



Development of an Innovative Smart Walking Aid with Electric Motor to Enhance Safety and Satisfaction Among Older Adults

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Received 19 July 2025; Received in revised form 27 October 2025

Accepted 7 January 2026; Available online 27 March 2026

ABSTRACT

Thailand's rapidly aging population faces increasing mobility challenges, with falls representing a major cause of injury, dependence, and reduced quality of life. This study reports the development and pilot evaluation of a smart walking aid with an electric motor designed to improve walking safety and confidence among older adults. A quasi-experimental, mixed-methods design was employed, involving ten older adults with mobility limitations and their ten primary caregivers. Walking confidence was assessed before and after use of the device using a paired-samples t-test, and user experiences were explored through semi-structured in-depth interviews. Quantitative findings revealed a statistically significant improvement in walking confidence, with mean scores increasing from 2.65 (SD = 0.50) to 4.18 (SD = 0.42), $t(9) = 7.15$, $p < 0.001$, Cohen's $d = 2.25$. Qualitative feedback reinforced these results, highlighting enhanced feelings of safety, reduced physical exertion, and decreased caregiver burden. Participants recommended practical refinements such as simplified height adjustment, wireless charging, larger control buttons, and safety features including voice alerts and floor-level illumination. These findings emphasize the importance of user-centered design in assistive technology and demonstrate the potential of smart walking aids to promote mobility, independence, and caregiver relief, aligning with Thailand's public health strategy and the Sustainable Development Goals (SDG 3 and 9).

Keywords: Assistive technology; Older adults; Occupational health; Smart Walker; Sustainable innovation

1. Introduction

Demographic change is a recognized global megatrend, fundamentally reshaping societies by shifting population structures from being dominated by working-age individuals to those characterized by a growing elderly cohort [1]. This transformation is primarily driven by advances in medical science, which have extended life expectancy and reduced mortality, along with declining birth rates [2]. While this trend has presented complex socio-economic challenges in nations like Japan, Italy, and across the European Union, the demographic transition is especially pronounced in Thailand. The nation officially entered an “aging society” in 2005, when the elderly accounted for 10.4% of the population [3]. By 2018, this proportion had risen sharply to 17.5% (approximately 11.6 million people). In 2019, Thailand reached a pivotal milestone when, for the first time, the number of older adults exceeded that of children. Projections indicate that Thailand became a “complete aged society” in 2021 and is on track to become a “super-aged society” by 2031, with older adults expected to represent 28% of the population [4].

This demographic shift has profound public health implications, as older adults are now the primary users of healthcare services. The aging process is compounded by a high prevalence of non-communicable diseases (NCDs), occurring at rates four times higher among older adults compared to other age groups. Approximately 80% of Thai older adults have at least one chronic condition, while only 27.5% are classified as being in good health [5]. Within this context, falls are a particularly severe threat. They are a leading cause of serious injury and premature death, with around 20% of older adults who fall requiring hospitalization and 10–15% suffering hip fractures or

other severe injuries that demand specialized care [6]. These consequences impose a substantial economic burden on the health-care system and family caregivers while simultaneously reducing independence and quality of life [7]. Consequently, there is an urgent need for interventions tailored to the functional needs of this vulnerable group [8].

To address these challenges, Thailand’s 20-Year National Strategic Plan for Public Health emphasizes building an inclusive and adaptive health system. The plan highlights modernization across the continuum of care ranging from health promotion and disease prevention to treatment and rehabilitation and prioritizes the integration of technology and innovation to improve quality of life. This national agenda aligns closely with the United Nations Sustainable Development Goals (SDGs) [9], particularly Goal 3 (Ensure healthy lives and promote well-being for all at all ages) and Goal 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation). For aging populations, technological innovations are, therefore, a critical pathway to enhancing the efficiency, accessibility, and quality of healthcare services. Falls are not only a clinical issue but also a pressing public health concern in Thailand, requiring preventive solutions aligned with both national strategies and global mandates.

Despite this clear strategic direction, a significant gap remains between policy ambitions and the reality of assistive technology in Thailand. While various walking aids such as wheeled walkers and models with braking systems are available, most designs require substantial physical effort. These limitations make them unsuitable for older adults with sarcopenia, osteoarthritis, or other chronic conditions that impair mo-

bility. As a result, conventional walking aids often fail to provide adequate safety or ease of use, particularly on uneven or inclined surfaces. Market analysis shows that more advanced motor-assisted devices designed to reduce exertion remain inaccessible to most Thai older adults. Such products are often prohibitively expensive and available primarily overseas or in specialized medical facilities. This accessibility gap disproportionately affects vulnerable populations, especially those in rural or low-income areas.

In response to this urgent need for inclusive mobility solutions, the present study focuses on the development of a smart walking aid specifically designed to address the functional limitations of conventional devices. The prototype is powered by an electric motor and operated through an intuitive control interface, enabling older adults to walk with minimal physical effort. Integrated safety features, such as stable directional control, enhance usability. Future improvements may include automatic braking and obstacle detection systems. It is hypothesized that the smart walking aid will not only improve walking confidence and mobility safety but also reduce caregiver burden and enhance overall quality of life. This initiative represents a prototype for scalable, sustainable medical innovation that directly supports Thailand's 20-Year National Public Health Strategy and the SDGs, particularly within the context of an aging population.

2. Materials and Methods

This study employed a quasi-experimental, pre-test/post-test research design. To complement the quantitative approach, qualitative interviews were conducted to capture real-world user experiences and guide further refinement of the

prototype.

2.1 Study objectives

1. To design and develop a prototype of a smart walking aid equipped with an electric motor, ensuring safety, usability, and ergonomic suitability for older adults.

2. To assess the functional performance and user satisfaction associated with the smart walking aid, with a focus on enhancing mobility, independence, and overall quality of life among elderly users.

2.2 Participants and sampling

The study sample consisted of twenty participants, including ten older adults and their respective ten primary caregivers. Participants were recruited using purposive sampling based on predefined eligibility criteria. Given the exploratory nature of the study, it was designed as a pilot quasi-experimental mixed-methods investigation. Pilot studies in assistive technology often adopt small to moderate sample sizes, as their primary objective is to evaluate feasibility, refine prototype design, and capture in-depth qualitative insights rather than to establish population-level generalizability (Lenker & Paquet, 2003; Kairy et al., 2016). Accordingly, the inclusion of ten older adults and ten caregivers was considered appropriate to meet both the functional testing objectives and the qualitative exploration of user and caregiver experiences. In addition, the decision to employ a relatively small sample size is consistent with established methodological guidance for mixed-methods pilot studies in assistive technology, where the emphasis lies in feasibility testing and iterative refinement rather than statistical generalizability. Such studies intentionally balance quantitative assessment with qualitative depth to optimize prototype development and user-centered evaluation.



Fig. 1. Prototype of the motorized smart walker used in this study.

2.3 Inclusion criteria

1. Older adults: Aged 60 years or above; able to maintain balance while using a smart walking aid with at least three months of prior experience in walker use; and capable of clear verbal communication.

2. Caregivers: Designated as the primary caregiver with direct responsibility for assisting the older adult in mobility activities.

2.4 Research instruments

The primary research instrument was the prototype of a smart walking aid. Key specifications of the prototype of a smart walking aid Key specifications of the prototype are as follows.

The primary research instrument was a prototype smart walking aid specifically developed for this study to meet the mobility and rehabilitation needs of older adults. The smart walking aid incorporates a motorized propulsion system that enables con-

tinuous forward movement at a safe and controlled speed, effectively reducing the physical exertion required during ambulation while encouraging gradual engagement of lower-limb muscles. The frame is constructed from lightweight but durable steel, with an adjustable height of up to approximately 100 cm to accommodate different body sizes. Four anti-slip wheels (2–3 inches in diameter) with shock-absorbing properties provide stable movement across various surface types. The smart walking aid can support a maximum load of 100 kilograms, ensuring stability and safety for users in both household and clinical environments.

The propulsion mechanism is driven by two 12-volt linear actuator motors powered by a 24-volt rechargeable battery mounted at the front of the frame. The first motor regulates vertical height adjustment, while the second motor controls forward and backward motion as well as angular positioning to maintain balance. Both motors are managed by an Arduino-based control system programmed to deliver real-time responsiveness. The smart walking aid can operate in two modes: automatic, for continuous motor-assisted walking, and manual, for user-directed operation. Safety mechanisms include a handle-mounted control panel for on/off and speed adjustment, a mechanical braking system for rapid stopping, and anti-slip grips to minimize fall risk. These integrated features were designed not only to restore confidence and independence among older adults but also to reduce caregiver burden and provide a cost-effective alternative to imported motorized smart walking aids.

A semi-structured interview guide was developed to explore user experiences with the smart walking aid, focusing on usability, convenience, confidence, and over-

all satisfaction. The content validity of the instrument was evaluated by a panel of three experts in geotechnology and rehabilitation sciences. Each item achieved an Index of Item-Objective Congruence (IOC) greater than 0.5, indicating acceptable validity.

2.5 Data collection

Data collection was carried out with ten older adult participants and their respective caregivers using a quasi-experimental pre-test/post-test design. Each participant provided written informed consent prior to participation. Older adults were asked to complete a motor-assisted walking trial with the prototype smart walking aid in a controlled indoor environment. The trial consisted of walking a 10-meter distance on a smooth, flat surface under consistent and adequate lighting to minimize environmental confounders. Each participant performed three consecutive trials, with each trial lasting approximately five minutes and including scheduled rest breaks to prevent fatigue. During the trials, researchers directly observed user performance, focusing on gait stability, adaptation to the control system, and responses to the safety mechanisms of the smart walking aid.

Immediately following the walking trials, semi-structured in-depth interviews were conducted individually with both older adults and their primary caregivers. The interviews explored perceptions of usability, confidence, convenience, and overall satisfaction with the smart walking aid, as well as elicited suggestions for design improvements and functional enhancements. Each interview lasted approximately 45–60 minutes, was audio-recorded with participant consent, and subsequently transcribed verbatim for thematic content analysis.

2.6 Data analysis

Quantitative data were analyzed using both descriptive and inferential statistics. Descriptive statistics (frequencies, percentages) were used to summarize demographic characteristics and satisfaction scores. A Paired-Samples t-test was conducted once to compare pre- and post-intervention scores, with statistical significance set at $p < 0.05$ [10]. Prior to conducting the analysis, assumptions were checked and confirmed: the Shapiro–Wilk test indicated that the distribution of difference scores did not significantly deviate from normality, and the independence of observations was satisfied because scores were obtained at separate time points. Therefore, the use of the paired-samples t-test was considered appropriate. Qualitative data from the in-depth interviews were transcribed verbatim and analyzed using thematic content analysis. This involved systematic coding of the transcripts, grouping similar codes, and synthesizing them into overarching themes that reflected participants' perceptions, lived experiences, and specific suggestions for improvement of the smart walking aid.

2.7 Ethics

Ethical approval for the study protocol was obtained from the Ethics Committee of Sirindhorn College of Public Health, Yala (approval number: SCPHYLIRB-2568/388; approval date: 6 June 2025). All data were collected in accordance with ethical research standards [11]. Participants provided written informed consent, and all personal information was anonymized to ensure data privacy and confidentiality.

Table 1. Comparison of Walking Confidence Scores Among Older Adults Before and After Using the Smart Walking Aid (n = 10).

Measurement	Mean±SD.	t	p-value
Before Use	2.65±0.50	7.15	0.001*
After Use	4.18±0.42		

* $p < 0.05$

3. Results and Discussion

3.1 Intervention results

The results of the study are presented in two parts: (1) quantitative findings assessing the effectiveness of the smart walking aid on walking confidence among older adults, and (2) qualitative findings derived from in-depth interviews with older adults and their primary caregivers.

Part 1: Quantitative Results – Effectiveness of the Smart Walking Aid on Walking Confidence

A Paired-Samples t-test was conducted to examine the effect of the smart walking aid on walking confidence among ten older adult participants. The analysis revealed a statistically significant increase in walking confidence scores following the use of the device. The mean confidence score increased from $M = 2.65$ ($SD = 0.50$) before the intervention to $M = 4.18$ ($SD = 0.42$) after the intervention, $t(9) = 7.15$, $p < 0.001$. In addition, the effect size was large (Cohen's $d = 2.25$), indicating a clinically meaningful impact. The 95% confidence interval for the mean difference ($\Delta M = 1.53$) ranged from 0.92 to 2.14. These statistically significant improvements in walking confidence were mirrored in the qualitative feedback. Older adults described feeling safer and experiencing smoother, less tiring walking, while caregivers emphasized reduced physical support requirements during ambulation.

Part 2: Qualitative Analysis: Experiences and Feedback from Users and Care-

givers The analysis of in-depth interviews with older adults and their caregivers revealed several key themes regarding their experiences with the smart walking aid.

3.1.1 General information and user satisfaction among older adults

The majority of older adult participants (4 out of 10, 80%) reported a highly positive experience, describing the smart walking aid as both convenient and safe. They specifically attributed this to the motorized system, which they noted reduced physical effort and created a smoother walking motion. In line with this, 60% of users rated the physical support provided by the smart walking aid as high to very high. However, usability challenges were also identified. Two participants (40%) found it difficult to adjust the handle height to their specific needs and expressed initial unfamiliarity with the technological controls.

3.1.2 Suggestions and smart walking aid improvement from older adults

1) Perceived Safety and Enhanced Walking Confidence

The most commonly cited benefit was the increase in walking confidence. Four out of five participants described the smart walking aid as safe and convenient, primarily due to its motorized support system, which reduced exertion and provided smoother movement. This was especially appreciated during moments of fatigue or when walking on uneven terrain. One participant stated, “each step feels more stable and smoother,” while another remarked, “it feels like having a companion by my side.” This psychological reassurance encouraged greater independence, such as walking longer distances or venturing outside alone.

2) Usability Challenges and Design Recommendations



Fig. 2. Use of the smart walking aid by an older adult.

While overall satisfaction was high, some participants encountered difficulties. Two users found the handle height adjustment inadequate for daily variation, and several expressed unfamiliarity with the control system. Recommended improvements included extending battery life, incorporating a wireless charging dock, simplifying height adjustments, and providing a visual user manual with step-by-step illustrations. Introductory training for new users was also recommended.

3) Recommendations for Advanced Functional Enhancements

Participants suggested adding a voice alert system to notify users of low battery or technical issues particularly beneficial for those with visual impairments. Additionally, several participants recommended integrating floor-level lighting to aid nighttime navigation, especially for bathroom visits, thereby reducing fall risk without requiring bright overhead lights.

3.1.3 Suggestions and device improvement from caregivers

(1) Reduced Caregiver Burden and Perceived User Benefits

A major theme among caregivers was the reduction in both physical and mental caregiving burdens. Four out of five caregivers (80%) considered the smart walking aid highly beneficial, noting improvements in user safety and walking confidence. These perceived gains contributed to a tangible decrease in caregiving responsibilities. Specifically, three caregivers (60%) reported that the smart walking aid lessened the need to physically support older adults with balance limitations during ambulation.

(2) Practical Recommendations and Nuanced Perspectives on User Independence

Caregivers offered constructive suggestions to improve the smart walking aid. Most caregivers (80%) recommended increasing the size and visibility of control buttons and enhancing their responsiveness to better accommodate older users' needs. Echoing user feedback, two caregivers (40%) also identified difficulties with handle height adjustment. Additionally, caregivers expressed mixed opinions on the extent of user independence. While a majority (60%) believed that older adults could operate the device independently on flat surfaces, they noted that assistance remained necessary for navigating slopes or charging the battery. Conversely, the remaining caregivers (40%) asserted that continuous caregiver supervision was essential, particularly for individuals with mild cognitive limitations or unfamiliarity with assistive technology.

3.2 Discussion

The findings affirm that the developed smart walking aid was effective in significantly enhancing walking confidence among its older adult users. This conclusion is strengthened by the convergence of quantitative data, which showed a marked improvement in mean confidence scores ($\Delta M = 1.53$, $p < 0.001$), and qualitative feedback, where older adults described each step as “more stable and smoother” and caregivers reported a reduced need to physically support users. This alignment between numerical outcomes and lived experiences demonstrates both clinical effectiveness and practical benefits in everyday contexts. These outcomes are also consistent with the broader literature; international studies have concluded that smart walking aids improve gait stability and reduce fear of falling [12], while national research has shown that powered assistive technologies can improve gait posture and reduce fall risk [13]. Furthermore, the qualitative insight that the smart walking aid reduced physical strain aligns with reports that motorized walkers can decrease fatigue and increase daily activity performance [14].

However, the study also highlighted key challenges related to technology acceptance among older adults, a finding consistent with prior research [15]. Participant feedback pointed to the complexity of battery charging, difficulty in adjusting the handle height, and the need for more intuitive controls, emphasizing the critical importance of user-centered design. This observation resonates with Thai-based research, which has identified perceived ease of use as the most influential factor for technology adoption in this demographic [16]. Therefore, integrating co-design and universal design principles from the earliest

stages is essential to ensure long-term usability and acceptance [17]. A limitation of this study is its relatively small sample size and short duration. Nonetheless, the use of purposive sampling provided high-quality, in-depth data, a methodological approach that is widely supported for refining innovations within specific target populations [18].

The development of an innovative smart walking aid with an electric motor is a direct response to established needs in assistive technology. Conventional walking aids have been shown to lack adaptive features for addressing fatigue and balance issues in real-world use, thereby increasing fall risks in community settings [19]. For any new technology to be adopted, user acceptance is critical, depending largely on factors such as perceived usefulness and ease of use [20]. This acceptance can be further strengthened through practical training and feedback mechanisms that build user confidence [21]. Ultimately, design features such as intuitive controls and customizable dimensions are central to older adults’ willingness to integrate the smart walking aid into their daily lives [22]. Together, these principles form the foundation for the current research, which concludes that an ergonomically designed smart walking aid can significantly enhance both safety and satisfaction among older adults.

The present study provides important empirical evidence supporting the design and implementation of a smart walking aid that addresses the functional needs and preferences of older adults. Its integration of ergonomic design, intuitive controls, and motorized assistance aligns not only with theoretical models of technology acceptance and user feedback but also with broader public health objectives. The findings highlight the potential of this innovation to im-

prove mobility, reduce fall risk, and promote independence among aging populations. These implications are particularly relevant for Thailand's rapidly aging society, where accessible and easy-to-use assistive devices can ease the burden on health-care systems and reduce caregiver responsibilities, in line with national strategic health plans [23]. Future research should build on these findings through longitudinal studies with larger and more diverse samples, while also incorporating health economic evaluations. As emphasized by Koyanagi et al., investment in fall-prevention technologies should be viewed not only as a clinical intervention but also as a strategic policy direction toward achieving sustainable reductions in national healthcare expenditures.

This study has several methodological limitations that should be acknowledged. First, the purposive sampling approach may have introduced selection bias, as participants were recruited based on predefined criteria and may not represent the broader population of older adults with mobility challenges. Second, the follow-up period was relatively short, which limited the ability to evaluate long-term outcomes such as sustained walking confidence and device adherence. Third, the presence of a learning curve in using the smart walker may have influenced initial performance outcomes, as participants required time to become familiar with the device's motor-assisted functions. Addressing these limitations in future studies through randomized sampling, extended follow-up, and structured training protocols will strengthen the evidence base for the smart walker's effectiveness.

4. Conclusion

This study provides clear empirical evidence that the developed smart walking aid significantly enhances walking confi-

dence among older adults, as demonstrated by both statistical data and qualitative feedback. Participants and caregivers reported high levels of satisfaction with its safety, convenience, and ability to reduce caregiving burden. The core functions of the smart walking aid, particularly the motorized propulsion system and responsive controls, enabled older adults to walk with greater confidence and perceived independence.

Although the study was limited by its small sample size and short duration, the results underscore the strong potential of this innovation to address daily mobility needs in older adults. The findings also provide valuable directions for further development, including the integration of user-suggested improvements such as simplified height adjustment, wireless charging, and enhanced safety features, as well as the creation of structured user training programs. Future research, especially in health economics, is needed to evaluate long-term cost-effectiveness and to support the broader and sustainable integration of this smart walking aid into national health-care systems.

5. Recommendations

Findings from this study highlight the importance of user-centered design in the development of the smart walking aid. Product development should prioritize ergonomic refinements, including a simplified handle height-adjustment mechanism and a user interface with large, clearly labeled, and highly responsive control buttons. A more accessible battery charging system, such as a wireless charging dock, should also be introduced to accommodate older adults with physical or visual impairments. Advanced safety features, including voice alerts and floor-level illumination,

are recommended to enhance usability and reduce fall risk during nighttime use. To support effective adoption, the smart walking aid should be accompanied by comprehensive user manuals with visual instructions and beginner-friendly training programs, helping to build confidence among both older adults and their caregivers.

For future research, longitudinal studies with larger and more diverse populations are recommended to assess sustained user outcomes. Incorporating cost-effectiveness analyses will provide critical insights into the feasibility of scaling and integrating such innovations into Thailand's national healthcare system, in alignment with the Sustainable Development Goals (SDGs). In addition, employing controlled comparative designs, such as randomized controlled trials (RCTs) or extended longitudinal studies, will help validate the observed improvements, capture long-term outcomes, and generate stronger evidence for widespread adoption of the smart walking aid.

Acknowledgements

The authors would like to express their sincere gratitude to the older adults and their caregivers who participated in this study and generously shared their valuable experiences, which greatly contributed to the success of this research.

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