, H. K., ... & Lee, W. H. (2024). Clinical effects of walking exercise program for older adults applied with an exercise assist robot (Bot Fit): A randomized controlled trial. Journal of Bodywork and Movement Therapies, 40, 493-499.

Stan, O., Miclea, L., & Sarb, A. (2017). Elderly Fall Risk Prediction System. In S. Vlad & N. M. Roman (Eds.), International Conference on Advancements of Medicine and Health Care through Technology; 12th—15th October

2016, Cluj-Napoca, Romania (Vol. 59, pp. 228–231). Springer International Publishing. https://doi.org/10.1007/978-3-319-52875-5_49

Su, M., Wang, X., Qin, Y., & He, X. (2018). Research and design of a system to assist humans in standing. Computer Technology and Development, (04), 11-16.

Sun, S. Q., Jin, X., & Huang, Y. L. (2020). Study on the design of assistive rising chairs for elderly people. Industrial Design, 01, 157-158.

Sun, S., Jin, X., & Huang, Y. (2019). Design of a smart elderly assistive standing device based on the Internet of Things. Journal of Machine Design, (11), 140-144.

Tian, M., Lei, Y., & Li, J. (2021). A Triangle Design Framework for Functional Footwear for Chinese Older Adults. FASHION PRACTICE-THE JOURNAL OF DESIGN CREATIVE PROCESS & THE FASHION INDUSTRY, 13(1), 69–87. https://doi.org/10.1080/17569370.2021.1872898

Wan, L. J., & Li, S. (2022). Current research status of age-friendly transformation of intelligent products at home and abroad. Border Economy and Culture, 9, 116–120.

Wang, C., Zhang, W., Fan, D., Su, K., Quan, J., & Cao, Z. (2021). Design of a multifunctional walker with automatic mode switching. Equipment Manufacturing Technology, (06), 216-218.

Wang, G., Fu, H., Shi, J., & Lin, Q.Y. (2020). The relationship between emotional complexity and age in the elderly. Chinese Journal of Gerontology, (01), 215-219.

Wang, J. B. (2020). Innovative design of assistive chairs for the elderly based on the Jack software (Master's thesis, Guizhou University). https://doi.org/10.27047/d.cnki.ggudu.2020.001222

Wang, J., Liu, S., Wu, S., & Yao, N. (2023). Research on the design of aging-friendly bathroom cabinets based on QFD and AHP methods. Packaging Engineering, (04), 158-164. doi:10.19554/j.cnki.1001-3563.2023.04.019.

Wang, J.Z., Huang, L.P., Zhang, L., Liu, C.G., Wu, J.J., Liu, N., ... & Wang, L. (2022). Comparative study of functional fitness between elderly with possible sarcopenia and pre-sarcopenia. Chinese Journal of Sports Medicine, (06), 450-458. doi:10.16038/j.1000-6710.2022.06.002

Wang, K.K.(2022). Research on toilet assistive product design based on the behavioral characteristics of the elderly (Master's thesis, Hebei University of Science and Technology). Hebei University of Science and Technology. https://link.cnki.net/doi/10.27107/d.cnki.ghbku.2022.000021doi:10.27107/d.cnki.ghbku.2022.000021.

Wang, L. L., & Dong, M. J. (2020). Research on the design of assistive devices for the elderly to stand up. Journal of Hubei Normal University (Philosophy and Social Science), (03), 27-30.

Wang, N. (2018). Research on smart shoes based on wearable technology [D]. Beijing: Beijing Institute of Fashion Technology.

Wang, Y., Huang, L.Y., & Dong, C.Y. (2023). Research on elderly-friendly product design based on care theory. Industrial Engineering Design, (04), 73-82. doi:10.19798/j.cnki.2096-6946.2023.04.010

Wei, M. (2023). Research on the design of self-help assistive devices for the elderly (Master's thesis, Shandong Jianzhu University). https://link.cnki.net/doi/10.27273/d.cnki.gsajc.2023.000817doi:10.27273/d.cnki.gsajc.2023.000817.

Wei, X.Y., Wang, W., & Zhang, X.Q. (2018). Design of elderly-friendly furniture. Home of Drama, (31), 108-110.

Xu, J. (2022). Construction and application of functional fitness evaluation standards for the elderly in Suzhou community based on senior fitness tests (Master's thesis, Soochow University). Soochow University. https://link.cnki.net/doi/10.27351/d.cnki.gszhu.2022.002937doi:10.27351/d.cnki.gszhu.2022.002937.

Yang, X., & Xiong, X. (2021). Aging-friendly wardrobe design strategy based on user analysis. Forest Products Industry, (10), 80-84+87. doi:10.19531/j.issn1001-5299.202110017.

Yu, J. T., & Ma, C. B. (2024). Research on the design of assistive walkers for the elderly based on situational construction method. Design, 9, 1148.

Yu, Q. (2023). Study on the age-friendly design of nursing homes. Footwear Crafts and Design, (21), 169-171.

Yuan, H.Q., Tang, L.Z., & Han, Y.B. (2023). Current research status and prospects of exercise training in preventing falls in the elderly. General Nursing, (14), 1907-1910.

Yue, H., Zhu, T.-L., Zhou, Z.-J., & Zhou, T. (2022). Improvement of Evaluation Method of Elderly Family Medical Product Design Based on AHP. MATHEMATICAL PROBLEMS IN ENGINEERING, 2022, 4036030. https://doi.org/10.1155/2022/4036030

Zhang, M., Qiao, S., Wen, X., & Li, M. (2016). Research on barrier-free special chairs for the elderly. Art and Design (Theory), (05), 95-97. doi:10.16824/j.cnki.issn10082832.2016.05.037.

Zhang, N.N. (2022). Research on the design of elderly-friendly furniture in public spaces of nursing homes (Master's thesis, Taiyuan University of Technology). Taiyuan University of Technology. https://link.cnki.net/doi/10.27352/d.cnki.gylgu.2022.001485doi:10.27352/d.cnki.gylgu.2022.001485.

Zhang, W., & Jiao, L. (2023). Research on inclusive seating design in an aging environment. Forest Products Industry, (09), 51-56. doi:10.19531/j.issn1001-5299.202309009.

Zhang, W., Qu, C., Fu, W., et al. (2018). Design of wearable fall protection airbag system for the elderly. Chinese Journal of Gerontology, (15), 3832-3836.

Zhao, P. Y. (2023). Research on the ethical dilemmas and countermeasures of intelligent elderly care robots (Master's thesis, Yunnan Normal University). https://link.cnki.net/doi/10.27459/d.cnki.gynfc.2023.000729doi:10.27459/d.cnki.gynfc.2023.000729.

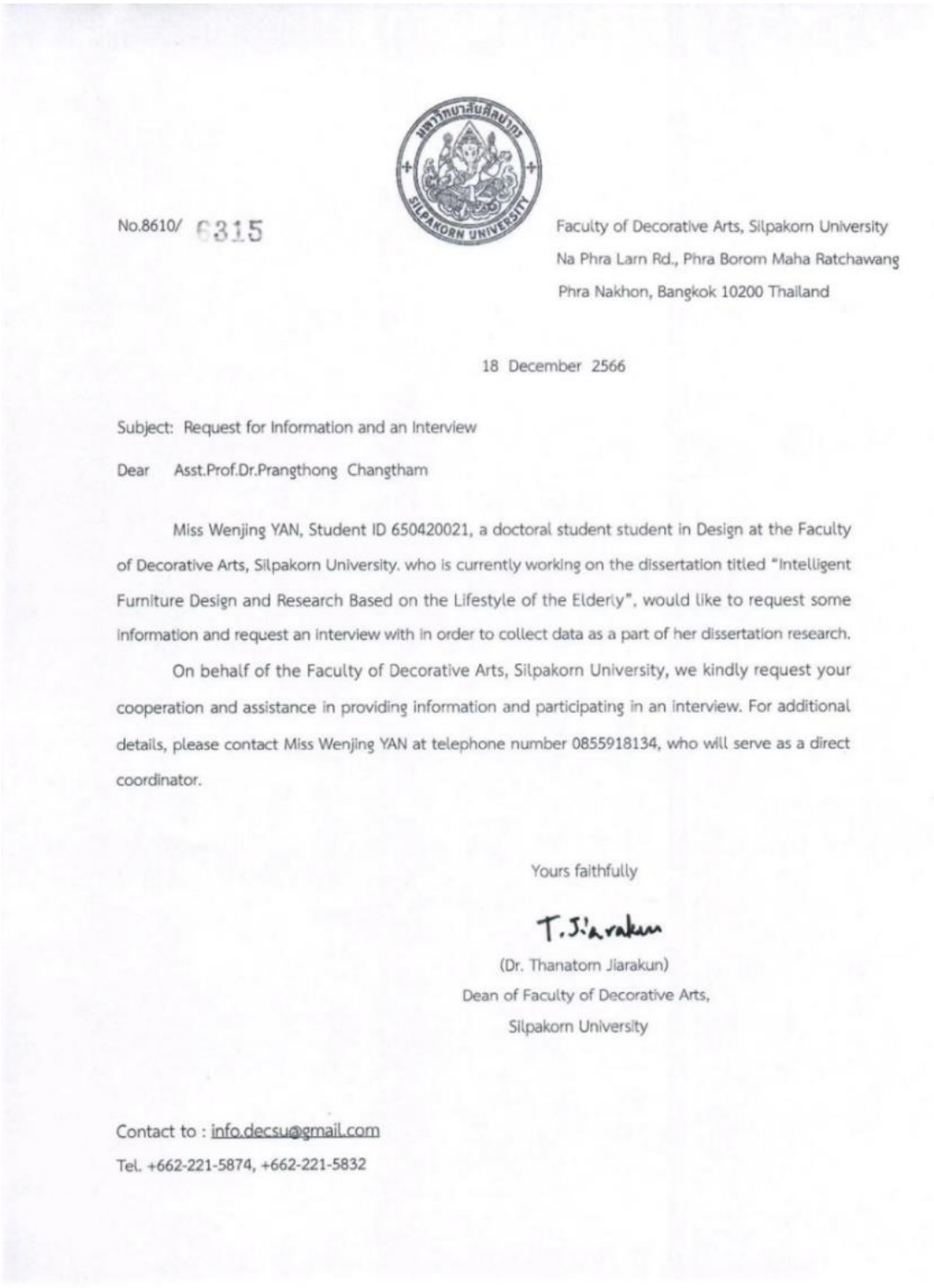
Zheng, A. (2022). Research on the design of aging-friendly home products (Master's thesis, China Academy of Art). Retrieved from https://link.cnki.net/doi/10.27626/d.cnki.gzmsc.2022.000083.

Zhou, C., Dai, Y., Huang, T., Zhao, H., & Kaner, J. (2022). An Empirical Study on the Influence of Smart Home Interface Design on the Interaction Performance of the Elderly. INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH, 19(15), 9105. https://doi.org/10.3390/ijerph19159105

Zhou, C., Zhang, Y., & Zhou, T. (2020). Research on aging-friendly furniture design for self-reliant elderly. Packaging Engineering, (16), 176-182+187. doi:10.19554/j.cnki.1001-3563.2020.16.026.

APPENDIX 1: EXPERT INVITATION LETTERS

Figure 63 Expert Invitation Letters (1)



No.8610/ 6315

Faculty of Decorative Arts, Silpakorn University
Na Phra Larn Rd., Phra Borom Maha Ratchawang
Phra Nakhon, Bangkok 10200 Thailand

18 December 2566

Subject: Request for Information and an Interview

Dear Asst.Prof.Dr.Prangthong Changtham

Miss Wenjing YAN, Student ID 650420021, a doctoral student student in Design at the Faculty of Decorative Arts, Silpakorn University. who is currently working on the dissertation titled "Intelligent Furniture Design and Research Based on the Lifestyle of the Elderly", would like to request some information and request an interview with in order to collect data as a part of her dissertation research.

On behalf of the Faculty of Decorative Arts, Silpakorn University, we kindly request your cooperation and assistance in providing information and participating in an interview. For additional details, please contact Miss Wenjing YAN at telephone number 0855918134, who will serve as a direct coordinator.

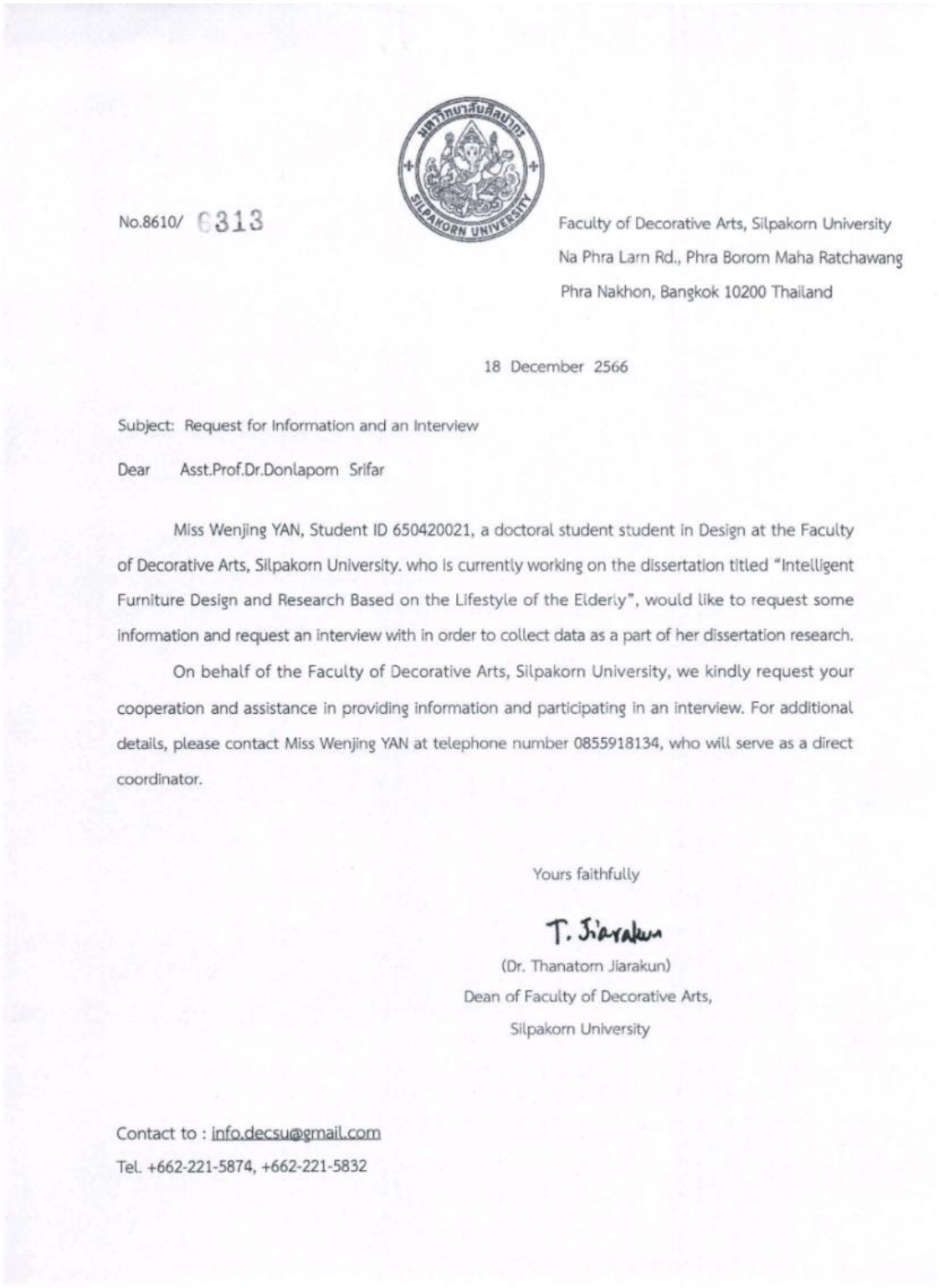
Yours faithfully

T. Jiarakun

(Dr. Thanatorn Jiarakun)
Dean of Faculty of Decorative Arts,
Silpakorn University

Contact to : info.decsu@gmail.com
Tel. +662-221-5874, +662-221-5832

Figure 64 Expert Invitation Letters (2)



No.8610/ 6313

Faculty of Decorative Arts, Silpakorn University
Na Phra Larn Rd., Phra Borom Maha Ratchawang
Phra Nakhon, Bangkok 10200 Thailand

18 December 2566

Subject: Request for Information and an Interview

Dear Asst.Prof.Dr.Donlaporn Srifar

Miss Wenjing YAN, Student ID 650420021, a doctoral student student in Design at the Faculty of Decorative Arts, Silpakorn University. who is currently working on the dissertation titled "Intelligent Furniture Design and Research Based on the Lifestyle of the Elderly", would like to request some information and request an interview with in order to collect data as a part of her dissertation research.

On behalf of the Faculty of Decorative Arts, Silpakorn University, we kindly request your cooperation and assistance in providing information and participating in an interview. For additional details, please contact Miss Wenjing YAN at telephone number 0855918134, who will serve as a direct coordinator.

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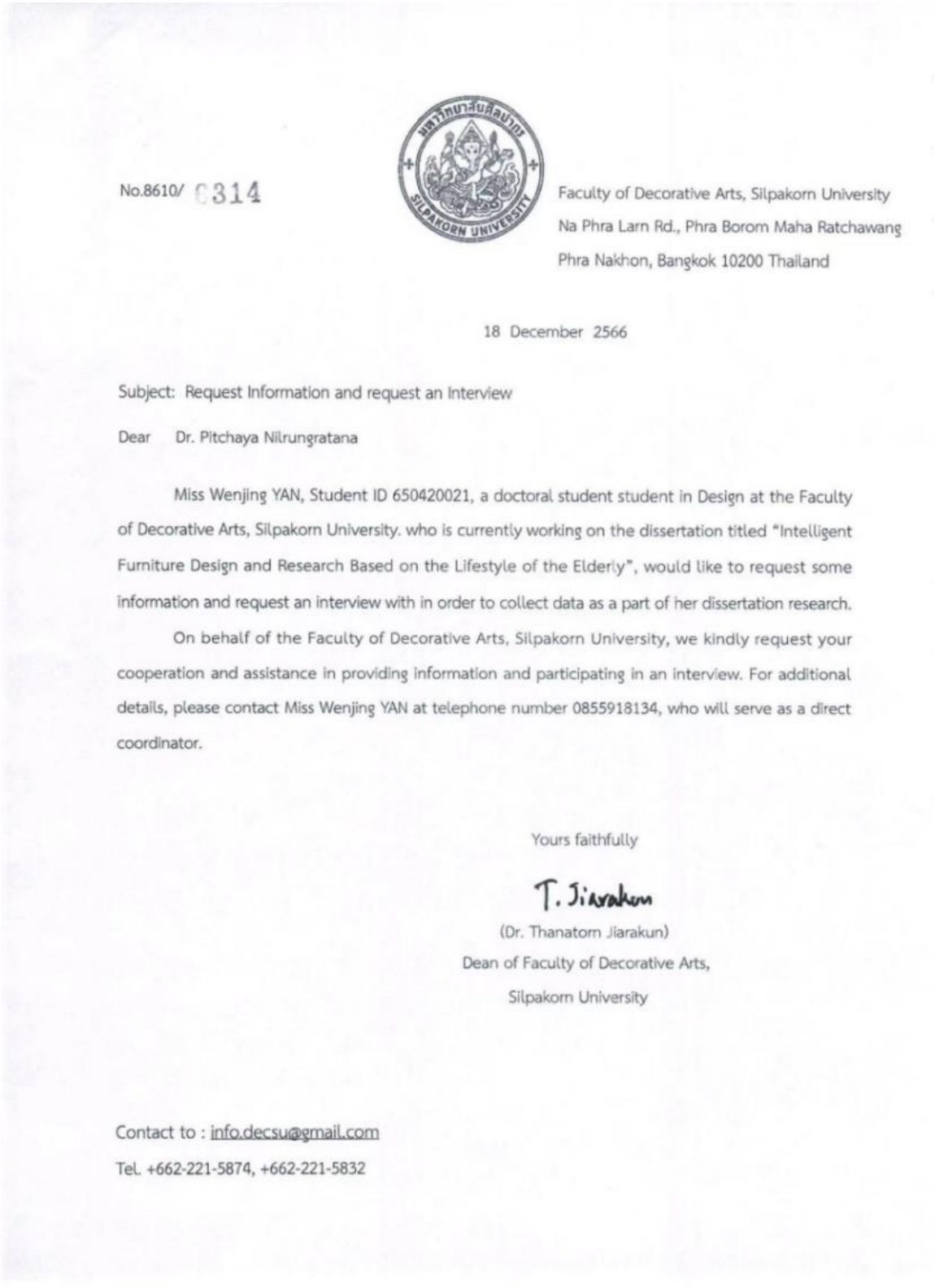
T. Jiarakun

(Dr. Thanatorn Jiarakun)
Dean of Faculty of Decorative Arts,
Silpakorn University

Contact to : info.decsu@gmail.com
Tel. +662-221-5874, +662-221-5832

Figure 65 Expert Invitation Letters (3)



No.8610/ 0314

Faculty of Decorative Arts, Silpakorn University
Na Phra Larn Rd., Phra Borom Maha Ratchawang
Phra Nakhon, Bangkok 10200 Thailand

18 December 2566

Subject: Request Information and request an Interview

Dear Dr. Pitchaya Nilrungratana

Miss Wenjing YAN, Student ID 650420021, a doctoral student student in Design at the Faculty of Decorative Arts, Silpakorn University. who is currently working on the dissertation titled "Intelligent Furniture Design and Research Based on the Lifestyle of the Elderly", would like to request some information and request an interview with in order to collect data as a part of her dissertation research.

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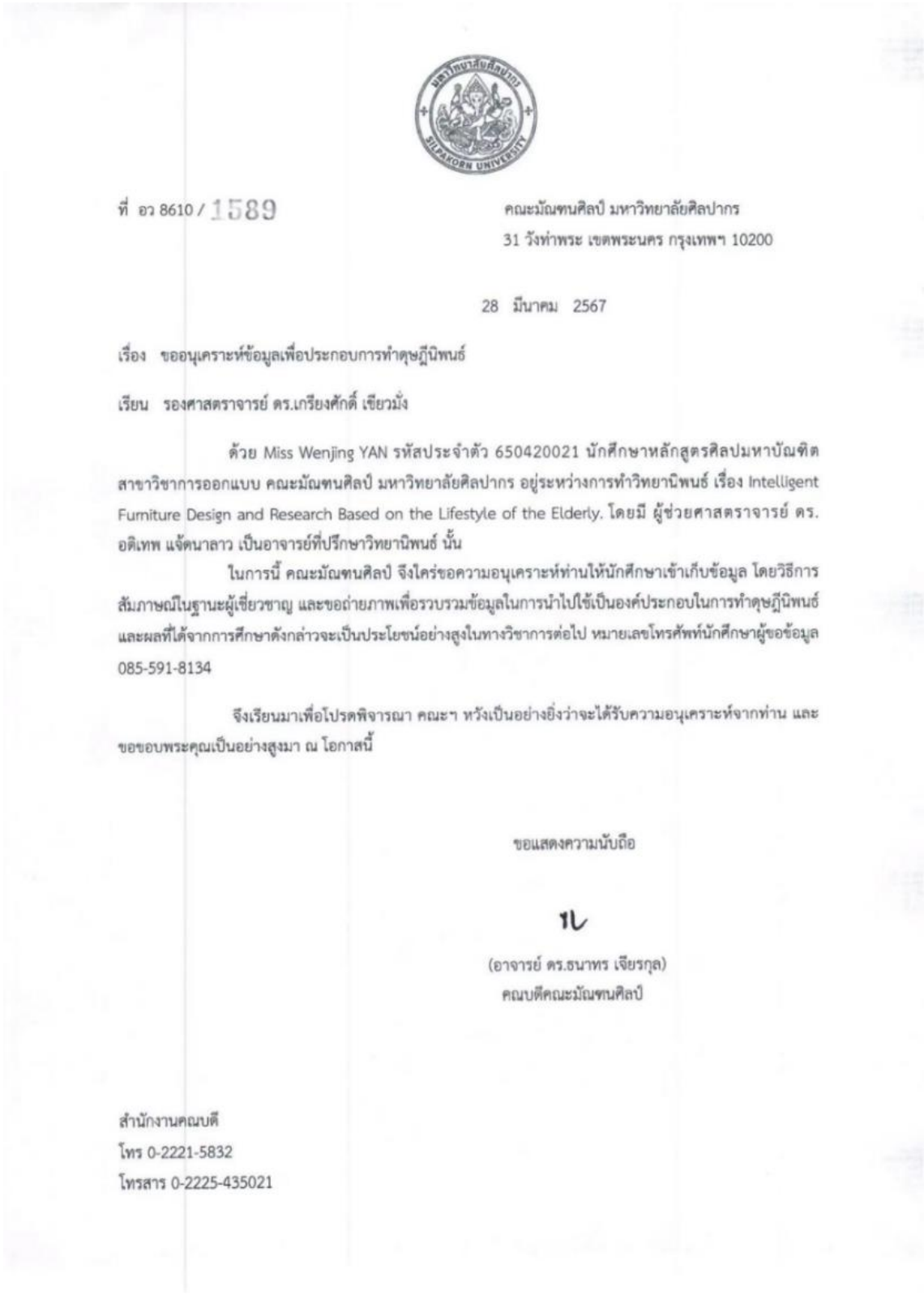
Figure 66 Expert Invitation Letters (4)



ที่ อว 8610 / 1589

คณะมัณฑนศิลป์ มหาวิทยาลัยศิลปากร
31 วังท่าพระ เขตพระนคร กรุงเทพฯ 10200

28 มีนาคม 2567

เรื่อง ขออนุเคราะห์ข้อมูลเพื่อประกอบการทำดุษฎีนิพนธ์

เรียน รองศาสตราจารย์ ดร.เกรียงศักดิ์ เชียวมั่ง

ด้วย Miss Wenjing YAN รหัสประจำตัว 650420021 นักศึกษาหลักสูตรศิลปมหาบัณฑิต สาขาวิชาการออกแบบ คณะมัณฑนศิลป์ มหาวิทยาลัยศิลปากร อยู่ระหว่างการทำวิทยานิพนธ์ เรื่อง Intelligent Furniture Design and Research Based on the Lifestyle of the Elderly. โดยมี ผู้ช่วยศาสตราจารย์ ดร. อดิเทพ แจ้ดนาลาว เป็นอาจารย์ที่ปรึกษาวิทยานิพนธ์ นั้น

ในการนี้ คณะมัณฑนศิลป์ จึงใคร่ขอความอนุเคราะห์ท่านให้นักศึกษาเข้าเก็บข้อมูล โดยวิธีการสัมภาษณ์ในฐานะผู้เชี่ยวชาญ และขอถ่ายภาพเพื่อรวบรวมข้อมูลในการนำไปใช้เป็นองค์ประกอบในการทำดุษฎีนิพนธ์ และผลที่ได้จากการศึกษาดังกล่าวจะเป็นประโยชน์อย่างสูงในทางวิชาการต่อไป หมายเลขโทรศัพท์นักศึกษาผู้ขอข้อมูล 085-591-8134

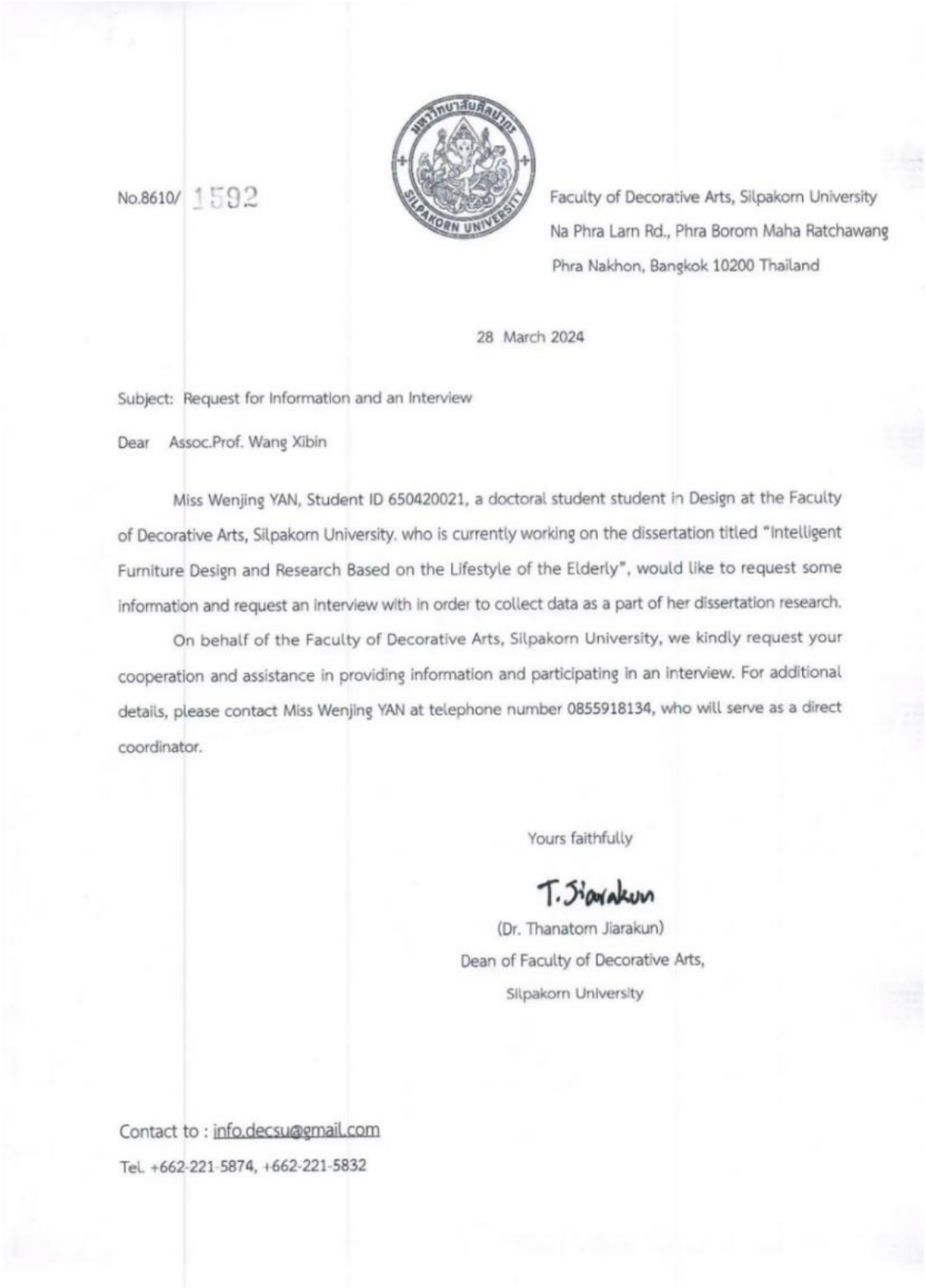
จึงเรียนมาเพื่อโปรดพิจารณา คณะฯ หวังเป็นอย่างยิ่งว่าจะได้รับความอนุเคราะห์จากท่าน และขอขอบพระคุณเป็นอย่างสูงมา ณ โอกาสนี้

ขอแสดงความนับถือ

(อาจารย์ ดร.ธนาทร เจียรกุล)
คณบดีคณะมัณฑนศิลป์

สำนักงานคณบดี
โทร 0-2221-5832
โทรสาร 0-2225-435021

Figure 67 Expert Invitation Letters (5)



No.8610/ 1592

Faculty of Decorative Arts, Silpakorn University
Na Phra Larn Rd., Phra Borom Maha Ratchawang
Phra Nakhon, Bangkok 10200 Thailand

28 March 2024

Subject: Request for Information and an Interview

Dear Assoc.Prof. Wang Xibin

Miss Wenjing YAN, Student ID 650420021, a doctoral student student in Design at the Faculty of Decorative Arts, Silpakorn University. who is currently working on the dissertation titled "Intelligent Furniture Design and Research Based on the Lifestyle of the Elderly", would like to request some information and request an interview with in order to collect data as a part of her dissertation research.

On behalf of the Faculty of Decorative Arts, Silpakorn University, we kindly request your cooperation and assistance in providing information and participating in an interview. For additional details, please contact Miss Wenjing YAN at telephone number 0855918134, who will serve as a direct coordinator.

Yours faithfully

T. Jiarakun

(Dr. Thanatorn Jiarakun)
Dean of Faculty of Decorative Arts,
Silpakorn University

Contact to : info.decsu@gmail.com
Tel. +662-221-5874, +662-221-5832

Figure 68 Expert Invitation Letters (6)

บันทึกข้อความ

ส่วนงาน สำนักงานคณบดีคณะมัณฑนศิลป์ โทร.ภายใน 104010

ที่ อว 8610/ **วันที่** 28 มีนาคม 2567

เรื่อง ขออนุเคราะห์ข้อมูลเพื่อประกอบการทำดุษฎีนิพนธ์

เรียน รองศาสตราจารย์ ดร.รัฐไท พรเจริญ

ด้วย Miss Wenjing YAN รหัสประจำตัว 650420021 นักศึกษาหลักสูตรศิลปมหาบัณฑิต สาขาวิชาการออกแบบ คณะมัณฑนศิลป์ มหาวิทยาลัยศิลปากร อยู่ระหว่างการทำวิทยานิพนธ์ เรื่อง Intelligent Furniture Design and Research Based on the Lifestyle of the Elderly. โดยมี ผู้ช่วยศาสตราจารย์ ดร. อติเทพ แจ้ดนาลาว เป็นอาจารย์ที่ปรึกษาวิทยานิพนธ์ นั้น

ในการนี้ คณะมัณฑนศิลป์ จึงใคร่ขอความอนุเคราะห์ท่านให้นักศึกษาเข้าเก็บข้อมูล โดยวิธีการสัมภาษณ์ในฐานะผู้เชี่ยวชาญ และขอถ่ายภาพเพื่อรวบรวมข้อมูลในการนำไปใช้เป็นองค์ประกอบในการทำดุษฎีนิพนธ์ และผลที่ได้จากการศึกษาดังกล่าวจะเป็นประโยชน์อย่างสูงในทางวิชาการต่อไป หมายเลขโทรศัพท์นักศึกษาผู้ขอข้อมูล 085-591-8134

จึงเรียนมาเพื่อโปรดพิจารณา คณะฯ หวังเป็นอย่างยิ่งว่าจะได้รับความอนุเคราะห์จากท่าน และขอขอบพระคุณเป็นอย่างสูงมา ณ โอกาสนี้

(อาจารย์ ดร.ธนาทร เจียรกุล)
คณบดีคณะมัณฑนศิลป์

APPENDIX 2: SURVEY RESULTS FROM 10 ELDERLY PARTICIPANTS

Figure 69 Survey Results from 10 Elderly Participants

Assistive Physical Balancing Innovation for Older People to get out of bed safety

感谢您参与我们的调查研究。本研究旨在深入了解老年人坐起困难的问题，设计出辅助老年人坐、起的产品，以提高老年人的生活质量。您的意见和建议对我们非常重要。

1. 姓名 [填空题] *
王阿姨
2. 年龄 [填空题] *
67
3. 所在养老院 [填空题] *
甘肃省渭源县养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
有，因为腿部没力，所以起来的时候比较困难
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
拉力绳，有点不平衡
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
操作简单，安全性高，价格便宜
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全、人体工程学、稳定
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
高度可调节、操作简单、便携
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
如果安全性高、价格便宜的话会考虑使用
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
第一肯定是安全

Assistive Physical Balancing Innovation for Older People to get out of bed safety

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1. 姓名 [填空题] *
王阿姨 1
2. 年龄 [填空题] *
70
3. 所在养老院 [填空题] *
甘肃省渭源县养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
有，因为经常腰疼腿疼
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
床边的护栏，有时用不上力
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
叫人、看电视、安全
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全、便宜、稳定
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
高度可调节、操作简单、便携
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
如果安全性高、价格便宜的话会考虑使用
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
便宜、安全、材料环保

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1. 姓名 [填空题] *
李阿姨
2. 年龄 [填空题] *
72
3. 所在养老院 [填空题] *
甘肃省渭源县养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
有时候有，有时候没有，下雨天的时候会腰疼腿疼，所以会起床侧坐下侧都会比较困难
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
暂时没用过，偶尔会叫护工帮忙
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
安全、可调节高低
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全、便宜、
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
操作简单、轻巧
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
会考虑使用，主要看它安不安全，贵不贵
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
便宜、安全、

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1. 姓名 [填空题] *
陈大爷
2. 年龄 [填空题] *
69
3. 所在养老院 [填空题] *
甘肃省渭源县养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
有，肠胃疼，腿疼，腰疼
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
拉力绳
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
可打电话
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全、便宜
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
操作简单，轻巧
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
会考虑使用，主要看它安不安全，贵不贵
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
便宜、安全、

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1. 姓名 [填空题] *
王大爷
2. 年龄 [填空题] *
75
3. 所在养老院 [填空题] *
甘肃省渭源县养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
有，腿疼
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
拉力绳
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
听奏腔、稳
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
可调节高低
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
会，减少对护工的依赖
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
便宜

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1. 姓名 [填空题] *
张阿姨
2. 年龄 [填空题] *
77
3. 所在养老院 [填空题] *
甘肃省定西市养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
有，下雨天会腿疼，有风湿病
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
护工帮助
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
主要是安全吧，其次就是能缓解疼痛
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全、稳
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
可调节高低，便携
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
会
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
暖色、安全

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1. 姓名 [填空题] *
胡大爷
2. 年龄 [填空题] *
70
3. 所在养老院 [填空题] *
甘肃省定西市养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
几乎没有
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
没有，偶尔护工会扶一下
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
如果真的起不来了也会有兴趣用
7. 你想给这个产品增加什么技术或功能？ [填空题] *
就帮助我轻松的坐下和起来
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
操作方便
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
会
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
安全

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1. 姓名 [填空题] *
陈阿姨
2. 年龄 [填空题] *
79
3. 所在养老院 [填空题] *
甘肃省定西市养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
有，要用不上力，腿也没力
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
拉力绳、护工帮助
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
可以帮助轻松的坐下和起来
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全，稳定
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
操作方便
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
会
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
安全

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1. 姓名 [填空题] *
陈大爷
2. 年龄 [填空题] *
76
3. 所在养老院 [填空题] *
甘肃省定西市养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
有，胳膊疼、腰疼
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
拉力绳、护工帮助
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
可以帮助轻松的坐下和起来、看视频
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
安全，舒适
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
操作方便、便于移动、可调节
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
会
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
安全

Assistive Physical Balancing Innovation for Older People to get out of bed safety

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1. 姓名 [填空题] *
陈大爷2
2. 年龄 [填空题] *
68
3. 所在养老院 [填空题] *
甘肃省定西市养老院
4. 你起床或坐下有困难吗？请描述一下。 [填空题] *
暂时没有，还算年轻
5. 你用过什么辅助产品帮助你起床？你感觉如何？ [填空题] *
没用过
6. 如果有一款新产品可以帮助你轻松起床，你会感兴趣吗？ [填空题] *
会
7. 你想给这个产品增加什么技术或功能？ [填空题] *
看视频、提醒吃药、可调节高低
8. 你认为辅助起床的产品应该考虑哪些安全特性？（如稳定性、安全性、易清洗性、保护性、环保材料、人体工程学等。） [填空题] *
稳、安全、环保
9. 你认为一款辅助起床的产品应该具备哪些适应性，才能满足不同个体的需求？（如高度可调，操作方便，适合不同床型，便于移动等。） [填空题] *
操作方便、便于移动
10. 你认为一款好的辅助起床产品会对你的日常生活产生怎样的影响？会提高你独立生活的能力吗？ [填空题] *
会
11. 你愿意使用这个产品吗？如果有，请分享你愿意使用它的原因。如果不是，是什么让你犹豫要不要用这样的产品？ [填空题] *
会
12. 你对辅助老年人起床的创新产品有什么建议或意见？ [填空题] *
安全、便宜

APPENDIX 3: RESULTS OF THE EXPERT INTERVIEWS

Figure 70 Results of the Expert Interviews

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1. 您认为目前市场上的辅助起床的产品存在什么问题？ [填空题] *

功能齐全的昂贵，便宜的功能不够

2. 在设计这样的辅助产品时，您认为应该优先考虑哪些因素，能确保产品的实用性和有效性？ [填空题] *

材料的选择，尺寸、简单的操作

3. 在设计这样的辅助产品时，您会加入哪些技术或功能，可以提高老年人在起床时的安全性？ [填空题] *

可调节高低、保持平衡

4. 你认为老年人起床困难的主要原因是什么？（例如，肌肉无力，平衡问题，害怕摔倒，或其他，请详细说明？） [填空题] *

肌肉无力，有基础病

5. 你觉得设计辅助平衡起床的产品时，应该采用哪些材料？ [填空题] *

木、不锈钢、铝合金等一些比较坚硬、稳的材料

6. 您认为在设计辅助老年人起床的产品时，一定要考虑哪些人体工程学原则？ [填空题] *

符合人体尺寸的产品、舒适性

7. 您对老年人起床的辅助平衡的产品有什么设计方面的建议？ [填空题] *

可调节性、易用性、稳定性

8. 对于未来的研究和开发，您认为有哪些方向是特别值得关注的，可以进一步提高这类产品的适用性？ [填空题] *

以用户为中心的设计、安全性

9. 你认为在设计帮助老人平衡起床的产品时应该加入哪些创新？ [填空题] *

个性化定制：考虑老年人不同的身体状况和生活习惯，提供可定制的功能，如座椅高度、扶手设计、脚踏板等
智能检测：实时监测老年人的心率、血压等

Assistive Physical Balancing Innovation for Older People to get out of bed safety

感谢您参与我们的调查研究。本研究旨在深入了解老年人坐起困难的问题，设计出辅助老年人坐、起的产品，以提高老年人的生活质量。您的意见和建议对我们非常重要。

1. 您认为目前市场上的辅助起床的产品存在什么问题？ [填空题] *

价格昂贵、操作复杂

2. 在设计这样的辅助产品时，您认为应该优先考虑哪些因素，能确保产品的实用性和有效性？ [填空题] *

环境适应性：确保产品设计能够适应不同的居住环境和条件
易用性：确保操作简单直观，避免复杂的设置或控制，减少用户的学习曲线

3. 在设计这样的辅助产品时，您会加入哪些技术或功能，可以提高老年人在起床时的安全性？ [填空题] *

可调节高低

防滑技术：使用防滑材料和设计，确保用户在起床过程中脚部稳定。

稳定性增强：设计宽大的底座和低重心，增加产品的稳定性，减少倾倒风险。

扶手支持：提供稳固的扶手，帮助用户在起床时有可靠的支持点。

紧急停止按钮：在显眼位置设置紧急停止按钮，以便用户或护理人员在需要时立即停止设备。

4. 你认为老年人起床困难的主要原因是什么？（例如，肌肉无力，平衡问题，害怕摔倒，或其他，请详细说明？） [填空题] *

关节僵硬：关节炎或其他关节问题可能导致关节僵硬，限制了老年人的活动范围。

平衡能力下降：由于神经系统功能退化，老年人的平衡感可能减弱，导致起床时容易失去平衡。

慢性疼痛：慢性疼痛，如腰背痛，可能使老年人在起床时感到困难。

5. 你觉得设计辅助平衡起床的产品时，应该采用哪些材料？ [填空题] *

如铝合金或不锈钢，用于框架和支撑结构，提供强度和稳定性
塑料：如聚丙烯（PP）或聚酰胺（PA），用于扶手和脚踏板，轻便且耐用
记忆泡沫：用于座椅和靠背，提供额外的舒适性和压力缓解
橡胶或硅胶：用于脚踏板或手柄，增加摩擦力，提高防滑性
织物：如透气的棉或亚麻织物，用于座椅和靠背的覆盖，提供柔软性和舒适度
木材：用于某些部件，如床头板，提供美观和温馨的外观

6. 您认为在设计辅助老年人起床的产品时，一定要考虑哪些人体工程学原则？ [填空题] *

舒适性、美观性、适应性

7. 您对老年人起床的辅助平衡的产品有什么设计方面的建议？ [填空题] *

易用性、稳定性、可调节高度、便携

8. 对于未来的研究和开发，您认为有哪些方向是特别值得关注的，可以进一步提高这类产品的适用性？ [填空题] *

简单易操作、价格实惠、安全稳定

9. 你认为在设计帮助老人平衡起床的产品时应该加入哪些创新？ [填空题] *

交互设计：优化用户界面，确保所有控制和指示都易于理解和操作，适合视力和听力下降的老年人。
轻便与便携：设计轻便、易于移动和存储的产品，方便老年人或护理人员根据需要调整位置。
安全性增强：设计时考虑各种安全特性，如防滑、防倾斜、紧急停止按钮和夜间照明。

Assistive Physical Balancing Innovation for Older People to get out of bed safety

感谢您参与我们的调查研究。本研究旨在深入了解老年人坐起困难的问题，设计出辅助老年人坐、起的产品，以提高老年人的生活质量。您的意见和建议对我们非常重要。

1. 您认为目前市场上的辅助起床的产品存在什么问题？ [填空题] *

功能细分不够，情感关怀不够贴心

2. 在设计这样的辅助产品时，您认为应该优先考虑哪些因素，能确保产品的实用性和有效性？ [填空题] *

人因，安全及安全感（功能性安及心理安全），材料，结构，便利性，情感关怀

3. 在设计这样的辅助产品时，您会加入哪些技术或功能，可以提高老年人在起床时的安全性？ [填空题] *

扶手支撑，臀部提升辅助，防滑材料

4. 你认为老年人起床困难的主要原因是什么？（例如，肌肉无力，平衡问题，害怕摔倒，或其他，请详细说明？） [填空题] *

肌肉无力，平衡问题，脑部供血问题，血脉不通

5. 你觉得设计辅助平衡起床的产品时，应该采用哪些材料？ [填空题] *

防滑性能好的橡胶、轻便的碳纤维或者铝合金、亲和力强的竹木等自然材料

6. 您认为在设计辅助老年人起床的产品时，一定要考虑哪些人体工程学原则？ [填空题] *

以人为本，安全可靠，数据化，标准化

7. 您对老年人起床的辅助平衡的产品有什么设计方面的建议？ [填空题] *

易用性，辅助类产品是为特殊人群设计的，必须强调易用性，易用性也包括可调节性。
安全性，安全是这类产品设计的核心要求，安全性的核心是平稳性，防止意外跌倒。

8. 对于未来的研究和开发，您认为有哪些方向是特别值得关注的，可以进一步提高这类产品的适用性？ [填空题] *

研究老年人的心理需求和生理功能需求同样重要，这样才能提升产品的设计高度，提升使用者的使用体验以及使用尊严。

9. 你认为在设计帮助老人平衡起床的产品时应该加入哪些创新？ [填空题] *

心理研究，易用性智能辅助研究。

APPENDIX 4: INSTITUTIONAL REVIEW BOARD CERTIFICATE

Figure 71 Institutional Review Board Certificate


PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

WENJING YAN

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0001269834 **24 January, 2024**

APPENDIX 5: CONFERENCE PAPERS INCLUDED CERTIFICATE

Figure 72 Conference papers included certificate


Co-organized by GURU KASHI UNIVERSITY

CERTIFICATE OF ATTENDANCE

This Certificate is Presented to

Wenjing Yan and Atithep Chaetnalao

For Presenting the Research Article Entitle

Age-Friendly Product Design: A Bibliometric Literature Review

The 7th International Conference on Learning Innovation in Science and Technology (ICLIST 2024)
Organized by the Faculty of Industrial Education and Technology
King Mongkut's University of Technology Thonburi
on March 21-23, 2024 at Amari Pattaya Hotel

T. Tanitteerapan

(Associate Professor Dr.Tanes Tanitteerapan)
Honorary Chairman
Dean of Faculty of Industrial Education and Technology

APPENDIX 6: EXHIBITION SITE

Figure 73 Exhibition site

APPENDIX 7: PRODUCT EXHIBITION

Figure 74 Product Exhibition

APPENDIX 8: 3D PRINTING PRODUCT EXHIBITION

Figure 75 3D Printing Product Exhibition

APPENDIX 9: PRODUCT INTRODUCTION POSTER

Figure 76 Product Introduction Poster


Assistive devices for improving sitting and standing balance in elderly individuals
Design process
Find the problem
The elderly have difficulty getting up, walking, sitting and standing due to the decline in physical function
Ask a question
How to solve the problem that the elderly sit and get up with the decline of their physical function?
Solve the problem
Design questionnaire
Expert review (IOC)
Passed the human ethics test (IRB)
Questionnaire and interview
Certificate of Completion
WENJING YAN
Sketch idea
3D model
3 experts were invited to perform model selection of 4 out of 8
Develop
Factory production
3D printing
MASTER OF FINE ART IN DESIGN
STUDY IN PROGRESS
EXHIBITION & SEMINAR 2024
Name : Wenjing Yan
Student ID : 650420021
Thesis

VITA

NAME	Wenjing YAN
INSTITUTIONS ATTENDED	Zhaoqing University
PUBLICATION	Yan W.J.(2024). Age-Friendly Product Design: A Bibliometric Literature Review. The 7th International Conference on Learning Innovation in Science and Technology, Pattaya, Thailand.
AWARD RECEIVED	MFA in Design Scholarship, AWARDED ON ACADEMIC YEAR 2024.