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A Study on the Design of Walking aids for Outdoor Use by the Elderly Applying Universal Design Principles

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Abstract

Existing research on walking aids has primarily focused on functional improvements, often neglecting negative aspects such as physical injuries and psychological discomfort, which limits the elderly's active participation in outdoor activities. This study aims to analyze issues related to outdoor walking stemming from physical and psychological factors in the elderly and to propose design directions for walking aids that align with their preferences. In-depth interviews were conducted with 13 elderly individuals aged 65 and above who use rollators, from May 2024 to June 2024. The interviews were analyzed using a questionnaire based on psychological factors identified in previous studies and functional aspects, utilizing Universal Design principles. The five-stage design thinking model from d.school was employed for problem definition. Issues related to walking aids were identified and analyzed during the 'Empathize' and 'Define' stages. The findings highlight priorities such as maintaining proper posture, reducing vibration, improving ease of folding and speed control, and providing additional storage space without causing discomfort. The proposed design directions reflect the needs and aspirations derived from the actual experiences of elderly individuals. The study's findings are expected to contribute to the development of walking aids that enhance usability and confidence, thereby improving the quality of life for elderly individuals.

Keywords: *Universal design, Design thinking, Elderly, Rollator*

1. INTRODUCTION

1.1 Background

As our society increasingly ages, the health of the elderly has emerged as a significant social issue. Due to degenerative diseases and other conditions, the elderly often have limited mobility, restricting their activities mainly to their homes. This confinement can result in feelings of anxiety, social isolation, and depression, thereby negatively impacting mental health and happiness [1]. Regular walking exercise, as a way for elderly to improve their daily activity patterns, not only enhances cardiovascular health and reduces stress but also increases lung capacity, strengthens lower limb muscles, and improves psychological functioning. [2].

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Therefore, in order for the elderly to sustain a healthy lifestyle, it is essential to maintain and enhance walking abilities. According to the 2021 Statistics Korea report, the life expectancy at age 65 is 21.6 years and at age 75 is 13.4 years, each increasing by 0.1 years from the previous year, which is above the OECD average [3]. Furthermore, the elderly wish to increase their leisure time to maintain a healthy lifestyle and very positively evaluate the beneficial effects of leisure activities [4,5]. This indicates that the elderly are likely to have a positive attitude toward improving their quality of life through various leisure activities. According to the 2021 global market trends report, there has been a rapid development of support solutions to enhance the elderly's quality of life, which help them live independently, and relevant suppliers have been focusing on developing age-friendly products [6]. However, existing research on walking aids, which are developed as customized products, mainly focuses on functional improvements and fails to adequately consider various aspects such as physical injuries and discomfort [7].

1.2 Study Purpose

To solve the problem, it is essential to support the elderly's independent living by increasing walking safety, such as the reduction in the rate of falls. This situation occurred since the current walking aids on the market failed to reflect the psychological and physical characteristics of the elderly sufficiently. Therefore, in order to support the elderly's healthy life and expand their activity patterns to outdoor activities, this study aims to deeply analyze the challenges the elderly face during outdoor walking and to propose design directions for walking aids that consider their physical functions and preferences. To this end, based on the 7 principles of universal design presented by the University of North Carolina's Universal Design Center, this study seeks to identify problems with the walking aids for outdoor activities, analyze various types of discomfort experienced by the elderly from a user-centric perspective, and draw design solutions to induce safe outdoor activities and improve the quality of life.

2. THEORY

2.1 Research method/scope

To comprehensively analyze the issues related to walking aids for the elderly, reflect users' opinions on their experiences, and establish design directions, this study applied the 'Empathize' and 'Define' stages in the d.school's design thinking process [8]. This process was chosen as previous domestic research mainly focused on functional improvements. This study tries to identify comprehensive issues in consideration of the elderly's psychological and physical characteristics in the stage 'empathize' of the design thinking process, and to analyze and define the drawn results in the stage 'define'. As a research tool, the interview questionnaire was developed using the research tools and methods analyzed in prior studies by Cheol Woong Moon (2017) [9] and Jeong Hee Kang (2014). The functional and physical issues were then analyzed according to the seven principles of universal design.

2.2 Research tools

2.2.1 Design Thinking

The design thinking assessment and analysis tool was used as a research method to analyze the elderly's experiences of walking aids. This study utilized the design thinking process from Stanford University's d.school, which is widely used in engineering and design fields. Design thinking means the overall problem-solving process reflecting a designer's mindset and work approach [10]. The d.school's design thinking process includes five stages: Empathize, Define, Ideate, Prototype, and Test, as illustrated in Figure 1. This study employed the 'Empathize' and 'Define' stages in the process in order to clearly and specifically define the issues experienced by users and proposed design directions for walking aids.

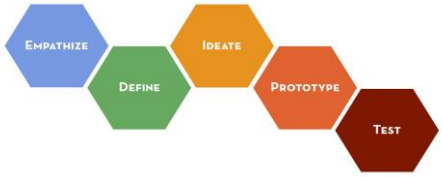

Figure 1. Design thinking process

2.2.2 Universal design principles

As a survey tool, an interview questionnaire was developed based on the 7 principles of universal design. This questionnaire was used to analyze the results from observations and responses. Universal design refers to the design of environments and products that can be used easily by all people, regardless of age or ability. Each item in the questionnaire addressed the seven principles of universal design: 'equitable use', 'flexibility in use', 'simple and intuitive use,' 'perceptible information', 'tolerance for error', 'low physical effort', and 'size and space for approach and use' as shown in Table 1. As a way of meeting the concept of universal design, this approach provides a strategy for design and is applied to develop a measurement tool and assessment to determine if a product or environment can be universally used by users [11].

Table 1. Universal design principles

No.	Contents	No.	Contents
1	Equitable Use	5	Tolerance for Error
2	Flexibility in Use	6	Low Physical Effort
3	Simple and Intuitive Use	7	Size and Space for Approach and Use
4	Perceptible Information		

2.3 Research Subject

In this study, user observation and focus group interview methods were utilized to meticulously analyze the experiences of elderly individuals using walking aids and to propose design directions for improving usability. Focus group interviews are a qualitative research method that involves collecting data through in-depth discussions with a group of participants who have a high level of experience and understanding of the topic under investigation [12]. This approach is useful for concretely exploring the fundamental concepts and components of specific phenomena and experiences [13]. Utilizing the research tools and methods analyzed in previous studies, an interview questionnaire was developed based on the functional issues of walking aids and the physical problems that occur during their use. To ensure the reliability of the study, interviews were conducted with participants who have experience using all three types of walking aids presented. To analyze the various issues of relationships between walking aids and users, the study involved observing the study participant's behavior and environments, and interviewing them in depth. The research participants included 13 elderly residents of Jocheon-eup, Jeju City [14] a region that, as of January 2024, has entered a super-aged society with elderly individuals comprising more than 20% of the total population. These participants were all elderly individuals using rollator-type walking aids, as specified under the Long-Term Care Insurance Act. The demographic characteristics of the research participants are presented in Table 2.

Table 2. Demographic characteristics of the sample

NO	Gender	Age	House hold	Type of residence	Type of Rollator	Period of use	Frequency of use

1	Female	92	Detached house	Single-person	Type 3 (Own Type 2)	20+ years	Everyday, 30min~1hour
2	Female	91	Detached house	Single-person	Type 3	5 years	Everyday, 30min~1hour
3	Female	88	Detached house	With husband	Type 3	20+ years	Everyday, 2~3hours
4	Female	87	Detached house	With husband	Type 3	20+ years	Everyday, 2~3hours
5	Female	78	Detached house	Single-person	Type 1	15 years	Everyday, 3~4hours
6	Female	77	Detached house	With husband	Type 3	8 years	Everyday, 2~3hours
7	Female	75	Detached house	Single-person	Type 3 (Own Type 2)	11 years	Everyday, 4~5hours
8	Female	74	Detached house	With husband	Type 3	6 years	Everyday, 1~2hours
9	Female	71	Detached house	With husband	Type 3	8 years	Everyday, 1~2hours
10	Female	70	Detached house	With husband	Type 1 (Own Type 2)	10 years	2~3days a weak (When have luggage)
11	Female	68	Detached house	Single-person	Type 3	7 years	3~4day a weak (When joints hurt)
12	Male	85	Detached house	With wife	Type 3	10 years	Everyday, 1~2hours
13	Male	78	Detached house	Not alone	Type 3	3 years	3~4days a weak (When have luggage)

Regarding study participation way, the participants in this study, who had their ability to communicate verbally and good cognitive abilities, were required to answer the questions about their perceptions before and after

using walking aids and their physical, psychological and social challenges needed to be addressed. In this way, information on users' types was gathered. The types of walking aids in this study were all models that had been previously distributed at the Hadong hall, and all participants had experience of using these three models. The walking aids were categorized into three types: lightweight portable walkers, standard walkers, and exercise walkers, which are the most commonly used models among elderly. The features of each type are shown in Table 3.

Table 3. Types of walking aids studied

Category	Specifications	Features
 **Type 1. Lightweight Portable Walking Aid**	Weight: Approximately 4kg Walking Aid Size: 550*440*830(mm) Wheel Size: 150mm	Advantage: Easy to carry Disadvantage: Low stability
 **Type 2. Standard Walking Aid**	Weight: Approximately 5~6kg Walking Aid Size: 630*510*860~930(mm) Wheel Size: 170mm	Advantage: Ample storage space Disadvantage: Difficult to fold
 **Type 3. Exercise Walking Aid**	Weight: Approximately 7~9kg Walking Aid Size: 630*840*920~1040(mm) Wheel Size: 200mm	Advantage: High stability Disadvantage: Heavy

2.4 Data collection and analysis

This study was conducted with 13 elderly individuals living in Jeju City, aged 65 and above, who used walking aids. Interviews were performed at Hadong Hall in Jocheon-ri, Jocheon-eup, as shown in Figure 2. Among the 13 participants, 2 used standard walking aids, 11 used exercise walking aids, and 3 also had lightweight portable walking aids at home. The exercise walking aids, used by many of the participants, were mostly provided by a local senior center, and newly supplied walking aids are distributed based on age. The elderly individuals at the Hadong Hall had been using walking aids for a minimum of 3 years to over 20 years. They had experience using various types of walking aids, not just a single kind. All study participants had experience using various walking aids rather than relying on a single type. Due to their direct experience with the characteristics and functions of different walking aids, they understood the issues and causes that could arise in various situations. Most of the elderly individuals used their walking aids daily or at least 2-3 times a week, primarily for activities such as visiting senior citizen centers, social gatherings, and daily walking.

Figure 2. Hadong hall

3. EXPERIMENTS

3.1 Research results/analysis results

Regarding the elderly's usability of walking aids, the behavioral observations and interviews were analyzed from two main perspectives. First, physical discomfort and external design issues were analyzed. Second, the users' perceptions of the walking aids and the physical, psychological, and social challenges they face were analyzed. From the analysis of physical discomfort and the external design of the walking aids, the following conclusions were drawn: First, regarding the physical discomforts caused by the use of walking aids, most of elderly participants saw shoulder, wrist, and elbow pains as typical ones. In additional responses, a significant number of elderly individuals reported pains in the back and knees. Second, regarding the external design, users experienced discomfort for their wrists and had difficulty gripping both the handles and brakes simultaneously due to the handle structure and shape, as shown in Figure 3. The hardness of the wheels led to vibrations, causing further discomfort. Additionally, many participants expressed a desire for a more robust overall design.

Figure 3. Using a walking aid while moving

Third, regarding a seat and storage space as basic functions, although the participants were satisfied with the presence of the functions, they reported physical discomfort when sitting and a psychological fear of rolling or sliding while seated. Most participants were hesitant to store valuables in the storage space, and all of the participants used it for carrying water. A summary of the interview results from the analysis on the seat and storage space is presented in Table 4.

Table 4. Comprehensive opinion about seat and storage space

Division	Research participant responses			
Seat	Uncomfortable seat pad and width improvements	Flimsy-looking	Concern that the walking aid might roll away when sitting down	Difficult in standing up from the seat
Storage space	Unsafe storage space for valuables	The space designated for water bottles needed	The safe space for tissues and wet tissues needed	Expansion of the storage space

Fourth, regarding the results from the interviews about the folding function, participants mainly used the function when storing the walking aids at home or placing them in a vehicle. Given the responses ranked in the first and second places, many found it difficult to fold the walking aids by themselves or were unaware of how to do so. The bulky nature of the folded walking aids prevented some users from using public transport

independently. As shown in Table 5, the elderly participants, who were able to walk by themselves, stored their walking aids folded in a home storage area, while others, who were unable to fold the walking aids themselves or unware of how to fold them, left them standing or lying outside.

Table 5. Appearance when storing a walking aid

		
Fold and store in a warehouse	Laying down outdoor	Leave outdoor

Firth, regarding the brakes, the interview results revealed that the participants had difficulties using the brakes on challenging terrain, because they struggled to manage the brakes while trying to maintain balance or found it hard to grip the brakes away from the handles. In addition, some participants were unaware of the presence of the brake because they didn't have enough strength to use the brake. The participants, unaware of how to fix the walking aids with the use of the brakes, resorted to parking their walking aids between structures, as shown in Figure 4.

Figure 4. Parked between structures

Sixth, regarding the handles, due to the thick handles, the elderly participants simply rested their hands on the handles while using the walking aids, or felt hand pain during prolonged use even though they were able to grip them. This issue is related to the external design. The participants suggested thinner handles for better grip and ease of using the brakes simultaneously. Seventh, regarding mobility, many participants expressed fear when navigating slopes, particularly downhill. They had difficulty controlling their walking aids with their strength while moving. They suggested that the walking aids only go straight in a straight-line movement, and only turn in a turning movement. Additional concerns included difficulty in recovering their walking aid's position after encountering curbs, or vibrations from uneven surfaces. A summary of these mobility issues is presented in Table 6.

Table 6. Comprehensive opinion about appearance, function, and movement

Division	Research participant responses			
Appearance	Hard-to-grip structure (wrist bending)	Difficulty in gripping the brake together with the handle	Hard wheels causing vibrations uncomfortably	It would be better to make the walking aid sturdy overall.

Folding	Difficulty folding the walking aid alone	Unaware of folding the walking aid	Unable to lift even if folded; too bulky to take on a bus alone	It would be better if it were less stiff.
Brake	Lack of the ability to use the brake because I should keep my balance	Difficulty in gripping the brake because it is far from the handle	Unable to use the brake due to lack of strength, so unaware of the presence of the brake function	No issues
Handle	The handle is too large to grip. I rest my hands on it.	Prolonged use causes pain in the hands. Softer handles would be better.	It would be better to make the handle thinner slightly to grip together with the brake.	-
Movement	Struggling with uphill paths, particularly fear of falling on downhill slopes	It would be better if the walking aid could only go straight in a straight-line movement and only turn in a turning movement.	Difficulty recovering the walking aid when it catches on curbs; hard to go up even in a slight elevation	Difficulty in passing on uneven surfaces due to vibrations

The subsequent interviews were conducted to analyze users' perceptions of walking aids and the physical, psychological, and social challenges they encountered after using their walking aids. Based on the interview results, the following conclusions were drawn: First, regarding the changes in the perception of people using walking aids, the participants expressed feelings of pity and anxiety when seeing others with bent backs and flimsy-looking walking aids, and had different opinions depending on the way of walking. It indicates that stable walking is an important factor and that they have a desire not to appear with such unstable walking. Second, regarding the changes in the perception of walking aids after their use, they suggested sturdier walking aids and the addition of lights for better visibility at night. In addition, they suggested wheel modifications due to the discomfort from vibrations, and improved seat comfort for longer use. Third, regarding the difficulty with physical adaptation at the time of using walking aids, the participants replied that they had pain in the upper body, particularly the shoulders, wrists, and elbows on which much strength is imposed when they use their walking aids. They also pointed out the limitations in height adjustment, indicating that their walking aids did not fit them well. Additionally, they mentioned chronic pain in the back and knees. These experiences of pain cause them to their hesitation to use rollator–type walking aids. Since they are unable to walk without walking aids, they can't help using them continuously and uncomfortably. Fourth, regarding the prejudice they had before using walking aids, the participants felt sorry for relatively younger elderly individuals using these walking aids, and male participants rejected using them and tended to believe that these walking aids are something one inevitably uses as they age. Fifth, regarding the anxiety about others' perception and recognition, relatively younger female elderly individuals worried that others might find them strange, and male elderly individuals were concerned about being teased by others. Sixth, regarding the use of public transportation, elderly individuals using rollator-type walking aids expressed negative opinions about bus usage. Those who used the bus relied that they leave their walking aids at the bus stop and take a cane onto the bus instead. They showed a tendency to use taxis for travel or avoid traveling far. Seventh, regarding challenging terrains, ramps were mentioned the most, especially sloped or curved downhill paths, which were a significant concern. High curbs or terrains with obstacles like protruding stones were also noted as burdensome, which related to the previously mentioned discomfort experienced during movement. Lastly, regarding the challenges they face when moving on ramps, most noted the difficulty in controlling speed on downhill slopes, which they found

frightening. The weight of the walking aids and the wind, which could push them off balance, were also mentioned as fear factors. A summary of the above contents is presented in Table 7.

Table 7. Comprehensive opinion, psychological challenges when using a walking aid

Division	Research participant responses			
Changes in the perception of people using walking aids	Feeling sorry for people with bend backs	Feeling anxious for people using flimsy walking aids	Feel different depending on the way of walking	The walking posture itself is good.
Changes in the perception of walking aids after using them	It would be better to make the walking aid sturdier.	It would be better if the walking aid had lights just as bicycles or motorcycles. Feeling uneasy after sunset	It would be better if the walking aid had robust wheels.	More comfortable seat would be helpful for travelling longer distances.
Physical adaptation limitations	Feeling pain in the shoulders, wrists, and elbows	Limitations to the height adjustment function; hard to fit my body	Feeling pain in the waist and knees	-
The impact of physical pain on the use of walking aids	Reluctant to use the walking aids with wheels when having pain in the shoulders	Sometimes using a cane when having pain in the waist	Compelled to use the walking aid because it is the only way to move around	-
Any prejudice	Feeling sorry for relatively younger people using walking aids	Thought that walking aids were not meant for elderly men.	It is natural to use a walking aid with age.	-
Any concern about others' perception or recognition	Worried that people would find it odd for a younger-looking elderly woman to use a walker.	Worried about teasing like 'what kind of stroller is that for older men?'	Young people might have such worries.	-
Any burdensome of public transportation use	Leaving the walking aid at the bust stop and taking a cane instead	Not even thinking about using public transportation	Calling a taxi	-
Challenging terrain features	Sloped areas, especially curved downhill paths	High curbs or ledges	Terrain with obstacles like stones or uneven surfaces	-

Any difficulties or fears when moving on sloped areas	Impossible to control speed on downhill paths	Rolling backward when struggling to push the walking aid uphill	-	-

4. RESULTS AND DISCUSSION

Ultimately, based on the elderly users' actual experiences and cases, the issues arising in their walking aids were analyzed in the design thinking process. The user's hidden needs were drawn from the analyzed results. The users' NEEDS, SEEDS, and POV (Point of View) were prioritized to help to establish differentiated design improvement plans for the development of walking aids. The comprehensive analysis results are presented in Table 7.

Table 8. NEEDS, SEEDS, POV

NEEDS	***SEEDS***
1. Feeling pain in the shoulders, wrists, and elbows since the arms are raised at the time of using the walking aid 2. Difficulty in using the folding function 3. Difficulty in using the brake and fear of going downhill since inability to grip it together with the brake 4. Feeling discomfort due to the vibrations from the hard wheels 5. Feeling anxious when putting valuables because there is no separate storage space	1. It would be helpful to maintain proper posture to avoid pain while walking. 2. It would be helpful to fold the walking aid easily and independently. 3. It would be helpful to control the speed easily on downhill paths. 4. It would be helpful to reduce vibrations that are transmitted through the wheels on rough terrain. 5. It would be helpful to have a separate storage space for valuables.
POV (Point of View)	
A walking aid that helps maintain proper posture while walking, reduces vibrations, has easy-to-fold function, easy speed control function and a separate storage space	

Given the study results, it was evident that the elderly did not just require tools to assist with walking, but desired to maintain proper posture and regain autonomy in their lives through the convenience of additional features. The results were drawn in the way of identifying the users' hidden needs and adequately reflecting the elderly's physical pain and damage, physical characteristics, and psychological elements that were not revealed in previous studies on walking aids. In conclusion, this study, which is differentiated from previous studies focusing only on the functional improvement in walking aids, is significantly meaningful in the point that it directly observed and analyzed the elderly in a representative region where a super-aged society has begun, and proposed new design directions for the walking aids to which the principles of universal design were applied to address the issues arising in the use of walking aids.

5. CONCULUSION

This study employed the 'Empathize' and 'Define' stages in the design thinking process to gather and analyze real experiences and cases of elderly individuals using walking aids, in accordance with the 7 principles of universal design. Based on the prioritized requirements of walking aid users, this study analyzed

the elderly's physical and psychological characteristics and their social challenges, and drew a conclusion with the proposed design directions for supporting more comfortable outdoor activities. It was found that the elderly desired the walking aids helping maintain proper posture to avoid pain, the function of folding walking aids easily by themselves, the function of controlling speed on downhill paths easily, the reduction of discomfort from the vibrations of hard wheels, and the separate storage for valuables. By drawing these points of view from users' perspectives, it is required to apply the critical points of each item that needs to be considered when walking aid designs are developed.

The proposed design development plan for walking aids, to which the principles of universal design were applied in this study, is expected to improve usability by alleviating physical pain and discomfort during use. Furthermore, it is anticipated to significantly contribute to improving the elderly's quality of life by helping them regain autonomy in their daily activities. Specifically, the proposal for a more convenient and safer walking aid design is expected to greatly contribute to improving accessibility for prospective elderly users. To this end, further research should expand to collect and analyze information on more diverse regions and different age groups among the elderly population and thereby to provide comprehensive guidelines for the development of walking aid designs for the elderly in the future.

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