Development and Evaluation of Walkway Rubber Sheets for Older Adults: Design, Safety, and Usability Testing

Nattina Wichaidith, Nuntaporn Klinjun, Akarapong Tuljittraporn, Puntharik Musikkachat*

Abstract: Walkways for older adults can reduce falls and enhance walking confidence during daily activities. This study aimed to develop an innovative rubber walkway prototype specifically for older adults at home and to evaluate their satisfaction with it. This study employed a design and development approach using a one-group posttest-only design. The sample consisted of 30 older adults aged 60 years or older, selected based on criteria including independent self-care ability, absence of foot wounds, proficiency in the Thai language, and willingness to participate. Participants tested the rubber walkway prototype by walking barefoot or in socks along a 2.4-meter path (1 meter of normal floor and 0.72 meters of prototype and 1 meter of normal floor), completing at least two round trips at natural stride length, and standing or walking on the prototype for at least ten seconds. Satisfaction was measured immediately post-test using a validated 15-item Questionnaire Assessing Design, Safety, and Usability domains. Satisfaction scores were interpreted using standardized thresholds (very satisfied: 4.51-5.00).

Most participants were female, with a mean age of 69.00 ± 8.89 years, living in homes with glazed tile floors, and walking barefoot indoors. Overall satisfaction, safety, usability, and design all received high ratings. Despite the high satisfaction scores, the overall rating (3.97, 95% CI [3.79, 4.15]) was below the very satisfied threshold (4.51), indicating a need for refinement and real-world efficacy testing at higher technology readiness levels. For nursing, these findings highlight the prototype's potential in home-based fall prevention programs—pending real-world efficacy testing and further development.

Keywords: Design, Innovation, Older Adults, Prototype, Rubber, Safety, Usability, Walking

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Introduction

Individuals aged 60 or above account for the older adult population. There has been an increase in both the number and proportion for the World Health Organization (WHO) forecasts that by 2030, one in six people worldwide will be 60 or older.[1] Addition-

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ally, projections show the global population aged 80 and over rising three times in 2020 to 426 million in 2039.[1] Thailand was becoming an ageing society in 2005, with the proportion of people aged 60 and above at 10.4%.[2] By 2025, it had fully transitioned into an aged society, with 13.9 million people aged 60 and above, accounting for approximately 21.1% of the total population.[3]

The efficiency of various body systems decreases with age, particularly in walking, where individuals take shorter steps and lift their feet less frequently. There are problems with balance and movement, making people at risk of falling. The risk of falling increases with age, and falls in older adults are a significant problem that can lead to injury or death. Each year, between 28-35% of individuals aged 65 and older experience falls, and the incidence rises to 32-42% for those aged 70 and above.[4] Older adults with a history of falls have a 40% chance of falling again.[4] Falls among older adults stem from interacting environmental and age-related factors. Environmental hazards, such as slippery floors or obstacles, compound vulnerabilities from reduced muscle strength and impaired balance.[4-10] The consequences of falls include physical injuries and psychological impacts, such as anxiety, a lack of confidence in walking, and fear of falling again, leading to a reduction in daily activities, such as walking.[11] Socially, falls decrease participation in community activities, while family and economic impacts arise from the caregiving burden placed on family members and loss of income from work.[5] In Thailand, environmental hazards in homes significantly exacerbate fall risks for older adults. Between 2017-2021, the prevalence of falls within the last six months was 18.5%.[12] Women were 1.5 times more likely to fall than men.[12] Studies indicate that >80% of Thai older adults reside in homes with glazed tile flooring,[7,13] a surface prone to slipperiness—especially when wet or combined with barefoot walking (practiced by > 96% of participants in our study). These tiles offer minimal shock absorption, increasing the impact on joints and leading to instability during walking.[14,15] Additionally, standard flooring, particularly cement, can be excessively hard, cold, or uneven, further compromising balance.[7,14] Such conditions are critical, as 55% of women fall in their homes, particularly in areas such as bedrooms, kitchens, and bathrooms.[12] A study of elderly housing in India[14] found that 73.33% of homes lacked non-slippery flooring—a significant environmental fall risk. The participants strongly preferred walkways with non-slip surfaces (65%), visual contrast, and secured carpets, confirming that flooring design directly mitigates fall hazards.[13,14] Designing age-adapted walkways mitigates these risks by addressing both factors simultaneously. Gait analysis of older Thais further[13] validates that walkway design impacts stability, aligning with global evidence that flooring interventions are critical for fall prevention.[14] However, no evidence-based flooring materials exist that holistically address design suitability, safety, and usability for elderly walking in residences. This gap is critical, as home flooring directly impacts daily activity safety. Walkways should not be slippery, should provide flexibility, reduce impact, and not cause pain while walking.[15] The floor should not be excessively cold or hot. Rubber provides the right balance of flexibility (not too hard or soft), enabling older adults to walk with stability and confidence in their daily home routines.

Previous studies[13-15] have shown a significant lack of suitable flooring surfaces specifically designed to address the holistic needs (design suitability, safety, and usability) of older adults walking inside the home. The ideal surface should be non-slippery, flexible enough to reduce the impact of walking, and adaptable to different areas within the home, providing the older adult with confidence in walking and reducing pain in the soles of their feet. Existing commercially available flooring products are expensive, and their installation requires specialized expertise, which limits access

to these materials. Therefore, our research team developed a prototype innovation called the "Walkway Rubber Sheets for Older Adults," designed to be placed on walking paths within homes, allowing older adults to move the prototype for their convenience easily.

Conceptual Framework and Review of Literature

Flooring is the most extensively studied interior-scale element for fall prevention in the living environments of older adults.[16] International research from the US, UK, Canada, Sweden, and Australia has evaluated various flooring types, including compliant materials such as rubberised surfaces (e.g., SmartCells, Kradal), carpets, and traditional options like tatami mats in Japan.[16] These studies demonstrate that compliant flooring can reduce hip impact by up to 35% and head impact by up to 60% without compromising balance or mobility in most older adults.[16] Compliant flooring systems, such as rubberised materials, carpets, and novel composite floors, have been studied internationally for their potential to reduce fall-related injuries among older adults.[15] Biomechanical laboratories show that such flooring can attenuate impact forces during falls by up to 51%, particularly at the hip and head, without compromising balance or mobility in most older adults.[15] However, these existing global solutions, while effective, often face limitations such as high costs, permanent installation requirements, and a lack of adaptability for diverse home environments.[15]

The National Science and Technology Development Agency (NSTDA) of Thailand developed Para-Walk.[17] This homogeneous rubber flooring material that emphasizes force distribution for stable walking, joint protection, and fall prevention through shock absorption and slip resistance. However, Para-Walk requires permanent installation and professional fitting, limiting its adaptability in homes.[17] Moreover, a Thai study on multi-purpose floor mats for self-massage[18] revealed that 37% and 45% of older adults regularly used mats for standing and walking activities, emphasizing their need for fall prevention. In the same study, sixty participants prioritized safety (87%) and utility (85%), underscoring that older adults value flooring solutions that address both comfort and stability.[18] Our study builds upon this international body of knowledge and local context. We aimed to create a prototype of flooring for the home that is specifically designed for shock absorption, stable footing, and is easily movable. The proposed Walkway Rubber Sheet seeks to combine the impact-attenuating properties of safety flooring with the flexibility and accessibility needed for typical home settings.

This research applied the Plan-Do-Study-Act (PDSA) Cycle, a four-step problem-solving model conceptualized by W. Edwards Deming.[19] The cycle was used to develop the Rubber Walkway Sheet for older adults in home settings. It enables evaluating the innovation's effectiveness, identifies areas for refinement, and contributes to the continuous development of the design through testing and implementation.[20] The PDSA Cycle consists of four distinct stages:[21] 1) Planning (Plan): Identifying problems, defining objectives for addressing them, reviewing relevant concepts, determining success indicators, creating a prototype mold, and designing a questionnaire to evaluate satisfaction with the prototype; 2) Testing (Do): Executing the planned actions, developing the prototype, testing the tools, and making necessary refinements; (3) Learning (Study): Using improved tools to gather data, analyze results, and evaluate outcomes; (4) Summarizing (Act): Consolidating findings to assess if objectives were met and provide recommendations for further improvement of the prototype (**Figure 1**).

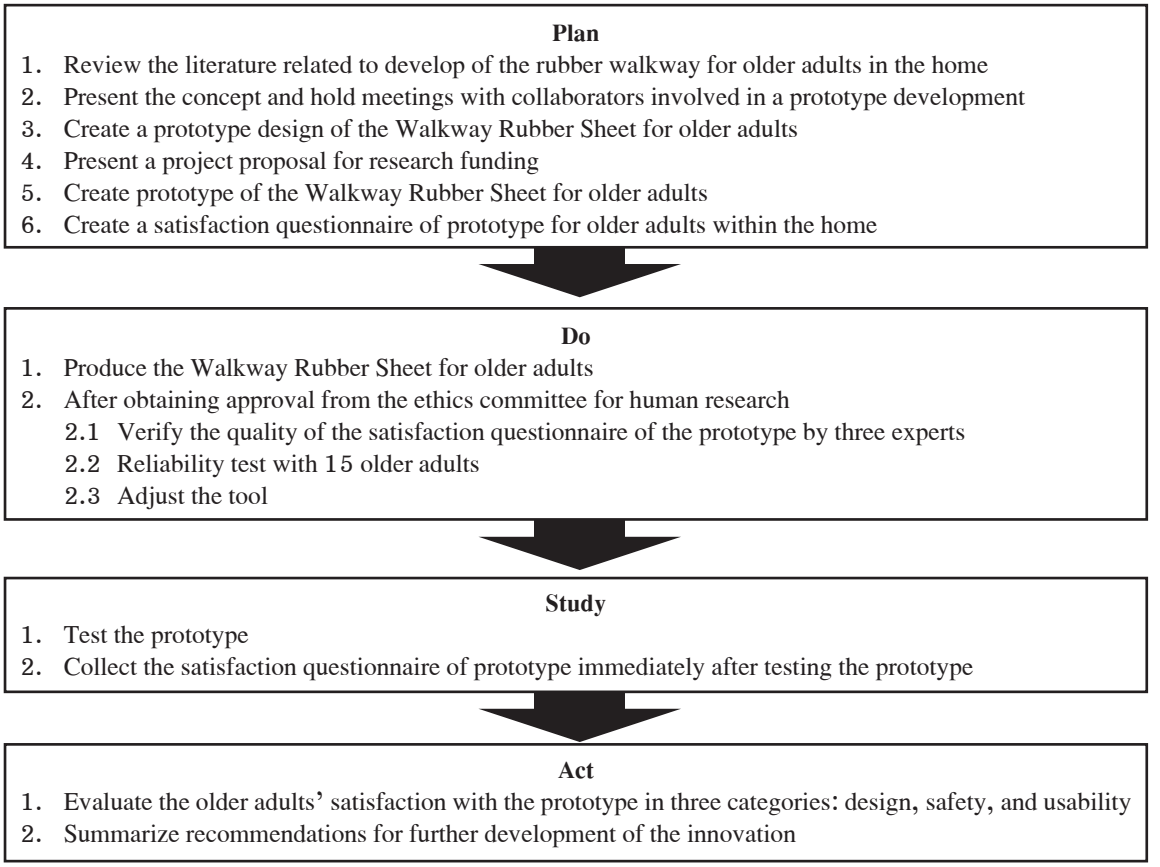

Figure 1. Conceptual framework for the Plan-Do-Study-Act cycle

Study Aims

This study aimed to develop an innovative rubber walkway prototype designed specifically for older adults at home and to evaluate participants' satisfaction with the prototype based on factors such as design, safety, usability, and overall innovation.

Methods

Study Design and Aims: This study employed a design and development (D&D) methodology following the Plan-Do-Study-Act (PDSA) cycle. The reporting of this study was guided by STROBE checklist for observational studies.[22] Prototype evaluation focused on user satisfaction assessment under controlled conditions. We adopted the Technology Readiness Level (TRL) 5 framework for prototype validation, where core technology components are tested in a relevant environment.[23] We focused on design, safety, and usability within controlled conditions with TRL 5 objectives. The PDSA cycle structured the process based on the study's aims:

Aim 1: Prototype development (PDSA: Plan and Do stages)

The development process began with designing the mold prototype (**Figure 2**), followed by creating rubber walkway sheets in 10 cm x 10 cm units with a thickness of 0.5 cm and a raised surface texture (height 0.3 cm x size 0.5 cm) for enhanced slip resistance. Each sheet featured a raised surface pattern to enhance grip and prevent slipping. However,

chemical modification of rubber can enhance properties like elasticity.[24] Our prototype is composed of a blend of natural rubber (NR) and ethylene-octene copolymer (EOC), enhanced with sawdust, clay, and oil. This formulation achieves comparable flexibility, shock absorption, and aging resistance to chemically modified rubber at a lower cost, while avoiding the complexity of processing. A vibrant color was added for aesthetic appeal (**Figure 3**). The design of each sheet allows for assembly into larger configurations, such as the 50 x 80 cm version (formed by 40 units in a 5 x 8 grid) used for testing (**Figure 4**).

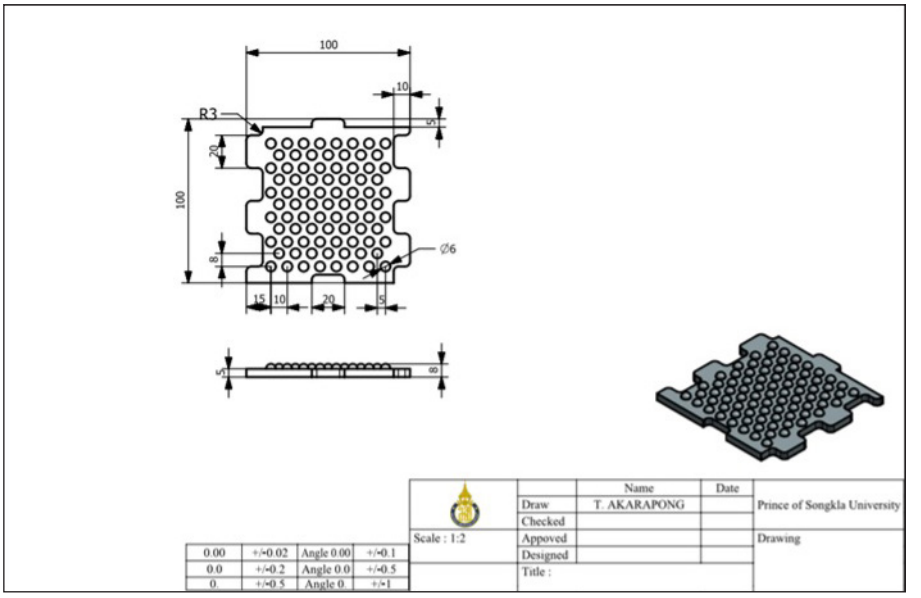

Figure 2. The mold-prototype (10 cm × 10 cm × 0.5 cm)
(Patent/Copyright Application Number 2502002537)

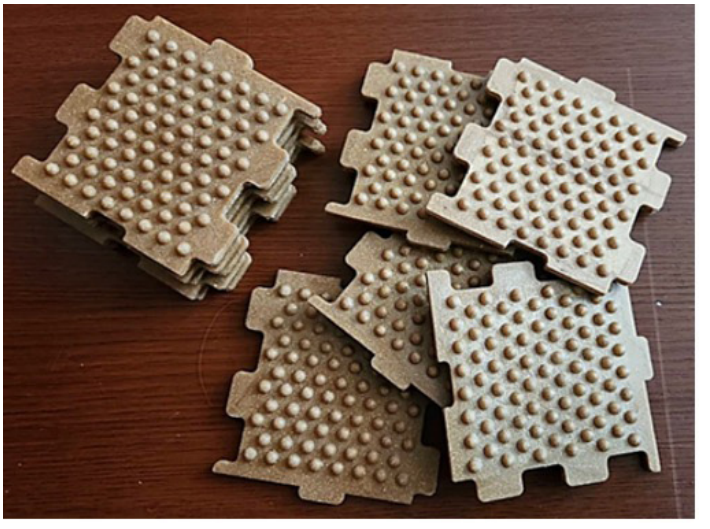

Figure 3. Rubber walkway prototype units (each 10 cm × 10 cm × 0.3 cm)

Aim 2: Prototype evaluation (PDSA: Study and Act stages)

The evaluation occurred in a community hall with unpolished cement flooring, simulating typical Thai home environments. Participants completed a minimum of two round trips (normal stride) on 2-3 meters (1 m normal floor → 0.72 m prototype → 1 m normal floor) to ensure adequate sensory exposure. This was followed by > 10 seconds of standing or walking exclusively on the prototype, a duration that reduces foot discomfort, which is critical for TRL 5 validity in a relevant environment.[23] Satisfaction was assessed immediately post-test.

Sample and Setting: The participants consist of 30 older adults aged above 60, residing in Hat Yai District, Songkhla Province. A purposive sample was selected to meet the minimum requirements for pilot testing in design-development research,[25] ensuring adequate variability in feedback while prioritizing feasibility for TRL 5 validation. Participants were selected based on the following criteria: the ability to perform independent self-care, the absence of foot wounds, fluency in Thai, and a willingness to participate. Recruitment was facilitated via community health networks. Public health volunteers identified potential participants using community registries and conducted initial home visits to explain the study objectives, eligibility criteria, and procedures. Eligible individuals expressing interest were invited to the research site for further screening, where researchers obtained written consent.

Ethical Considerations: This study adhered to the Declaration of Belmont and was approved by the Human Research Ethics Committee of the Center for Social and Behavioral Sciences at Prince of Songkla University. The research approval code was PSU IRB 2024 – LL – Nur – 018 (Internal). All participants received a detailed explanation of the research aim, data collection methods, confidentiality, and their rights. They also received a travel fee of 100 Thai baht (equivalent to approximately USD 3 at the time of the study). Each participant confirmed their willingness to participate in the study by signing a written consent form at the beginning of the data collection process. They were informed about the confidentiality of their responses and their rights as participants.

Research Instruments:

Instrument Development and Validation: The User Satisfaction Assessment Questionnaire domains (Design, Safety, Usability) were selected based on a review of constructs commonly used to evaluate healthcare innovations.[26,27] The research team then developed all individual items within the context of Walkway Rubber Sheets. The initial version consisted of 17 items. Content validity was assessed by three experts (two nursing instructors with experience in innovation and one with expertise in older adult care) using the index of item-objective congruence (IOC). The IOC scores ranged from -1 to +1, with a value of -1 indicating incongruence and a value of +1 indicating congruence. After expert review, some items were revised or removed, resulting in a 15-item questionnaire. The IOC of all items was 1. The questionnaire comprised two sections: **Section 1:** included general information with 11 items, including gender, age, weight, religion, education level, marital status, place of residence, chronic illnesses, fall history, type of home flooring, and foot condition during testing. Participants self-reported physician-diagnosed chronic conditions using a standardized checklist. Conditions included hypertension, diabetes, cardiovascular disease, and others. The history of falls is defined as an unintentional ground-level fall. Participants reported falls via binary response (yes/no) with details on timing and injuries. **Section 2** included satisfaction with the prototype Walkway Rubber Sheets for older adults with 15 items in three categories: Design (5 items), Safety (4 items), and Usability (6 items). The design focused on appropriateness for indoor use and aesthetics, with safety emphasized through slip resistance and stability. Usability was prioritized by ensuring ease of movement and maintenance. Satisfaction levels were interpreted

using standardized thresholds for a 5-point Likert scale (1 = very dissatisfied to 5 = very satisfied),[28] widely applied in the measurement of attitudes: Very Satisfied (4.51-5.00), Satisfied (3.51-4.50), Neutral (2.51-3.50), Dissatisfied (1.51-2.50), and Very Dissatisfied (1.00-1.50).[29-31] The "Very Satisfied" threshold (4.51-5.00) follows standardized 5-point Likert interpretation,[28-31] where scores > 4.50 exceed from the "Satisfied" category (3.51-4.50). This threshold setting aligns with common practice in user satisfaction studies. To capture unstructured feedback, each item in Section 2 was followed by an open-ended suggestions field, with an additional general comments section at the end. The questionnaire was pilot-tested with a separate group of 15 older adults who met the same inclusion criteria as the main study. The pilot test aimed to refine the questionnaire and assess its reliability. The Cronbach's alpha coefficient was well-established at 0.89.

The experimental equipment consisted of a rubber sheet with a raised surface of 0.3 cm, measuring 0.5 cm in size, and each sheet was 10 × 10 cm in size. These rubber sheets were assembled in 5*8 rows to form a large rubber sheet size of 50 × 80 cm (**Figure 4**).

Figure 4: The assembled sheet dimensions (50×80 cm)

Data Collection: This was conducted in December 2024, after receiving ethical approval. The researchers promoted the research project through public health volunteers and selected the participants based on established criteria. The researchers explained the objectives and data collection procedures. Once the participants understood the research process and signed the consent form, the Walkway Rubber Sheets were assembled in the experimental area, with a 2-3-meter distance (1 meter of regular flooring, 72 cm of the Walkway Rubber Sheet, and approximately 1 meter of regular flooring). The participants walked barefoot or in socks back and forth for at least two rounds and stood or walked on the sheet for at least 10 seconds. The participants assessed their satisfaction immediately after testing. Participants could walk or stand on the sheet at any time during the data collection process, based on their willingness and comfort.

Data Analysis: To present the general characteristics, descriptive statistics were employed, including frequency distributions, percentages, means, and standard deviations. The Shapiro-Wilk test confirmed that the total satisfaction score followed a normal distribution ($p > 0.05$). Descriptive statistics (mean, SD, 95% CI) summarized satisfaction scores. We estimated 95% CI for the population mean satisfaction levels to quantify proximity to the 4.51 thresholds (representing the lower bound of the very satisfied category). We analyzed the data using SPSS Statistics 26 standard version (Concurrent Perpetual License).

Results

Participant Characteristics

Of the 30 participants, the majority were female (66.7%), aged 69 ± 8.89 years. Most participants were primary school graduates (53.3%), reporting chronic illness (76.7%), not reporting falls (60.0%), and an average weight of 62.53 ± 10.72 kilograms. The majority (80.0%) lived in homes with tile floors. Regarding daily life habits, most participants (96.7%) walked barefoot inside their homes (**Table 1**).

Table 1. Characteristics of participants (N = 30)

Characteristics	Number (%)
Gender	
Male	10 (33.3)
Female	20 (66.7)
Age (years), Mean = 69.00, SD = 8.89, Min-Max = 60-90	
Over 60-69	17 (56.7)
70-79	8 (26.7)
80-89	4 (13.3)
90-99	1 (3.3)
Marital status	
Single	1 (3.3)
Couple	22 (73.3)
Widowed	7 (23.3)
Highest educational level	
Less than primary school graduate	2 (6.7)
Primary school graduate	16 (53.3)
Secondary school graduate, or vocational certificate	4 (13.3)
Bachelor's degree	8 (26.7)
Underlying disease*	23 (76.7)
Hypertension	12 (52.2)
Hyperlipidemia	9 (39.1)
Diabetes	5 (21.7)
Arthritis	3 (13.0)
Stroke	2 (8.7)
Lung disease	2 (8.7)
Cancer	2 (8.7)
Kidney disease	1 (4.3)
Osteoporosis	1 (4.3)
History of falls	12 (40.0)
Weight (kilograms), Mean = 62.53, SD = 10.72, Min-Max = 45.00-86.50	
45-54	7 (23.3)
55-64	11 (36.7)
65-74	9 (30.0)
75-84	2 (6.7)
85-94	1 (3.3)

Table 1. Characteristics of participants (N = 30) (Cont.)

Characteristics	Number (%)
Flooring materials in house	
Glazed tiled floor	24 (80.0)
Terrazzo floor	3 (10.0)
Cement floor	2 (6.7)
Rubber floor tile	1 (3.3)
Foot condition walking in house	
Walking barefoot	29 (96.7)
Wearing socks	1 (3.3)

Note. *One participant might have more than one answer.

Satisfaction with the Walkway Rubber Sheets

Descriptive statistics (mean, SD, frequencies) summarized participant characteristics and satisfaction scores. All satisfaction scores met normality assumptions (Shapiro-Wilk $p > 0.05$). A one-sample t-test compared the mean satisfaction score to the 4.51 criterion. The participants expressed a satisfied level of overall satisfaction with the Walkway Rubber Sheets, achieving a mean score of 3.97. Satisfaction was evaluated across three key categories, all of which received satisfied scores: safety (mean = 4.15), usability (mean = 3.91), and design (mean = 3.90). When analyzing individual items, participants rated the safety feature, "The Walkway Rubber Sheets grip the floor firmly and are not slippery," as the most satisfactory, with a mean score of 4.27. The second highest satisfaction was attributed to the safety feature, "The Walkway Rubber Sheets are lightweight and easy to move around the house," with a mean score of 4.23. Additionally, participants expressed high satisfaction with the design feature, "The Walkway Rubber Sheets' surface is not slippery, reducing the risk of tripping and falling," which also received a mean score of 4.23. The overall satisfaction was 3.97 (95% CI [3.79, 4.15]), below the Very Satisfied threshold (4.51) but within the Satisfied range (3.51-4.50) (**Table 2**).

Table 2. The satisfaction with the prototype (N = 30)

Variables	Mean	SD	Level
Design	3.90	0.51	Satisfied
1. The shape of the rubber walkway sheet is well-suited for use.	3.87	0.73	Satisfied
2. The rubber walkway sheet is aesthetically pleasing and attractive.	3.70	0.79	Satisfied
3. The rubber walkway sheet features a modern design.	3.87	0.73	Satisfied
4. The size of the rubber walkway sheet is appropriate for indoor use.	3.83	0.59	Satisfied
5. The rubber walkway sheet is lightweight and easy to move around the house.	4.23	0.50	Satisfied
Safety	4.15	0.48	Satisfied
6. The rubber walkway sheets grip the floor firmly and are not slippery.	4.27	0.58	Satisfied
7. The rubber walkway mats' surface is not slippery, reducing the risk of tripping and falling.	4.23	0.63	Satisfied
8. The edges and corners of the rubber walkway sheet are smooth and pose no tripping hazard.	4.03	0.62	Satisfied
9. Walking and standing on the rubber walkway sheet instills confidence in its safety against falling.	4.07	0.52	Satisfied

Table 2. The satisfaction with the prototype (N = 30) (Cont.)

Variables	Mean	SD	Level
Usability	3.91	0.67	Satisfied
10. The surface of the rubber walkway sheet enhances the walking experience within the home.	4.00	0.74	Satisfied
11. The rubber walkway sheet is durable and suitable for long-term use.	3.93	0.69	Satisfied
12. Standing or walking on the rubber walkway sheet provides comfort for the feet.	4.07	0.91	Satisfied
13. You feel satisfied when walking on the rubber walkway sheet.	3.97	0.89	Satisfied
14. The rubber walkway sheet is easy to clean and maintain.	3.67	0.88	Satisfied
15. You would like to use the rubber walkway sheet to cover walkways inside the house.	3.83	1.15	Satisfied
Your overall satisfaction with the prototype	3.97	0.49	Satisfied

Thematic analysis of open-ended feedback identified five areas for improvement. Eight participants (26.7% of the sample) provided specific recommendations for prototype improvement. All proposed: a) enlarging the raised surface pattern for comfort; b) increasing material softness to reduce foot pain during prolonged use; c) increasing surface roughness; d) expanding the sheet for ease of moving; and e) real-world testing. These suggestions emphasize the importance of improving the efficiency of a future Prototype (**Table 3**).

Table 3. Participant suggestions for prototype refinement (N = 8)

Suggestion category	Frequency	Representative quotes	Design implication
a. Enlarge raised surface pattern	3/8	Enlarge the massage button size	Optimize texture dimensions for comfort
b. Increase rubber softness	3/8	Soften the rubber; walking causes foot pain	Revise material composition
c. Increase surface roughness	1/8	Need the rubber sheet to be a little rougher	Revise material composition
d. Expand sheet dimensions	1/8	Replace small modular units with larger sheets for easy moving	Should not use small 10 × 10 cm pieces—assembly feels unstable; make larger 50 × 80 cm sheets
e. Use in home	1/8	Want it to be used at home	Used at home for real testing

Discussion

Older adults experience age-related deterioration, which can lead to balance problems caused by slower walking, shorter steps, reduced foot lift, and decreased muscle strength, thereby increasing their risk of falling.[32,33] Additionally, inappropriate flooring in a home increases the risk of falls.[14] When a fall occurs, they are more likely to experience subsequent falls, resulting in fear, anxiety, and a lack of confidence in walking due to the fear of falling again.[11,34] Therefore, the Walkway Rubber Sheet for older adults is an innovation designed to give older adults confidence in walking, provide comfort for the feet, prevent falls in older adults, and be suitable for use in daily life. This sheet is made from natural rubber (NR), ethylene octene copolymer (EOC), sawdust, clay, and oil. Most participants were older women, many of whom had chronic illnesses, and who walked barefoot indoors. These factors influence their experience with the Sheet.

The findings of this study highlight the effectiveness of our innovation for older adults in a controlled setting, covering design, safety, and usability. The study supports the importance of designing home environments that reduce fall risks for older adults, particularly by avoiding improper flooring materials. The high satisfaction in all categories can be directly linked to key prototype features addressing common flooring hazards as follows: **Safety** (Highest rated: mean = 4.15) show participants' strong acceptance of safety features, particularly the firm grip (Item 6, mean = 4.27) and non-slip surface reducing trip and fall risk (Item 7, mean = 4.23), likely due to the raised surface (0.3 mm height) designed explicitly for slip resistance and the material composition (NR, EOC, sawdust, clay, oil) providing stable footing, due to a natural property of rubber that is highly flexible, and abrasion resistance.[24] This material composition directly contrasts with the hazardous slipperiness of standard glazed tile flooring,[33] as reported by participants. **Usability** (mean = 3.91) showed that participants felt comfortable using the prototype (Item 10, mean = 4.00). Standing or walking on the prototype felt comfortable (Item 12, mean = 4.07). Ease of cleaning and maintenance (Item 14, mean = 3.67) scored relatively lower; the overall usability underscores the prototype's practicality for daily use. **Design** (mean = 3.90) demonstrated satisfaction with the shape, modern design, and appropriate size for indoor use, which can be attributed to the choices of suitable materials for house floors (use of dark, matte, non-shiny colors). The high score for being lightweight and easy to move around the house (Item 5, mean = 4.23) is consistent with the satisfaction of usability, a key usability requirement identified in the literature review.[18] Feedback suggesting larger pre-assembled sheets (**Table 4**) indicates potential for further optimizing this aspect.

The scale satisfied all categories, suggesting that the Walkway Rubber Sheets could address key concerns.[9,14,34] Participants were delighted with the grip of the floor, which was firm and non-slippery, and the surface reduced the risk of tripping and falling, indicating that the prototype improves safety during brief exposure. The satisfaction score of the usability suggests a desire to use the prototype to walk within the house and a feeling of comfort while walking on it. The satisfaction with the design indicates that the prototypes have a suitable shape for use as a walkway inside the house. The design is lightweight and easy to move around, making it well-suited for daily use. Therefore, the Walkway Rubber Sheet for older adults is an innovative product designed to enhance walking confidence and foot comfort, aiming to contribute to fall prevention in daily life. The higher safety satisfaction scores indicate that participants felt more confident about falling safely when walking or standing on the rubber mat. However, this TRL 5 study prioritized controlled validation; its short exposure design limits inference to real-world efficacy. We strongly recommend, in the longer term, real-world home studies (TRL 6-7)[23] to measure functional outcomes, such as gait parameters, fear of falling scales, and fall incidence. Consistent with the overall satisfaction, the rating of 3.97 fell slightly below the criterion of very satisfaction of 4.51, suggesting areas for improvement. Further investigation is needed to improve the Walkway Rubber Sheet by making it larger, easier to assemble, and more convenient to move around the house. Additionally, the raised button surface should be made softer and increased in size. Testing in real-world conditions is also necessary.

The results focus on flooring interventions, which play a crucial role in fall prevention and confidence in walking safety for older adults, as most participants in the study lived in homes with tile floors and walked barefoot, making it practically possible to enhance home safety. Future research, as a TRL 5 validation study, should have a primary focus on user satisfaction to assess the acceptability of design, safety, and usability, key metrics for early-stage prototyping. Future TRL 6-7 studies should evaluate functional outcomes using an in-home setting, including homes and aged care settings.

Limitations

This study has two limitations. First, assembling each Walkway Rubber Sheet (10 × 10 cm) into a large size (50 × 80 cm) required 40 pieces, which takes time and effort. This process affected the stability of the sheet connections, and as a result, the research team could not test the prototype inside the house.

Second, the brief exposure protocol (2-3 meters; >10 seconds of standing or walking; > 2 walking trials) was designed to prioritize participants' initial impressions, comfort, and safety. However, it may not adequately represent long-term usability. Future TRL 6-7 studies should extend exposure longitudinally, implement designs to track satisfaction and functional outcomes over time, and test prototypes in real-world home environments.

Conclusions and Implications for Nursing Practice and Research

The Walkway Rubber Prototype could be further developed for use by older adults. The participants were satisfied with the prototype in all categories (design, safety, usability), particularly in safety due to its firm grip on the floor, non-slip surface, and reduced risk of tripping and falling. Design efficacy is lightweight and easy to move, aligning with the needs of older adults for home adaptability. Gaps for improvement should include expanding the Walkway Rubber Sheet, enlarging the raised button, and making it softer to reduce foot pain. Additionally, increasing surface roughness and conducting real-world home testing should be considered. The prototype addresses critical risks for Thai older adults (80% use slippery glazed tiles; 96.7% walk barefoot indoors), but assembly complexity and brief lab-based testing limit real-world applicability.

For nursing practice, these findings provide evidence supporting the use of rubber walkway prototypes as part of holistic fall-prevention strategies, not only in Thailand but also internationally. Nurses can advocate their use in home safety motivations while leading real-world validation (TRL 6-7) through community partnerships. This approach will allow older adults to provide more accurate assessments of their satisfaction, leading to further refinements that align with their actual needs and to the inclusion of interdisciplinary input in future studies.

Author Contributions

Conceptualization, Study design, Patent application: N.W., N.K., A.T.
Data curation: N.W., N.K., P.M.
Writing—original draft: N.W., N.K.
Mold design, Prototype development: A.T.
Funding acquisition, Formal analysis (statistics), Manuscript revision, Project administration: N.K.
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การพัฒนาและการประเมินผลแผ่นยางทางเดินเพื่อผู้สูงวัย : ด้านการออกแบบ ด้านความปลอดภัยและด้านการใช้งาน

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บทคัดย่อ : พื้นทางเดินที่เหมาะสมกับผู้สูงอายุสามารถลดการหกล้ม และเพิ่มความมั่นใจในการเดินปฏิบัติกิจวัตรประจำวันได้ การศึกษานี้มีวัตถุประสงค์เพื่อพัฒนาต้นแบบนวัตกรรมแผ่นยางทางเดินภายในบ้านของผู้สูงอายุและเพื่อประเมินความพึงพอใจของผู้สูงอายุต่อการใช้นวัตกรรมแผ่นยางทางเดินภายในบ้าน การศึกษานี้ใช้วิธีการออกแบบและพัฒนา โดยเป็นการศึกษากลุ่มเดียววัดผลเฉพาะหลังการทดลอง กลุ่มตัวอย่างเป็นผู้สูงอายุ 60 ปีขึ้นไปจำนวน 30 คน คัดเลือกตามเกณฑ์ ดังนี้ สามารถดูแลตนเองได้ดี ไม่มีบาดแผลที่เท้า สามารถสื่อสารภาษาไทย และสมัครใจเข้าร่วมการทดลอง กลุ่มตัวอย่างได้ทดสอบต้นแบบแผ่นยางทางเดิน โดยการเดินเท้าเปล่าหรือสวมถุงเท้าในระยะก้าวปกติตามทางเดินระยะทาง 2.4 เมตร (พื้นปกติ 1 เมตร พื้นแผ่นยางทางเดิน 0.72 เมตร และพื้นปกติ 1 เมตร) เดินไป-กลับอย่างน้อย 2 รอบและยืนหรือเดินย่ำบนพื้นแผ่นยางทางเดินอย่างน้อย 10 วินาที ความพึงพอใจต่อการใช้นวัตกรรมถูกประเมินทันทีหลังทดสอบ โดยใช้แบบประเมินความพึงพอใจจำนวน 15 ข้อที่ผ่านการตรวจสอบความถูกต้องแล้ว ลักษณะแบบประเมินเป็นแบบมาตราส่วนประมาณค่า ซึ่งประเมินด้านการออกแบบ ด้านความปลอดภัย และด้านการใช้งาน คะแนนความพึงพอใจถูกตีความโดยใช้เกณฑ์มาตรฐาน (พึงพอใจมาก : 4.51-5.00)

กลุ่มตัวอย่างส่วนใหญ่เป็นเพศหญิง อายุเฉลี่ย 69.00 ± 8.89 ปี อาศัยอยู่ในบ้านที่มีพื้นบ้านเป็นพื้นกระเบื้อง และเดินเท้าเปล่าภายในบ้าน กลุ่มตัวอย่างมีความพึงพอใจต่อการใช้นวัตกรรมโดยรวมอยู่ในระดับมาก โดยมีความพึงพอใจต่อการใช้นวัตกรรมทั้ง 3 ด้าน ได้แก่ ด้านการออกแบบ ด้านความปลอดภัยและด้านการใช้งานอยู่ในระดับมาก แต่คะแนนเฉลี่ยความพึงพอใจต่อการใช้นวัตกรรมในภาพรวม (3.97, 95% CI [3.79, 4.15]) ต่ำกว่าเกณฑ์ความพึงพอใจมากที่สุด (4.51) ซึ่งบ่งชี้ถึงความจำเป็นในการปรับปรุงและทดสอบประสิทธิภาพของนวัตกรรมแผ่นยางทางเดินในในระดับความพร้อมด้านเทคโนโลยีที่สูงขึ้นสำหรับการพยาบาล ผลการวิจัยเหล่านี้เน้นย้ำถึงประสิทธิภาพของต้นแบบแผ่นยางทางเดินในการป้องกันการหกล้มที่บ้าน ซึ่งอยู่ระหว่างการทดสอบประสิทธิภาพในการทดลองใช้จริงภายในบ้าน

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