# INTEGRATED LIFESTYLE MEDICINE AND HEALTH LITERACY TRAINING FOR DUAL FALL AND DEMENTIA PREVENTION AMONG OLDER ADULTS IN RURAL THAILAND: A COMMUNITY-BASED PEER EDUCATION RESEARCH AND DEVELOPMENT STUDY

*Kridsada Sirichaisit*

**Regional Health Promotion Center 8 Udonthani, Department of Health, Ministry of Public Health, Thailand**

**Abstract**

**Background:** Thailand's ageing population faces rising burdens of falls and dementia, major causes of disability and healthcare costs. Limited health literacy and rural healthcare access, especially in Health Region 8, heighten these risks. Community-based, lifestyle-focused interventions offer a promising path toward sustainable, peer-led health promotion.

**Objective:** This study aimed to develop and evaluate an integrated lifestyle medicine and health literacy training program for elderly health coaches to manage dementia and fall risks among community-dwelling older adults.

**Methods:** A four-phase community-based quasi-experimental research and development study with a nonrandomized pre-post intervention design was implemented over 12 months across seven northeastern Thai provinces. The study included 6,227 participants in four groups: coaches (n=1,007) and risk participants (n=5,220), each stratified by falling risk alone or combined with dementia risk. The integrated lifestyle medicine and health literacy program was delivered through two modalities: intensive coach training, followed by implementation of peer education. Outcomes included the Timed Up and Go (TUG) test, Mini-Cog assessment, flexibility and strength tests, and knowledge assessments. Statistical analysis employed Wilcoxon signed-rank tests and Linear Mixed Models using R version 4.5.1.

**Results:** Significant improvements were observed across the total participants (n=6,227, all $p < 0.001$): TUG improved by 2.05 seconds (95% CI: -2.14 to -1.96), Mini-Cog by 1.11 points (95% CI: 1.08 to 1.15), flexibility by 0.45 points, strength by 4.49 repetitions, and knowledge by 1.56 points. Subgroup analyses showed consistent benefits across all four groups, with combined-risk participants demonstrating the most significant improvements (TUG: -2.3 seconds; Mini-Cog: +1.2 points).

**Conclusion:** The integrated program effectively improved both fall risk and cognitive function through sustainable peer education, with participants at combined risk showing the most significant benefits. Comparable outcomes between coaches and peer-educated participants validate scalability. These findings support integrating dual-prevention interventions into Thailand's national healthy aging strategies and primary care systems as a cost-effective model for addressing multiple age-related risks in resource-limited settings.

**Keywords:** lifestyle medicine, health literacy, fall prevention, dementia prevention, community intervention

J Southeast Asian Med Res 2025: 9: e0259
https://doi.org/10.55374/jseamed.v9.259

Correspondence to:
Sirichaisit K, Regional Health Promotion Center 8 Udonthani, Department of Health, Ministry of Public Health, Thailand
E-mail: kridsada.s@anamai.mail.go.th

Received: 5 October 2025
Revised: 18 November 2025
Accepted: 5 December 2025

## Introduction

Population ageing is a global phenomenon with profound implications for health and social systems. Worldwide, the proportion of people aged 60 years and older is increasing faster than any other age group. By 2030, one in six people globally will be aged 60 years or over, rising from 1 billion in 2020 to 1.4 billion.[1] Between 2020 and 2050, the number of people aged 80 years and older is expected to triple, reaching 426 million.[1] The majority of this growth will occur in low- to middle-income countries, where health and social care infrastructure is often least prepared to meet the needs of older adults. Thailand exemplifies this demographic transition, having already entered the stage of a super-aged society. In 2023, older adults aged 60 years and above accounted for 20.8% of the national population, totaling approximately 14.9 million people, and this proportion is projected to continue increasing.[2] This rapid demographic shift underscores the urgency of addressing age-related conditions such as Dementia, which are leading contributors to morbidity, disability, and healthcare costs. It highlights the need for sustainable, community-based strategies to promote healthy ageing.

Despite growing evidence supporting separate fall prevention and dementia prevention programs, few studies have integrated both conditions within a unified lifestyle medicine framework delivered through community peer-education models. While multicomponent interventions have shown promise for individual conditions, the potential synergistic benefits of addressing overlapping risk factors through a single, comprehensive program remain underexplored, particularly in resource-limited rural settings.

Falls are a significant health concern among older adults, contributing significantly to morbidity, disability, and mortality. Globally, falls are the second leading cause of unintentional injury deaths, with an estimated 684,000 fatalities each year, more than 80% of which occur in low- and middle-income countries.[3] In the United States, over 14 million adults aged 65 and older report falling each year, with approximately 37% of those who fall experiencing an injury that required medical treatment or restricted their activity for at least one day, resulting in an estimated 9 million fall injuries.[4] In Thailand, national cross-sectional studies have documented fall prevalence among elderly populations, with variations across different time periods and geographic regions.[5] Hip fractures remain a particularly severe consequence, associated with high mortality rates and significant long-term functional impairments, representing a major public health burden globally. [6,7] These findings underscore the urgent need for comprehensive fall-prevention strategies tailored to aging populations.

Dementia represents a significant global health challenge, particularly among older adults aged 65 years and above, with substantial disease burden documented across diverse populations.[8] The World Health Organization recognizes Dementia as a significant public health priority affecting millions worldwide, necessitating comprehensive preventive strategies and interventions.[9] In Thailand, Dementia poses an increasingly critical concern for the elderly population, with multiple factors contributing to its progression.[10] Chaowilai et al. emphasize the urgent need for protective guidelines tailored explicitly for the Thai elderly to mitigate dementia risk.[11] However, addressing this challenge

is complicated by varying levels of health literacy among the elderly, which significantly influence health outcomes and behaviors.[12,13] Studies have shown that the Thai elderly exhibit diverse levels of health literacy,[14] which directly affects their ability to engage in health-promoting behaviors and dementia-prevention strategies.[15] Consequently, researchers have recognized the critical need to develop targeted health literacy promotion models specifically designed to enhance dementia prevention among the Thai elderly population.[16]

Thailand's Health Region 8, which includes seven northeastern provinces (Nong Khai, Bueng Kan, Loei, Nong Bua Lamphu, Nakhon Phanom, Udon Thani, and Sakon Nakhon), has older persons accounting for nearly 21.6% of the regional population.[17] This region faces particular challenges due to its predominantly rural setting, including limited access to healthcare services, a high prevalence of non-communicable diseases, and suboptimal health literacy among older adults, all of which increase vulnerability to falls and Dementia.[18] Dementia screening remains inadequate, constrained by shortages of trained personnel and healthcare resources, leaving many older adults unaware of their risk status.[19] Nevertheless, emerging evidence suggests that community-based interventions focusing on lifestyle modification, such as regular physical activity, balanced nutrition, cognitive stimulation, and stress reduction, can significantly reduce dementia risk and promote healthy ageing.[20,21] These findings highlight the importance of developing sustainable, community-driven health promotion programs tailored to the needs of older adults in northeastern Thailand.

Given these challenges, there is a critical need for community-based interventions that can simultaneously address both fall and dementia risks while building local capacity for health promotion. Although lifestyle interventions have demonstrated efficacy for fall prevention and cognitive health independently, research integrating both conditions within a peer-led, lifestyle medicine framework remains limited, especially in Southeast Asian contexts. Training older adults with Dementia and increased risk of falling to become coaches for their peers represents an innovative approach that leverages shared experiences and cultural understanding while building sustainable local capacity.

The purpose of this study was to develop and evaluate an integrated lifestyle medicine and health literacy[13,16] training program for elderly health coaches, enabling them to effectively manage both dementia and fall risks among community-dwelling older adults through a scalable, peer-led health promotion model. It was hypothesized that this integrated intervention would significantly improve both fall risk indicators (TUG performance) and cognitive function (Mini-Cog scores) across all participant groups, with participants presenting combined falling and dementia risks showing greater improvements due to the synergistic effects of addressing multiple overlapping risk factors simultaneously.

## Methods

*Study design*

This study employed a four-phase quasi-experimental research and development study with a nonrandomized pre-post intervention design implemented over 12 months. All participants received the intervention either as trained coaches or as recipients of peer education. The research and development approach facilitated systematic program development, implementation, and evaluation tailored to the community context.

The study was conducted across Health Region 8 in northeastern Thailand, encompassing seven provinces: Nong Khai, Bueng Kan, Loei, Nong Bua Lamphu, Nakhon Phanom, Udon Thani, and Sakon Nakhon. Participants were recruited from 642 subdistricts across 87 districts in these seven provinces through purposive sampling in collaboration with Health Promotion Center 8 and local health services. The geographic distribution ensured broad regional representation, with recruitment sites including both urban and rural subdistricts to reflect the diversity of northeastern Thailand's elderly population.

The study was approved by the Health Promotion Center 8 Udon Thani Ethics Committee for Human Research (No. HPC08027) and adhered to ethical guidelines for human research. The study was conducted across four sequential phases spanning from September 2024 to August 2025. Phase 1 (September-October 2024) involved a comprehensive situation analysis through an extensive literature review and baseline data collection to establish the foundation for the intervention program. Phase 2 (November 2024-January 2025) focused on program development activities, including the design of training curricula and the development of outcome measurement tools tailored to the target population. The core implementation occurred during Phase 3 (February-July 2025), which encompassed the delivery of the training program and systematic data collection at two time points: a baseline assessment and a 3-month follow-up to assess sustained effects. Finally, Phase 4 (August 2025) was dedicated to comprehensive data analysis, program evaluation, and preparation of study findings and recommendations. This phased approach ensured systematic program development, rigorous implementation, and thorough evaluation of intervention outcomes across the study period.

*Participants*

The study enrolled elderly community members divided into four groups by role and risk profile: **Coach–Falling Risk Only** (n=269), older adults trained as health coaches with falling risk; **Coach–Falling + Dementia Risk (Combined Risk)** (n=738), trained coaches with combined risks; **Peer education recipients –Falling** Risk Only (n=1,204), high-risk members with falling risk who received peer education; and **Peer education recipients –Combined Risk** (n=4,016), high-risk members with combined risks who also received peer education. Participants were recruited through purposive sampling in collaboration with Health Promotion Center 8 and local health services across all seven provinces in Health Region 8. Baseline characteristics were compared between the coach and risk groups using Wilcoxon signed-rank tests for continuous variables and chi-square tests for categorical variables.

Participants were recruited through a sequential three-step screening process. First, community-dwelling older adults aged 60-69 years were recruited from Health Region 8 through collaboration with Health Promotion Center 8 and local health services. Second, all eligible individuals underwent fall risk screening using the Timed Up and Go (TUG) test[22] (>12 seconds) and/or a history of falls within 6 months. Third, participants with fall risk underwent Mini-Cog cognitive screening[23] that is frequently used to evaluate cognition in older adults in various settings. The primary objective of this review was to determine the accuracy of the Mini-Cog for detecting dementia in a community setting. Secondary objectives included investigations of the heterogeneity of test accuracy in the included studies and potential sources of heterogeneity. These potential sources of heterogeneity included the baseline prevalence of dementia in study samples, thresholds used to determine positive test results, the type of dementia (Alzheimer's disease dementia or all causes of dementia (scores ≤3 indicating cognitive impairment), stratifying them into falling risk only or combined falling and dementia risk groups. Exclusion criteria included severe cognitive impairment preventing informed consent, acute medical conditions requiring hospitalization, and inability to perform mobility assessments safely.

All 6,227 enrolled participants completed the 3-month follow-up assessment, resulting in zero attrition. This high retention was achieved through strong community engagement within existing village networks, regular contact by peer coaches, home visits by local health volunteers for those unable to attend scheduled assessments, the relatively short follow-up period, and convenient community-based assessment locations (village health centers, temples, community halls). All analyses were conducted on complete cases with paired baseline and follow-up measurements (n=6,227), requiring no imputation methods. (**Figure 1**)

*Integrated lifestyle medicine and health literacy program*

The integrated lifestyle medicine and health literacy program was delivered through a comprehensive community-based approach with two distinct modalities: coach training and peer education.

**Modality 1: Coach Training:** Coach training provided intensive instruction to selected community elders using a structured manual that integrated six lifestyle medicine domains: nutrition, physical activity, stress management, sleep hygiene, substance use reduction, and social engagement within a dual-focused fall and dementia prevention framework. The curriculum emphasized brain-healthy and musculoskeletal-supportive nutrition, the E75 exercise program[24,25] to enhance balance, strength, and cognition, and strategies for stress reduction, sleep optimization, and minimizing substance use. Social relationship-building activities were incorporated to mitigate isolation-related risks. Dual-risk assessment protocols combined the TUG test for fall risk with the Mini-Cog for cognitive screening. At the same time, intervention strategies addressed overlapping risk factors such as medication effects, sensory impairments, and social isolation. Practical training emphasized community feasibility through low-resource tools (a chair, a timer, paper, and a pen) and rotating skill-based stations covering exercise leadership, physical assessment, cognitive screening, memory games, and targeted brain training. This design ensured that community coaches acquired comprehensive, sustainable competencies to deliver integrated fall and dementia prevention interventions.

**Modality 2, Peer Education:** Following their training, coaches implemented peer education within their communities, focusing on knowledge transfer, practical skill demonstration, and ongoing support for high-risk community members. The peer education model emphasized the development of health literacy skills encompassing knowledge acquisition, practical application, and knowledge dissemination to community members.

Program fidelity was maintained through standardized coach training using a curriculum manual delivered by trained facilitators from Health Promotion Center 8, with completion documented through attendance records. Coaches received written materials and practical guides to ensure consistent implementation of peer education activities across seven provinces. Assessment procedures were standardized across all sites, with assessors trained to administer identical protocols for outcome measures (TUG test, Mini-Cog, flexibility and strength tests, and knowledge assessments) using the same equipment. Data collection occurred at baseline and 3-month follow-up to ensure systematic assessment across all participants and groups.

*Outcome measures*

Outcomes included integrated fall and dementia risk assessments that captured the interconnected nature of both conditions through validated, dual-purpose measurement tools. The TUG test measured functional mobility and fall risk.[22] Participants stood from a standard chair (46 cm height), walked 3 meters, turned around, walked back, and sat down, with time recorded in seconds. Times >12 seconds indicated increased fall risk, with each second improvement representing clinically meaningful fall risk reduction and reflecting executive function and motor planning abilities relevant to cognitive screening. Lower times indicate better mobility and reduced fall risk. The Mini-Cog assessed cognitive function using three-word recall and clock drawing (score range: 0-5).[23] Cognitive screening test that is frequently used to evaluate cognition in older adults in various settings. The primary objective of this review was to determine the accuracy of the Mini-Cog for detecting dementia in a community setting. Secondary objectives included investigations of the heterogeneity of test accuracy in the included studies and potential sources of heterogeneity. These potential sources of heterogeneity included the baseline prevalence of dementia in study samples, thresholds used to determine positive test results, the type of dementia (Alzheimer's disease dementia or all causes of

dementia Scores ≤ 3 indicated possible cognitive impairment and increased dementia risk, while also identifying cognitive factors that contribute to fall risk through impaired judgment and spatial awareness. Higher scores reflect better cognitive function. Back Scratch Test: upper body flexibility was assessed by having participants reach behind their back, above and below, to touch their fingers.[26] Scoring: 0=fingers do not touch (>5 cm apart), 1=fingers touch or close (<5 cm), 2=fingers overlap (range: 0-2 points). Higher scores indicate better flexibility, necessary for functional independence in activities of daily living and balance recovery responses critical for fall prevention. In the 2-Minute Step Test, participants marched in place for 2 minutes, lifting their knees to a target height (midpoint between the kneecap and the iliac crest).[27] the TMST has the advantage of requiring limited space, only a few minutes' time, and no expensive equipment. These advantages notwithstanding, the test must be clinimetrically sound if it is to be recommended. We sought therefore to summarize the literature addressing TMST performance and measurement properties. Relevant literature was identified by searches of 3 electronic databases (PubMed, Scopus, and Cumulative Index of Nursing and Allied Health Total right knee lifts reaching the target height were counted as repetitions. Higher counts indicate better lower-body strength and cardiovascular endurance, essential for fall prevention through improved balance and for supporting brain health and cognitive function through aerobic capacity. Additionally, a comprehensive Knowledge Assessment (range: 0-10 points) was administered pre- and post-intervention to evaluate coaches' understanding of integrated fall and dementia prevention strategies, their risk-factor identification capabilities, and their mastery of intervention techniques applicable to both conditions.

*Data collection*

Anthropometric measures, including body weight and BMI, were assessed for their dual relevance to fall risk, where underweight status increases fragility, and obesity impairs balance, and dementia risk, as both malnutrition and obesity contribute to cognitive decline. All data were collected by public health personnel.

*Statistical analysis*

Descriptive statistics were calculated for baseline characteristics, presented as means with standard deviations for continuous variables and frequencies with percentages for categorical variables. Baseline comparisons used Mann-Whitney U tests for continuous variables and chi-square tests for categorical variables. Within-group changes from baseline to 3-month follow-up were analyzed using Wilcoxon signed-rank tests as appropriate, with Cohen's d effect sizes calculated.

**Primary analysis:** Linear Mixed Models (LMM) examined the overall program effect across all participants. For each outcome (TUG, Mini-Cog, Back Scratch Test, Step Test), LMMs included fixed effects for time (baseline vs. follow-up), role (coach vs. peer education recipient), risk profile (falling only vs. combined risk), their interactions (time × role, time × risk, time × role × risk), and covariates (age, sex, province-level characteristics). Random intercepts were specified for province and participants nested within province.

**The random intercept** for province (1 | province_id) accounted for geographic clustering and variations in coach-to-participant ratios across provinces (range: 1:3.0 to 1:6.7). Province-level covariates (population, income, life expectancy, HALE, doctor-per-population) were included as fixed effects to control for contextual differences in healthcare infrastructure and socioeconomic conditions.

**Secondary analysis:** Difference-in-differences (DID) analyses examined whether intervention effects differed by delivery modality and risk profile using interaction terms from the LMMs. Key interactions tested were: (1) time × role (coaches vs. peer education recipients), (2) time × risk (falling only vs. combined risk), and (3) time × role × risk (differential modality effect by risk profile). Post-hoc estimated marginal means (EMMs) and DID contrasts compared coaches versus peer education recipients within each risk stratum.

Results are presented as means with standard deviations for descriptive statistics, estimated marginal means with 95% confidence intervals from LMMs, Cohen's d effect sizes with 95% confidence intervals for within-group comparisons, and model coefficients and p-values for interaction terms. Forest plots visualize treatment effects across outcomes. Statistical significance was set at $p < 0.05$. All analyses were conducted using R version 4.5.1.

## Results

*Baseline characteristics*

The study enrolled 6,227 participants across seven provinces in Health Region 8. Among the coach groups, 269 participants had falling risk only (83.6% female, mean age 63.7±2.50 years) and 738 had combined risk (73.3% of total coaches). In the community groups, 1,204 participants had only a falling risk, while 4,016 had combined risks. Baseline characteristics showed statistically significant but clinically small differences between groups in age ($p$<0.001), gender distribution ($p$=0.033), and BMI ($p$=0.037). The four-group design allowed for comprehensive analysis of intervention effects across different risk profiles and participant roles within the community-based peer education model. Participants were recruited from all provinces in Health Region 8, with the most significant representation from Udon Thani (25.8% of

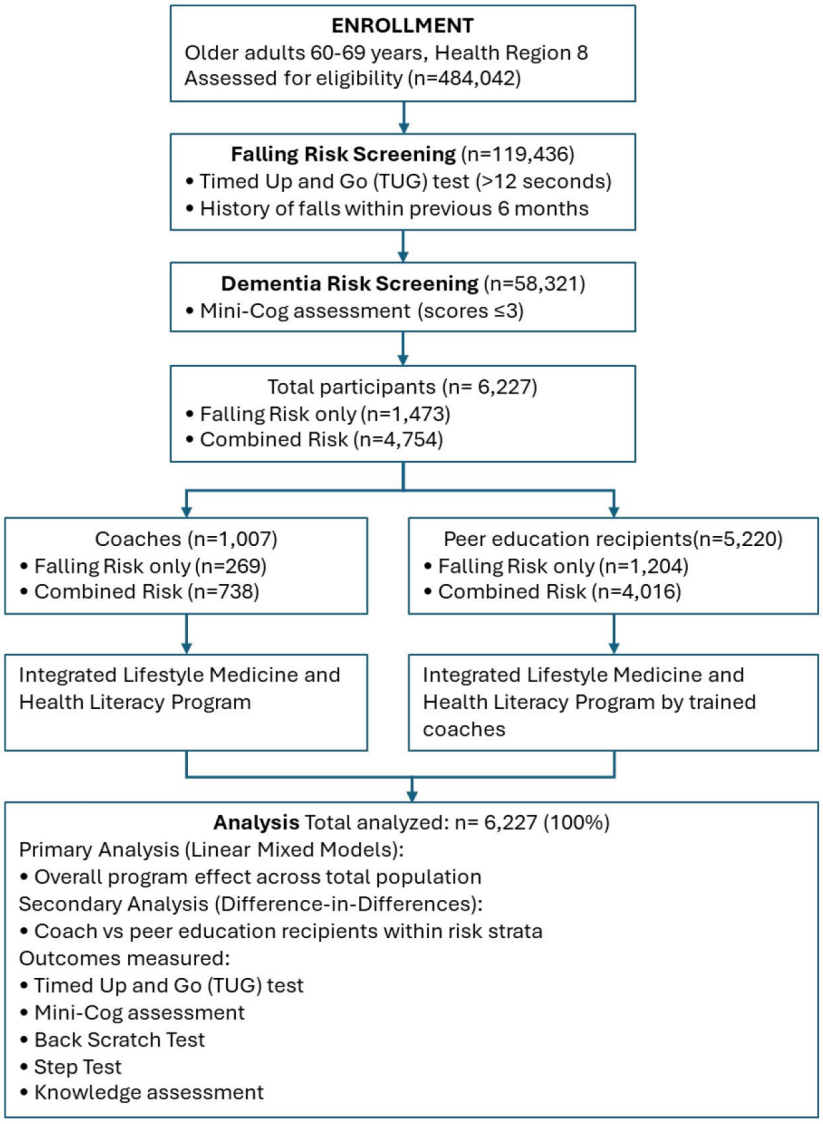



**Figure 1.** Participant Flow Diagram

the risk group, 22.4% of the coach group) and Sakon Nakhon (21.6% of the risk group, 19.9% of the coach group). (**Table 1**)

*Intervention Outcomes*

*Overall program effectiveness*

The integrated lifestyle medicine and health literacy program demonstrated significant improvements across all outcome measures in the total study participants (n=6,227) from baseline to 3-month follow-up (all $p < 0.001$). Functional mobility, assessed by the Timed Up and Go test, improved by a mean of 2.05 seconds (95% CI: -2.14 to -1.96), representing a clinically meaningful reduction in fall risk. Cognitive function, as measured by Mini-Cog scores, increased by 1.11 points (95% CI: 1.08 to 1.15), indicating enhanced cognitive reserve. Upper body flexibility measured by the Back Scratch Test improved by 0.45 points (95% CI: 0.43 to 0.47), while lower body strength and balance assessed through the Step Test in The study was conducted across Health Region 8 in northeastern Thailand, encompassing seven provinces: Nong Khai, Bueng Kan, Loei, Nong Bua Lamphu, Nakhon Phanom, Udon Thani, and Sakon Nakhon. Participants were recruited from 642 subdistricts across the country, with an increase of 4.49 repetitions (95% CI: 4.11 to 4.88). Knowledge scores increased by 1.56 points (95% CI: 1.47 to 1.66), demonstrating an effective improvement in health literacy.

*Subgroup analysis by delivery modality and risk profile*

Subgroup analyses revealed consistent improvements across both delivery modalities (coach training and peer education) and all four risk profile groups (**Table 2, Figure 2**). For the

**Table 1.** Baseline characteristics of participants

| Characteristic | Coach (n=1007) | Risk (n=5220) | *p*-value |
|---|---|---|---|
| Age, years | 63.7 (2.50) | 63.9 (2.55) | <0.001 |
| Female, n (%) | 942 (83.6) | 3145 (81.2) | 0.033 |
| Falling risk, n (%) | 1007 (100.0) | 5220 (100.0) | <0.001 |
| Falling and dementia risk, n (%) | 738 (73.3) | 4016 (76.9) | 0.014 |
| Health Insurance, n (%) | | | <0.001 |
| Universal Coverage Scheme | 854 (84.8) | 4582 (87.8) | |
| Civil Servant Medical Benefit Scheme | 136 (13.5) | 536 (10.3) | |
| Social Security Scheme | 3 (0.3) | 11 (0.2) | |
| Local Government Health Scheme | 14 (1.4) | 89 (1.7) | |
| Body Weight (kg) | 59.9 (10.1) | 59.5 (9.8) | 0.482 |
| BMI (kg/m²) | 24.66 (3.81) | 24.41 (3.71) | 0.037 |
| TUG (seconds) | 12.71 (2.79) | 12.41 (2.86 | <0.001 |
| Mini-Cog (score) | 2.66 (1.53) | 2.71 (1.41 | 0.381 |
| Scratch (score) | 1.62 (0.76) | 1.60 (0.74) | 0.191 |
| Step (steps) | 72.37 (21.06) | 71.60 (18.92) | 0.677 |
| Province, n (%) | | | <0.001 |
| Udon Thani | 226 (22.4) | 1348 (25.8) | |
| Nong Khai | 100 (9.9) | 300 (5.7) | |
| Nakhon Phanom | 120 (11.9) | 604 (11.6) | |
| Nong Bua Lamphu | 100 (9.9) | 303 (5.8) | |
| Sakon Nakhon | 200 (19.9) | 1125 (21.6) | |
| Loei | 141 (14.0) | 942 (18.0) | |
| Bueng Kan | 120 (11.9) | 598 (11.5) | |

Values are mean±SD, or n (%). *p*-values from Mann–Whitney U, or chi-square, as appropriate.

TUG test, mean reductions ranged from -1.1 to -2.3 seconds across groups (all $p < 0.001$), with the most pronounced improvement observed in the peer education group with combined risk (-2.3 seconds, 95% CI: -2.7 to -1.9), followed by coaches with combined risk (-2.2 seconds, 95% CI: -2.5 to -1.9). Mini-Cog scores increased by 0.9-1.2 points across all groups (all $p < 0.001$), with participants in combined risk categories showing greater improvements (1.2 points) compared to those with falling risk only (0.9-1.0 points).

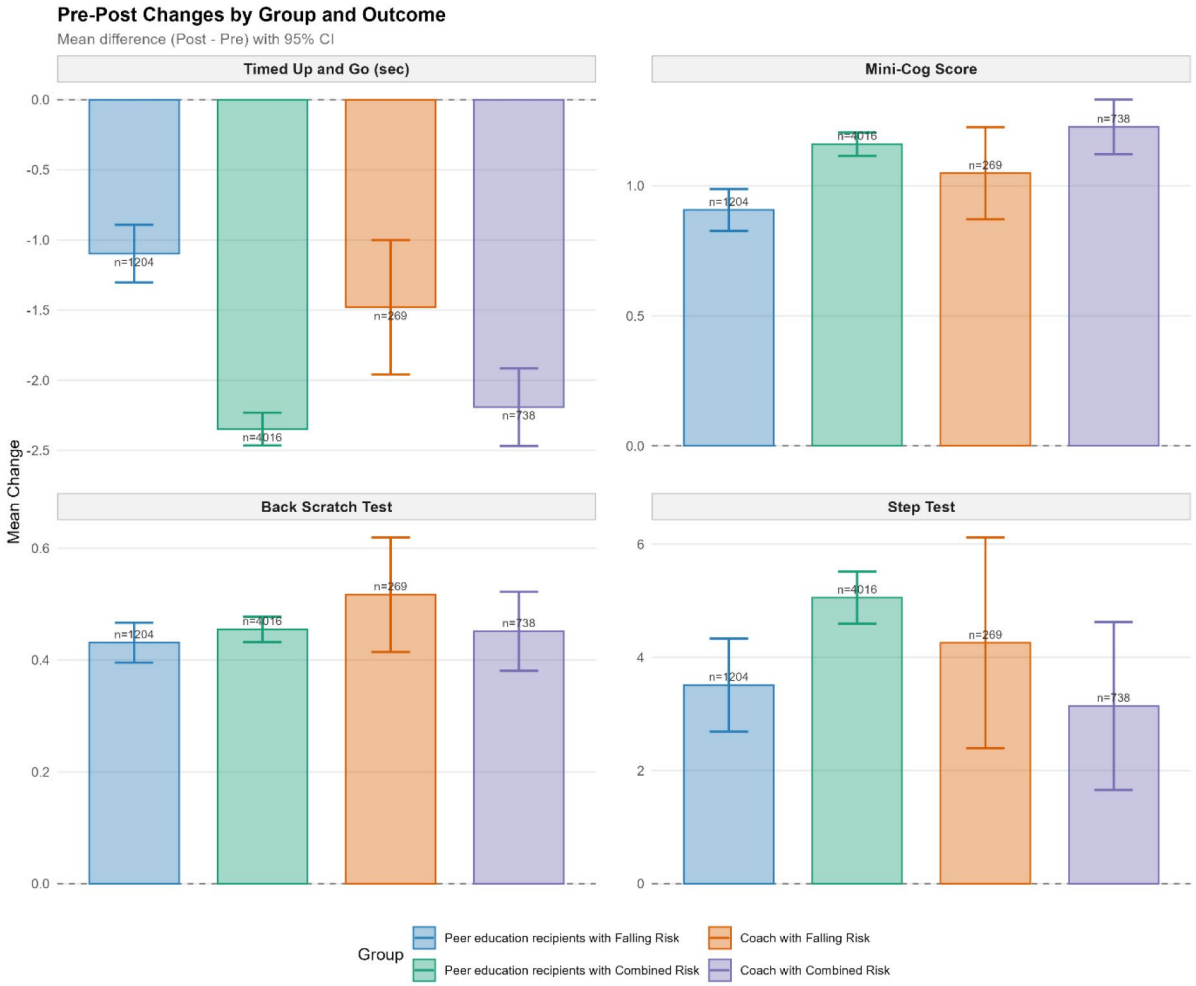
Upper body flexibility measured by the Back Scratch Test exhibited consistent improvements of 0.4-0.5 points across all groups (all $p < 0.001$), while lower body strength and balance assessed through the Step Test showed significant gains ranging from 3.1 to 5.1 repetitions (all $p < 0.001$). Knowledge scores increased substantially in all groups, with improvements of 1.5-1.7 points (all $p < 0.001$), indicating effective educational outcomes regardless of intervention modality. Anthropometric measures showed minimal, mostly non-significant changes (body weight: -0.1 to -0.3 kg; BMI: ≤0.1 kg/m²). The forest plot analysis (**Figure 2**) confirmed the consistency of positive treatment effects, with confidence intervals for functional and cognitive measures excluding zero, thereby corroborating the intervention's statistical significance and clinical relevance across both coaching approaches and risk profiles.

**Table 3** presents the interaction effects of coaching intervention and time (group coach: date_from_baseline) on six health outcomes. Significant interactions were found for two outcomes: Mini-Cog ($\beta = -0.071$, $p = 0.007$) and step count ($\beta = -1.478$, $p < 0.001$).

**Table 2.** Comparison of pre- and post-intervention outcomes in coach and risk groups

| Outcome | Coach (Falling Risk) | | | | | Coach (Combined Risk) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Mean Difference | Cohen's d (95% CI) | *p*-value | Pre | Post | Mean Difference | Cohen's d (95% CI) | *p*-value |
| TUG | 12.1 ± 2.7 | 10.6 ± 2.5 | -1.5 | -0.4(-0.6, -0.2) | <0.001 | 13.0 ± 2.8 | 10.8 ± 2.4 | -2.2 | -0.6(-0.8, -0.4) | <0.001 |
| Mini COG | 2.6 ± 1.5 | 3.6 ± 1.4 | 1 | 0.7(0.5, 0.9) | <0.001 | 2.7 ± 1.5 | 3.9 ± 1.1 | 1.2 | 0.8(0.6, 1.1) | <0.001 |
| Back Scratch Test | 1.5 ± 0.7 | 2.1 ± 0.7 | 0.5 | 0.6(0.4, 0.8) | <0.001 | 1.6 ± 0.8 | 2.1 ± 0.8 | 0.5 | 0.5(0.3, 0.7) | <0.001 |
| Step Test | 70.4 ± 19.5 | 74.6 ± 19.5 | 4.3 | 0.3(0.1, 0.5) | <0.001 | 73.1 ± 21.6 | 76.2 ± 21.3 | 3.1 | 0.2(0.0, 0.3) | <0.001 |
| Knowledge Score | 7.7 ± 1.6 | 9.3 ± 1.0 | 1.7 | -0.1(-0.3, 0.1) | <0.001 | 7.3 ± 1.6 | 8.9 ± 1.5 | 1.5 | 1(0.8, 1.2) | <0.001 |
| Outcome | Peer education recipients (Falling Risk) | | | | | Peer education recipients (Combined Risk) | | | | |
| | Pre | Post | Mean Difference | Cohen's d (95% CI) | *p*-value | Pre | Post | Mean Difference | Cohen's d (95% CI) | *p*-value |
| TUG | 11.7 ± 2.5 | 10.6 ± 2.6 | -1.1 | -0.3(-0.5, -0.1) | <0.001 | 12.6 ± 2.9 | 10.3 ± 2.4 | -2.3 | -0.6(-0.8, -0.4) | <0.001 |
| Mini COG | 2.7 ± 1.4 | 3.6 ± 1.3 | 0.9 | 0.6(0.4, 0.8) | <0.001 | 2.7 ± 1.4 | 3.9 ± 1.1 | 1.2 | 0.8(0.6, 1.0) | <0.001 |
| Back Scratch Test | 1.6 ± 0.7 | 2.0 ± 0.7 | 0.4 | 0.7(0.5, 0.9) | <0.001 | 1.6 ± 0.7 | 2.1 ± 0.8 | 0.5 | 0.6(0.4, 0.8) | <0.001 |
| Step Test | 73.6 ± 20.7 | 77.1 ± 20.6 | 3.5 | 0.2(0.0, 0.4) | <0.001 | 71.0 ± 18.3 | 76.1 ± 20.5 | 5.1 | 0.3(0.1, 0.5) | <0.001 |

Values are mean ± SD. TUG = Timed Up and Go test; BMI = Body Mass Index; Mini-COG = Mini-Cognitive Assessment; CI = Confidence Interval; SD = Standard Deviation. p-values from Wilcoxon signed-rank tests.




*Mean differences (95% CI) from baseline to 3-month follow-up for seven outcomes across four groups: Peer education recipients-Falling Risk, Peer education recipients-Combined Risk, Coach-Falling, Coach-Combined.*

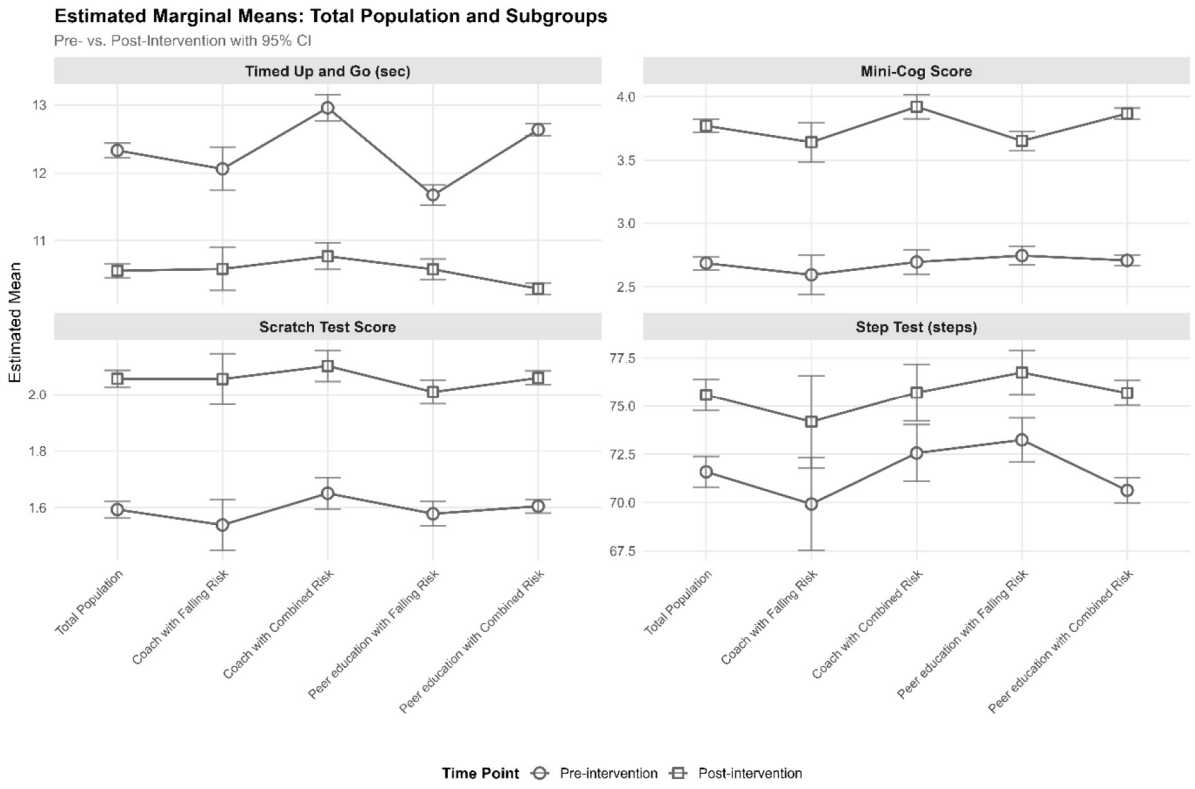
**Figure 2.** Estimated change (95% CI) for pre-post test in coach and peer education recipient groups

**Figure 3** presents estimated marginal means for four primary outcomes at baseline (circles) and at 3-month follow-up (squares) across all participants and subgroups. Consistent improvements were observed in all categories. The TUG test decreased by approximately 2.0 seconds overall, with all groups showing reduced times, indicating improved mobility. Mini-Cog scores increased by 1.1 points, Scratch Test scores improved by 0.5 points, and Step Test performance increased by 4.5 repetitions across the total participants. All groups demonstrated parallel trajectories with overlapping confidence intervals, indicating equivalent program effectiveness across delivery modality (coach training vs. peer education) and risk profile (falling risk only vs. combined risk), confirming the broad applicability of the integrated lifestyle medicine and health literacy program.

**Figure 4** presents the difference-in-differences analysis, showing minimal differential treatment effects between coach and risk groups across most outcomes, with confidence intervals generally spanning zero. For the **MiniCOG** and Back **Scratch Test**, point estimates were near zero with overlapping confidence intervals, indicating equivalent cognitive and flexibility gains across modalities. The **TUG test** showed small negative estimates favoring the coach group in both risk categories, but confidence intervals included zero, suggesting non-significance. The **Step Test** showed the greatest variation, with a positive estimate for the dementia-risk comparison (a wide interval extending beyond 5 repetitions) and a negative, non-significant estimate for the falling-risk comparison.

**Table 3.** Interaction effects of intervention and time on outcomes

| Outcome | Coefficient (β) | *p*-value |
|---|---|---|
| Timed Up & Go (sec) | 0.106 | 0.083 |
| Mini-Cog (score) | -0.071 | 0.007 |
| Back Scratch Test (score) | -0.004 | 0.788 |
| Step Count | -1.478 | <0.001 |




*Estimated marginal means (EMMs) with 95% confidence intervals for four primary outcomes at baseline (circles) and 3-month follow-up (squares) across total participants and subgroups. Panels show: TUG test in seconds (top left), Mini-Cog score in points (top right), Scratch Test score in points (bottom left), and Step Test in repetitions (bottom right). Categories on the x-axis: Total Participants, Coach with falling risk, Coach with combined risk, Peer education with falling risk, and Peer education with combined risk. For TUG, lower values indicate better mobility; for other outcomes, higher values indicate better performance. All groups showed significant improvements (p<0.001) with overlapping confidence intervals, demonstrating consistent program effectiveness across delivery modalities and risk profiles. EMMs derived from Linear Mixed Models adjusting for age, sex, and province characteristics, with random intercepts for province and participant.*

**Figure 3.** Estimated Marginal Means: Total Participants and Subgroups at Pre- and Post-Intervention

Slope differences (β coefficients) with 95% CIs comparing coaches versus peer education recipients participants for falling-only and combined-risk strata. Coefficients represent group_risk×date_from_baseline interaction terms from separate Linear Mixed Models for each outcome, adjusting for age, sex, province characteristics, with random intercepts for province and participant. The dashed line at zero indicates no differential effect. CIs crossing zero indicate non-significant interactions (parallel trends).

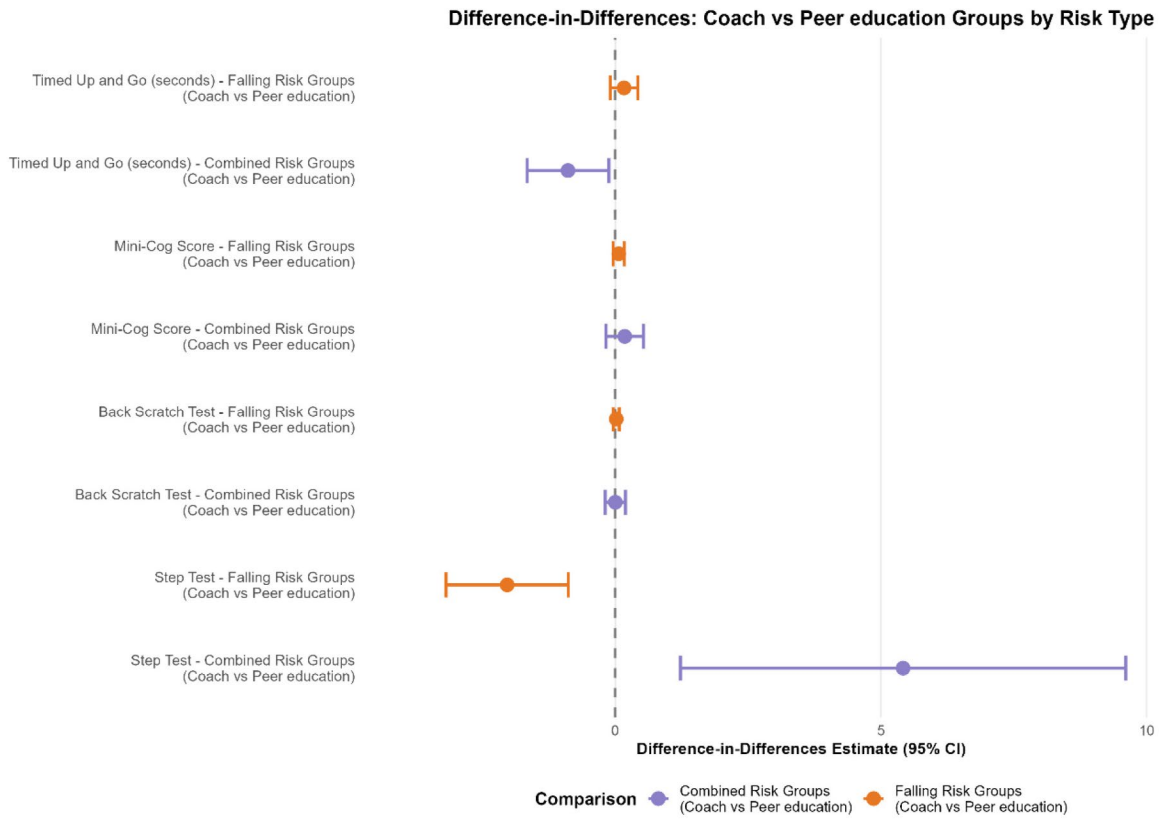



**Figure 4.** Differences in difference estimate of test outcome between coach and peer education recipient groups from linear mixed models

## Discussion

This study demonstrates the effectiveness of an integrated lifestyle medicine and health literacy program delivered through community-based coach training and peer education modalities, improving fall risk and cognitive function among older adults in rural Thailand. By employing a four-group analysis design, the study provided insights into the effectiveness of a dual fall–dementia prevention intervention across different risk profiles and participant roles within a peer education model. The use of a structured manual and simplified dual-risk assessment tools (TUG for falls, Mini-Cog for cognition) proved highly effective in building local capacity for integrated health promotion. These findings are consistent with prior evidence showing that multicomponent lifestyle interventions can reduce fall risk while enhancing cognitive outcomes in older adults.[28,29]

*Clinical significance and interpretation*

The magnitude of improvements observed in this study, TUG reductions exceeding two seconds and Mini-Cog gains of 1.0-1.2 points, are clinically meaningful. Faster TUG performance is associated with reduced fall incidence and preserved independence,[29] while Mini-Cog improvements reflect enhanced cognitive reserve and a delayed onset of Dementia.[28] These concurrent benefits suggest that integrated lifestyle interventions may be more effective than single-domain approaches, as shared risk factors such as physical inactivity, poor nutrition, and social isolation contribute to both falls and Dementia.[30] Supporting this interpretation, exercise has been shown to improve balance and neuroplasticity[31] while social engagement mitigates both mobility decline and cognitive deterioration.[32]

*Equivalence of peer education and direct training*

The parallel trajectories and overlapping confidence intervals across all four groups indicate equivalent intervention effectiveness regardless of coaching modality or risk profile.

These findings demonstrate that trained coaches effectively transmitted improvements to risk participants through peer education, validating the scalability of this community-based model. This peer-led approach is particularly valuable in resource-limited rural settings where access to trained healthcare professionals is constrained.

The intervention demonstrated consistent effectiveness across all seven provinces despite substantial variations in coach-to-participant ratios (1:3.0 to 1:6.7). The overlapping confidence intervals (**Figure 3**) and the random-intercept structure for province in the models indicate robust program effectiveness independent of implementation intensity. This consistency trengthens generalizability across diverse rural contexts with varying resource levels.

*Differential response in combined-risk participants*

The finding that participants with combined falling and dementia risk demonstrated the largest effect sizes warrants critical examination. Several mechanisms may explain this differential response. First, the integrated intervention may have produced synergistic effects by simultaneously addressing overlapping pathophysiological mechanisms; for example, improved physical activity enhances both balance and cerebral blood flow, while cognitive stimulation activities may improve both executive function and fall risk awareness. Second, participants who were aware of multiple risk factors may have demonstrated greater motivation and engagement with the intervention, resulting in better adherence to lifestyle modifications. Furthermore, participants with combined risk demonstrated the largest effect sizes, suggesting that individuals with dual vulnerabilities may derive the greatest benefit from integrated interventions; this challenges traditional healthcare approaches that treat falls and cognitive decline as separate conditions, highlighting the efficiency of comprehensive prevention programs that address overlapping risk factors.[30] The peer education model's success, with community participants achieving improvements comparable to their trained coaches, underscores the feasibility of sustainable, community-led interventions for complex health challenges.[33]

*Generalizability and broader implications*

The program's success across seven provinces within Health Region 8 demonstrates the effectiveness of integrated, peer-delivered approaches in rural, resource-limited settings, extending international evidence for lifestyle interventions.[34,35] However, findings should be interpreted within this region's specific context: predominantly rural villages with strong social networks, Thai-Lao cultural values that emphasize respect for elders and mutual support, and established village health volunteer infrastructure. These contextual factors likely facilitated high engagement and zero attrition. Generalizability is strongest in similar rural Thai and Southeast Asian settings with comparable social structures and cultural values. Substantial adaptation would be required for urban populations, individualistic cultural contexts, or regions lacking village-based health infrastructure. This study reinforces the potential of community-based strategies in culturally appropriate contexts.

Several limitations should be acknowledged. The quasi-experimental pre-post design, without a control group or randomization, limits causal inference, as observed improvements cannot be definitively attributed to the intervention rather than to secular trends, regression to the mean, practice effects, or concurrent health initiatives. Selection bias may exist, as volunteers may have been more health-conscious than the general elderly population.

The three-month follow-up period was insufficient to assess sustained benefits or clinically critical outcomes such as actual fall incidence, hip fractures, or dementia diagnosis. The Mini-Cog, while appropriate for large-scale screening, is a brief cognitive screening tool that may not capture subtle cognitive changes. Systematic data on intervention fidelity—including coach adherence, peer education quality and frequency, and implementation variation—were not collected, limiting understanding of dose-response relationships.

Although the province was included as a random effect, the study did not formally test province-specific intervention effects or whether coach-to-participant ratios (1:3.0 to 1:6.7) moderated outcomes. The study was conducted exclusively in rural northeastern Thailand with strong village networks and Thai-Lao cultural values, limiting generalizability to urban settings, different cultural contexts, or regions with weaker community infrastructure.

Future studies should employ cluster-randomized controlled designs with longer follow-up periods (≥2 years) to establish causal relationships and evaluate clinical outcomes. Comprehensive cognitive assessments, systematic fidelity monitoring, and province-stratified analyses are needed to strengthen the evidence base for scalable community strategies across diverse contexts.

*Recommendations for future research and studies in Thailand*

Future research should extend these findings through long-term prospective studies (≥2 years) that examine sustained intervention effects, including their impact on actual fall incidence, hip fractures, dementia diagnosis, and mortality. Cost-effectiveness analyses comparing dual-prevention programs with single-condition interventions and usual care are essential for informing resource allocation decisions. Implementation studies should assess long-term intervention fidelity, training quality, and coaching sustainability across diverse community contexts. Additional research priorities include adapting the model for urban populations, integrating it into primary healthcare systems, and measuring broader long-term outcomes, such as functional independence, quality of life, healthcare utilization, social participation, and caregiver burden.

*Policy recommendations*

This study demonstrates the feasibility of integrated fall and dementia prevention through peer education in rural northeastern Thailand, with short-term improvements across all groups. However, several limitations preclude immediate policy recommendations: quasi-experimental design limits causal inference; a three-month follow-up is insufficient for sustained effects; clinical endpoints (fall incidence, fractures, dementia diagnosis) were not assessed; and cost-effectiveness remains unknown. Future cluster-randomized trials with ≥2-year follow-up, hard clinical outcomes, and economic evaluation are essential before considering broader implementation. If subsequent research confirms long-term effectiveness and cost-efficiency, this community-based model could potentially inform national healthy aging strategies and primary care systems. These findings currently best serve to guide the design of more definitive evaluation studies.

## Conclusion

This study demonstrated that an integrated lifestyle medicine and health literacy program, delivered through coach training and peer education modalities, effectively reduced fall risk and improved cognitive function among older adults in rural Thailand. The intervention produced clinically meaningful improvements across all participant groups, with those at combined risk showing the most significant benefits. The comparable outcomes between trained coaches and peer-educated participants validate the scalability and sustainability of this approach in resource-limited settings.

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