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# Development of an Active Game Aimed at Promoting Arm Exercise in Older Adults: An Expert Assessment of Appropriateness

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## Abstract

Thailand's rapidly aging population has led to increased concerns regarding sedentary behavior, limited physical activity, and restricted access to rehabilitation among older adults. To address these issues, this study developed an active game designed to promote upper-body exercise through AI-based color-detection and pose-analysis technology, allowing older adults to perform safe and engaging arm exercises at home without the need for complex equipment. The research aimed to (1) develop the active game, (2) evaluate its usability and appropriateness, and (3) assess expert perceptions of game design, exercise safety, and motion-tracking performance. The system underwent expert evaluation by two groups: five Game Development Experts and five Exercise and Health Experts. Data were analyzed using descriptive statistics (Mean  $\pm$  SD). Results showed high levels of agreement from game experts, with particularly strong ratings for Safety & Physical Appropriateness ( $4.8 \pm 0.40$ ) and Usability & Interface Design ( $4.7 \pm 0.45$ ). Exercise and health experts also provided favorable evaluations, especially for Exercise Safety ( $4.0 \pm 0.08$ ) and Alignment with Health & Fitness Objectives ( $4.0 \pm 0.05$ ). Overall, findings indicate that the developed active game is safe, usable, motivating, and suitable for promoting arm exercise in older adults. The system demonstrates potential as an accessible digital tool to reduce sedentary behavior and support active aging.

**Keyword:** Active Game, Arm Exercise, Older Adults

## 1. Introduction

Thailand is rapidly transitioning into an aged society, with the proportion of individuals aged 60 and above increasing steadily. This demographic shift has resulted in several major public health concerns, particularly those related to sedentary behavior, insufficient levels of physical activity, and difficulties in accessing rehabilitation services. Recent national surveys indicate that many older adults spend an average of seven hours per day in sedentary activities and often fall short of the World Health Organization's recommendation of 150–300 minutes of physical activity per week. These patterns contribute to a range of health issues, including

reduced muscle strength, limited joint mobility, poor cardiovascular endurance, and an increased risk of chronic diseases.

Despite the clear benefits of regular movement and rehabilitation, older adults frequently encounter multiple barriers that hinder their ability to engage in consistent exercise. High costs of rehabilitation programs, difficulties in transportation, the need for specialized equipment, and the lack of accessible community-based exercise solutions are among the most cited challenges. These limitations contribute to prolonged inactivity and reduced independence in daily living. Furthermore, traditional exercise programs may not be appealing or motivating enough for older adults, leading to low adherence and inconsistent participation over time.

Recognizing these challenges, the concept for the project titled “Active Game Aimed at Promoting Arm Exercise in Older Adults: An Expert Assessment of Appropriateness” was initiated. The project aims to provide an engaging, accessible, and user-friendly digital solution that encourages upper-body exercise and promotes healthy movement behaviors among older adults. By integrating AI-based color-detection technology, the system can accurately monitor arm and shoulder movements, provide real-time feedback, and support personalized exercise routines without requiring expensive equipment.

The platform also features an elderly-friendly interface designed to reduce cognitive load and ensure ease of use, allowing older adults to exercise safely and independently in their own homes. This approach not only helps reduce sedentary behavior but also offers opportunities for long-term health monitoring, improved motivation, and enhanced quality of life. Through increased accessibility and innovative design, the system serves as a practical tool for supporting active aging and addressing key health challenges faced by older adults today.

## **2. Objectives**

1. To develop an active game aimed at reducing sedentary behavior and promoting upper-body exercise among older adults.
2. To evaluate the usability, appropriateness, and safety of the system.
3. To assess the performance of AI color-detection and pose-analysis technologies in detecting movement.
4. To investigate health-related outcomes, such as exercise frequency, range of motion (ROM), and user adherence.
5. The body of the research paper is organized into five sections.

## **3. Literature review**

Research on physical-activity interventions for older adults increasingly spans both traditional exercise programmes and technology-mediated approaches such as active video games. The selected literature addresses three complementary domains: (1) technological foundations for interactive exercise systems, (2) evidence on the effectiveness of exercise interventions (including active video games) for older adults and those with sarcopenia, and (3)

qualitative understanding of older adults' sedentary behaviour and meaning-making. Synthesising findings across these domains highlights promising directions and remaining gaps for designing acceptable, effective, and context-sensitive active-game interventions for fall prevention and functional improvement.

Abe et al. (2024) examine interactive game development using device-free pose-estimation techniques, offering a technical foundation for systems that can track users' full-body movement without wearable sensors. This line of work is important for older-adult applications because device-free approaches reduce barriers related to device setup, comfort, and usability. Abe et al. discuss evaluation of game interaction and demonstrate feasibility of capturing posture and motion data suitable for real-time game feedback. From a design perspective, such technologies enable low-friction, home-based exergames that can monitor exercise form and provide immediate feedback features that may improve safety and adherence among older users.

Two recent systematic reviews synthesize evidence on exercise and active-game interventions in older populations. Cabroler-Molina et al. (2025) review exercise interventions in older adults with and without sarcopenia, offering a broad view of how exercise impacts strength, function, and sarcopenia-related outcomes. Their synthesis underscores that tailored exercise programmes can improve muscle function and mitigate sarcopenia-related decline, but effectiveness varies with intervention type, intensity, and adherence. Deng et al. (2024) specifically review active video games (AVGs) and report that AVGs can improve health-related physical fitness in older adults; their meta-analytic synthesis supports AVGs as an effective modality for aspects of fitness such as balance, strength, or cardiovascular metrics depending on study designs and outcome measures. Together, these reviews suggest that AVGs can be an effective delivery format for exercise, particularly when exercises are designed to target known risk factors for falls (e.g., lower-limb strength, postural control).

Ngowsiri et al. (2020) conducted a quasi-experimental study aimed at evaluating the effects of a Holistic Health Promotion Program (HHPP) on the quality of life (QOL) among the elderly in Bangkok. The HHPP used in the study was a 12-week program covering both physical and mental aspects, including nutritional education, emotional and stress management through deep breathing and meditation, and the practice of Rusie Dutton (the traditional Thai yoga from Wat Pho). The findings revealed that the experimental group who participated in the program showed significantly improved health behaviors, as well as health status and quality of life, particularly in the physical and environmental domains. Furthermore, significant improvements were noted in food consumption behavior, emotional/stress management, and the psychological domain of QOL. In conclusion, the HHPP is effective in developing health behaviors and the quality of life of the elderly, supporting its application in other areas.

Niklasson et al. (2023) offer a qualitative, phenomenological-hermeneutic exploration of what sedentary behaviour means to older adults. Their findings emphasize that sedentary behaviour is not merely a health metric but is intertwined with meanings, daily routines, social roles, and perceived barriers to activity. This perspective is crucial for intervention design:

acceptability and sustained use of AVGs depend not only on efficacy but on how older adults interpret the activity whether as meaningful, enjoyable, socially reinforcing, or intrusive. Incorporating users' lived experience into design (e.g., by enabling social features, framing activities around meaningful tasks, or reducing perceived stigma) can enhance uptake and adherence.

Uiphanit et al. (2025) study developed a game-based learning web application designed to improve phishing awareness among middle school students. The system was tested with 130 Grade 7 learners, and the results showed a significant increase in their knowledge of phishing after interacting with the game. Students also reported high acceptance of the game-based format, indicating that this approach is effective and suitable for enhancing cybersecurity awareness in young learners.

Cross-cutting themes and implications.

Several convergent themes emerge from the literature:

1. Feasibility of technology-mediated exercise: Device-free pose estimation offers a practical route to deploy AVGs in home or community settings without burdening users with wearables (Abe et al., 2024).

2. Effectiveness when tailored: Both systematic reviews show beneficial effects of exercise and AVG interventions when programmes are appropriately targeted (Cabrolier-Molina et al., 2025; Deng et al., 2024). Tailoring by functional status (e.g., sarcopenia) and progression is important.

3. Value of culturally/contextually grounded exercises: Traditional exercise formats such as Rusie Dutton provide validated movement repertoires that can be digitized into game mechanics for fall-prevention goals (Ngowsiri et al., 2020).

4. Need to address meaning and motivation: Qualitative insights reveal that older adults' perceptions of sedentary behaviour influence readiness to participate; interventions must attend to motivations, social context, and perceived benefits (Niklasson et al., 2023).

## 4. Methodology

### Operational Procedures

#### 1. Review and collect relevant information and related research.

The literature review process for developing this research begins with clearly defining the scope and keywords across three main areas: exercise in older adults and sarcopenia, the effectiveness of Active Video Games (AVGs), and device-free sensing technology. This is followed by a systematic search and selection of literature from databases, focusing on gathering evidence regarding the efficacy of interventions (both traditional and AVGs), technical advancements that reduce user burden, and qualitative data on older adults' needs, motivations, and perceptions. The final step involves synthesizing the information and identifying gaps to justify the research, emphasizing the scarcity of AVG protocols explicitly designed for arm exercise and the systematic integration of qualitative insights into game design.

## 2. Design and develop the game.

### 2.1 . Game Character Design



Fig.1. Character Design



Fig.2. Character Animation



Fig.3. 4 games in total in the game menu design

## 2.2 Coding

```

public class CameraControllers : MonoBehaviour
{
    void ImgProc()
    {
        if (mCamera.isPlaying)
        {
            displayTexture.SetPixels32(mCameraPixels());
            pixels = displayTexture.GetPixels32();
            pixels = ImageProcessors.Instance.DetectColors(pixels);
            clusters = ImageProcessors.Instance.ClusterLabel(pixels);

            ApplyTexture();
            DebugMovement();
        }
        else
        {
            return;
        }
    }

    void ApplyTexture()
    {
        displayTexture.Apply();
        plane.material.mainTexture = displayTexture;
    }

    public void DebugMovement()
    {
        Vector3 movementPos =
            ImageProcessors.Instance.FindCentroid(ImageProcessors.Instance.FindLargestCluster(c
            lusters));

        movementPos.x /= displayTexture.width; //[0,1]
        movementPos.x = 1.0f - movementPos.x; //[0,1], just reflect
        movementPos.x += 0.5f; //[-0.5,0.5]
        movementPos.y /= displayTexture.height; //[0,1]
        movementPos.y -= 0.5f; //[-0.5,0.5] */
        movementPos.z = -0;

        float ratio = (float)Screen.width / Screen.height;
    }
}

```

**Fig.4.** Develop Unity game programs using C#.

## 2.3 Results of game program design and development



**Fig.5.** Health Me Mini games

### 3. Conduct usability evaluation.

The usability and appropriateness of the active game were assessed through a rigorous expert evaluation involving two distinct groups: **Game Development Experts** focused on technical feasibility, game mechanics, and usability, and **Exercise and Health Experts** concentrated on the safety, appropriateness, and effectiveness of the arm exercise protocols for older adults. Both groups used structured questionnaires, typically rated on a Likert scale, to evaluate key dimensions such as Technical Usability, Game Quality, and Exercise Appropriateness.

#### 4. Analyze the data.

Data analysis was performed using descriptive statistics (Mean  $\pm$  SD) to summarize the expert evaluation results. All statistical calculations were conducted using the IBM SPSS Statistics software, version 23.

### Results

The evaluation was carried out by five Game Development Experts (four men, one woman) who had an average age of 37 and possessed an average of 8 years of experience in game development.

**Table 1:** Game Development Experts Evaluation Results (Mean  $\pm$  SD)

Evaluation Criteria	Mean $\pm$ SD
Appropriateness of Game Design	4.6 $\pm$ 0.55
Engagement & Motivation	4.5 $\pm$ 0.50
Usability & Interface Design	4.7 $\pm$ 0.45
Game Control & Interaction	4.5 $\pm$ 0.60
Safety & Physical Appropriateness	4.8 $\pm$ 0.40
Aesthetic & Multimedia Quality	4.6 $\pm$ 0.50
Overall Usability & Experience	4.7 $\pm$ 0.45

Rating scale: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree

The Game Development expert evaluation results indicate that the game received high ratings across all aspects, reflecting its overall quality and suitability for older adults. Safety & Physical Appropriateness scored the highest (Mean = 4.8  $\pm$  0.40), suggesting that experts consider the game safe and physically suitable for the target users. Usability & Interface Design and Overall Usability & Experience also received strong ratings (Mean = 4.7  $\pm$  0.45), highlighting that the game interface is user-friendly and provides a positive experience. Engagement & Motivation and Game Control & Interaction scored slightly lower (Mean = 4.5), but still indicate good levels of user engagement and interaction. Overall, the results suggest that the game is well-designed, motivating, safe, and enjoyable for older adult users.

For a group of five Exercise and Health Experts (two men, three women) served as the evaluators, reporting an average age of 40 and an average of 12 years of specialized experience in exercise and health practices.

**Table 2:** Exercise and Health Experts Evaluation Results (Mean  $\pm$  SD)

<b>Evaluation Criteria</b>	<b>Mean <math>\pm</math> SD</b>
Appropriateness of Exercise Movements	3.92 $\pm$ 0.12
Exercise Safety	4.0 $\pm$ 0.08
Appropriateness of Exercise Intensity & Duration	3.92 $\pm$ 0.15
Alignment with Health & Fitness Objectives	4.0 $\pm$ 0.05
Elderly-Friendly Exercise Design	3.96 $\pm$ 0.10
Accuracy of Motion Tracking	3.92 $\pm$ 0.14
Overall Health Benefits	3.96 $\pm$ 0.09

Rating scale: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree

The evaluation results from exercise and health experts indicate that the exercise program received generally high ratings across all criteria. Exercise Safety and Alignment with Health & Fitness Objectives scored the highest (Mean = 4.0), suggesting that the exercises are safe and well-aligned with intended health goals. Appropriateness of Exercise Movements, Intensity & Duration, and Accuracy of Motion Tracking showed slightly lower scores (Mean = 3.92–3.96), indicating minor variations in expert opinions. Overall, the results suggest that the exercise program is suitable, safe, and beneficial for older adults, with exercises designed to support health, fitness, and user-friendly implementation.

## 5. Conclusion and Discussion

This study successfully developed an active game that integrates AI-based color-detection and pose-analysis technology to encourage arm exercise among older adults. The use of device-free sensing aligns with previous research demonstrating that such technologies can effectively support interactive exercise without requiring wearable equipment (Abe et al., 2024). The results from expert evaluations confirm that the system is both technically robust and appropriate for the target population. Game Development Experts highlighted the game's strong usability, clear interface, and high level of physical safety, indicating that the design effectively reduces barriers typically associated with technology use among older adults.

Exercise and Health Experts similarly rated the system favorably, particularly in terms of exercise safety and alignment with health goals. This corresponds with evidence showing that well-structured exercise programs can improve functional outcomes in older adults, including those with sarcopenia (Cabroler-Molina et al., 2025). Although ratings for movement appropriateness and motion-tracking accuracy were slightly lower, they still fell within a positive range, suggesting the game provides an adequate level of precision for general health-promotion purposes. This aligns with findings from Deng et al. (2024), who reported that active

video games can enhance health-related physical fitness when movements are appropriately monitored.

The combination of playful interaction, real-time feedback, and simplified interface design contributes to the system's ability to enhance motivation and reduce sedentary behavior key factors identified as essential for sustained physical activity in older adults. These behavioral considerations are supported by qualitative research showing that older adults' engagement in physical activity depends heavily on perceived meaning, enjoyment, and routine (Niklasson et al., 2023). Additionally, the focus on safe, structured arm movements echoes traditional exercise programs such as Rusie Dutton, which have been shown to reduce fall risk and promote functional mobility (Ngowsiri et al., 2020).

In conclusion, the developed active game demonstrates strong potential as an innovative and accessible tool for promoting arm exercise and supporting active aging. The system aligns with broader evidence that active video games when designed with safety, usability, and engagement in mind can effectively complement physical activity interventions for older adults. Future work should include user testing with older adults, long-term follow-up studies, and expanded motion-tracking enhancements to further improve accuracy and individualization of exercise programs.

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