Leveraging Knowledge Management Techniques for Developing Multimedia Exercise Guides for Elderly Fall Prevention

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Abstract

In this research study, the primary objective was to develop a comprehensive exercise program specifically designed for elderly individuals. The focus was on evaluating various exercise postures and validating their impact on muscle groups. By integrating knowledge management systems with knowledge engineering methodologies, the aim was to optimize the design of exercise postures and promote optimal health outcomes for the elderly.

Divided into three distinct experiments, the study employed a systematic approach to acquire, represent, and validate knowledge related to exercise postures for the elderly population. The use of knowledge management systems and engineering methodologies facilitated the design of effective exercise postures tailored to meet the unique needs and capabilities of elderly individuals. Experiment I focused on knowledge acquisition through

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structured interviews with physical therapists. The acquired knowledge was used to screen and prioritize exercise postures suitable for elderly individuals. Expert recommendations and analysis were employed to select a set of exercise postures. Using a matrix combination approach, 189 possible exercise postures were generated by combining aerobic and dance postures. Through a screening process, 52 postures were selected as suitable for elderly individuals. Experiment II utilized kinesthetic representation techniques to visually represent the 52 selected exercise postures for the elderly. Additionally, frame representation was employed to capture muscle specifications associated with each posture. The representation design was validated by physical exercise experts. In the first step of Experiment III, a total of 52 exercise postures were implemented and evaluated with elderly participants. The implementation and validation process aimed to identify the best and most appropriate postures for the elderly, considering factors such as satisfaction levels, difficulty levels, and safety considerations. Through this rigorous evaluation, the initial selection of 52 postures was narrowed down to a final set of 21 suitable postures. The validation results provided valuable insights into the effectiveness of the exercise postures and their impact on the elderly participants. It ensured that the chosen postures were not only effective in promoting optimal health outcomes but also minimized the risk of injury. The iterative assessment and refinement process contributed to the development of an evidence-based exercise program specifically tailored to the unique needs and capabilities of elderly individuals. For the second step of Experiment III, the effects of the selected exercise postures on different muscle groups were validated. Three physical exercise experts evaluated the impact on upper limb, trunk, and lower limb muscles. Specific muscle groups, such as brachioradialis, deltoid, quadriceps, and hamstring, were found to be strongly focused on during the exercises, while trunk muscles were rated as poor overall. The evaluation involved implementing and evaluating a total of 52 exercise postures with elderly participants. The selection of the final 21 postures was based on the evaluation results and provided insights into satisfaction levels, difficulty levels, and safety considerations for each exercise posture. The validation outcomes showed a high level of agreement among the experts, ranging from 79% to 91%.

For conclusion, this research aimed to enhance exercise programs for the elderly by developing more effective methodologies for designing exercise postures. By considering the specific requirements of the elderly population and utilizing knowledge management systems, the study successfully created exercise postures that maximize health benefits and overall well-being.

Through the implementation of knowledge engineering methodologies and the utilization of knowledge management systems, the research optimized the design of exercise postures for elderly individuals. The division of the study into three experiments enabled a comprehensive analysis of the acquired knowledge, leading to the development of exercise postures specifically tailored to the needs of the elderly population.

Keywords: Elderly, exercise, posture, KMS.

1 Introduction

The American Heart Association recommends that healthy adults engage in at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity per week to maintain good health and wellbeing [1]. Elderly individuals, however, confront distinctive challenges that can inhibit their commitment to regular physical activity. The presence of chronic conditions, mobility restrictions, and social isolation underscore the urgency of consistent exercise in this demographic [2, 3].

While exercise regimes aimed at enhancing overall physical function, preventing falls, and curtailing the risk of chronic diseases can markedly elevate the life quality of seniors [4, 5] crafting such programs for the elderly is intricate. Challenges arise due to physical limitations, persistent health conditions, and cognitive decline [6, 7]. To diminish risks of injury and cardiovascular strain, engaging in low to moderate-intensity activities is advised [8, 9]. Yet, the intersection of age-induced fitness reductions, chronic illnesses, and medication necessitates tailoring exercise programs to the distinct requirements and capabilities of the elderly.

Maintaining good posture is crucial when designing exercise programs for elderly individuals. Poor posture can lead to various physical problems, such as back pain, spinal dysfunction, joint degeneration, muscle fatigue, and the risk of falls, particularly in older adults [6]. Despite hospitals and schools having developed programs to educate people on body posture, the lack of expert knowledge in this area remains a significant challenge [10].

Therefore, leveraging expert knowledge in the design of exercise programs for the elderly is essential, and knowledge engineering could be a useful methodology for capturing and representing expert knowledge in this field [11]. By using knowledge engineering, it is possible to capture and represent a vast amount of expert knowledge for designing posture-focused exercise programs for elderly individuals [8]. However, developing a knowledge management system (KMS) based on a knowledge engineering process can be challenging.

The objective of this research is to design and develop a KMS for exercise posture design in the elderly, incorporating exercise expert guidelines to improve the quality and consistency of exercise recommendations for elderly individuals. The KMS aims to leverage expert knowledge through the development of a knowledge representation schema that captures and organizes expert knowledge about exercise posture design for the elderly. The KMS will allow healthcare professionals to design and customize exercise programs for elderly individuals by selecting and combining posture-focused exercises that are tailored to the individual's physical limitations, chronic conditions, and cognitive impairments.

This study will explore the use of knowledge engineering to design and develop a KMS for exercise posture design in the elderly. The proposed KMS will incorporate a knowledge representation schema, an inference engine, and a user interface to support healthcare professionals in designing exercise programs for elderly individuals. The KMS will be evaluated by healthcare professionals for its usefulness and usability in designing posture-focused exercise programs for elderly individuals.

To designing exercise programs for the elderly is a complex task due to their unique physical and cognitive limitations. Good posture is crucial for the elderly, and the lack of expert knowledge in this area can lead to inadequate exercise recommendations and ultimately result in poor health outcomes. Therefore, developing a KMS based on a knowledge engineering process can be an effective way to leverage expert knowledge to improve the quality and consistency of exercise recommendations for elderly individuals. The proposed KMS aims to provide healthcare professionals with a tool to design and customize exercise programs for elderly individuals that are tailored to their physical limitations, chronic conditions, and cognitive impairments.

2 Literature Reviews

To study the appropriate design of exercise postures for the elderly. The following literature reviews must be studied.

2.1 Necessary of Exercise Posture Design for Elderly

In general, a physically active lifestyle should be promoted to maintain good health [9], bearing in mind that certain populations are at particular risk of poor physical function and could potentially benefit from early intervention [10]. However, long-term maintenance of physical activity is a challenge [12], because lifestyle habits and barriers to physical activity are often ingrained in the older population [13].

Promoting physical activity is crucial for good health, especially for high-risk populations. However, maintaining long-term activity can be challenging due to ingrained habits and barriers [13].

Evidence suggests that humans naturally coordinate limb movements [14–16], preferentially using homologous muscles. This coupling is observed in activities like walking and swimming. Neural connections between upper and lower limb networks, such as propriospinal connections, contribute to this coordination. Research demonstrates that incorporating upper limb movement during rhythmic tasks enhances lower limb muscle recruitment [17]. Increased upper limb muscle [18] activity leads to greater muscle activation in passively moving legs, and passive arm swings improve muscle activation in lower limbs. These findings highlight the potential of upper limb activation or feedback to enhance lower limb muscle activation [19] and overall movement performance [11].

But anyway, the good exercise design for elderly. Must have the rules to make the elderly exercise properly, for example, there must be health check before exercise, should not be exercise fever and tired [13], do not make sudden changes in exercise posture or rhythm. Or elderly individuals who are new to exercise should not engage in exercise sessions lasting longer than 30 minutes.

2.2 Information Reviews for Elderly Exercise Posture Design

The objective of data reviews for posture selection is to gather and analyze information about the body postures of older adults and their relation to the risk of falls. This information is then used to design interventions to help older adults maintain better balance and prevent falls.

This research synthesizes findings from various sources to identify suitable exercise types and techniques for elderly individuals. The analysis of data reveals patterns and correlations between posture and falls, leading to the development of tailored posture interventions. Three recommended exercise types for the elderly are outlined [14]:

- Aerobic cardio-vascular endurance. This type of exercise uses large muscle groups continuously and rhythmically to increase heart and

blood vessel endurance. Examples include walking, jogging, cycling, and swimming [20].
- Resistance exercise This type of exercise can increase muscle performance and is divided into two types based on the weight used: using your own weight or resistance, and the use of external weights such as dumbbells and weight machines [14].
- Flexibility exercise. This type can cause a range of motion in the joints, such as stretching the muscles used to warm up or relax the body, or dance, boxing, and yoga [15].

In this research, the selection of aerobic cardio-vascular endurance exercise [14] involving elderly individuals is supported by studies highlighting its health benefits, improvement in endurance and stamina [21], weight management effects [18], positive impact on mood and mental well-being [18], as well as its accessibility and versatility [19]. Aerobic exercise offers a comprehensive approach to promoting cardiovascular health, enhancing physical and mental well-being, and accommodating varying fitness levels and mobility [20].

While aerobic cardio-vascular endurance exercises offer holistic health benefits, a tailored approach that considers the specific requirements of posture in elderly individuals can optimize these benefits. This necessitates a comprehensive design that addresses both upper and lower body movements, as discussed in the subsequent section on posture design and combination [20, 22].

2.3 Upper and Lower Posture Design and Combination

This study focuses on the design of home-based exercise systems with a particular emphasis on Aerobic Cardiovascular Endurance exercise. Aerobic exercise has been found to have numerous benefits, including improving heart function, respiration, and blood circulation. It also places stress on major muscles, effectively engaging them and prompting the heart muscle to work. Additionally, it has been shown to have a positive impact on the nerves in elderly limbs.

The benefits of posture combination, as demonstrated in the studies of Bai, Xiaorong, et al. (2022) [22], highlight the potential to improve physical performance. Building upon this knowledge, the present research aims to combine the principles of Aerobic Cardiovascular Endurance exercise and the unique characteristics of 9-step dance to design a comprehensive home-based exercise system specifically tailored for improving posture in the elderly population. Aerobic exercise, renowned for its positive effects on heart function, respiration, and blood circulation, will be integrated into the exercise program to engage major muscle groups and enhance overall physical well-being. Additionally, the incorporation of 9-step dance, with its rhythmic and coordinated movements, will provide a dynamic and enjoyable approach to target specific muscle groups in the lower body.

This combined approach recognizes the importance of addressing both the upper and lower body in posture improvement. The classification of arm movements in aerobics will guide the design of exercise postures for the upper body, ensuring targeted muscle engagement and postural alignment. Simultaneously, the principles of 9-step dance will inspire the development of exercise postures that promote balance, coordination, and strength in the lower body.

By synergistically utilizing the benefits of both Aerobic Cardiovascular Endurance exercise and 9-step dance, this research seeks to create an effective and engaging exercise system that not only enhances posture but also contributes to the overall physical and psychological well-being of elderly individuals. The combination of these two approaches will provide a holistic and tailored solution for promoting optimal posture and improving quality of life in the elderly population. Using 9-step dance to design exercise postures will explain the benefit of these two types that were used to design in this research.

2.4 Aerobic Exercise [16, 23]

Aerobic exercise is of paramount importance in improving heart function, respiration, and blood circulation. It plays a pivotal role in strengthening major muscle groups and stimulating the heart muscle, leading to favorable adaptations in the nerves of elderly limbs. To maximize the benefits, it is recommended from American College of Sports Medicine (ACSM) [14] to engage in aerobic exercise sessions lasting 20–30 minutes, complemented by 5–10 minutes of pre-exercise stretching and post-exercise relaxation. For elderly individuals who are new to exercise, a gentle initiation with a 5–10 minutes routine at an intensity level of 50–60% is advised. A wide range of aerobic exercises lends itself to the design of upper body postures, including aerobic dancing, jumping rope, jogging, swimming, cycling, dancing, walking, Chinese boxing, standing, and arm swinging. As this research endeavors to design exercise postures tailored to the elderly, a comprehensive exploration of various exercise postures within the realm of aerobics becomes

 (a) Unilateral posture: Involves alternating arms extended overhead, promoting individual limb coordination.	 (b) Symmetrical posture: Engages both arms extended directly from the chest, synchronized with leg movements, to foster bilateral coordination.	 (c) Asymmetrical posture: Entails stretching one arm overhead while alternately pulling down with the opposite arm, enhancing cross-body coordination.

Figure 1 Examples of aerobic postures.

indispensable. Notably, a previous study delved into the classification of arm designs in aerobics, distinguishing between unilateral movements performed one at a time and bilateral movements encompassing symmetrical or asymmetrical actions of both arms in opposing directions [16]. These invaluable insights pave the way for designing upper body postures in aerobic exercises specifically targeted at the elderly population.

2.5 9-step Dance Characteristics

This study incorporates a 9-step dance routine, informed by research on lower limb musculature [21], to address the pressing issue of falls among the elderly and their consequent impact on quality of life. The intervention aims to fortify bones and muscles, enhance endurance, and improve flexibility through a 3-Dimensional training regimen performed on a flat grid. The dance steps are strategically numbered for ease of recall, as illustrated in Figure 2.

Evidence from various countries has established the effectiveness of this innovative approach in health promotion and fall prevention among older adults. The 9-step dance is an adaptation of the speed-focused 9-square dance exercise [24], derived from the traditional Kao-ta routine. Both exercises consist of square-grid movements, are equipment-free, and align with the safety and simplicity advocated in Thai traditional medicine [25]. They share foundational principles with established balance improvement practices.

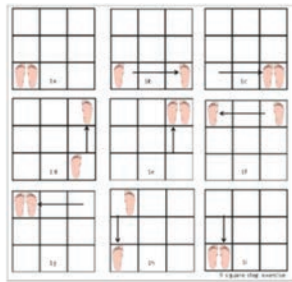

Figure 2 The 9-step dance grid for fall prevention.

Preparatory position: Stand with both feet within the bottom left square (1a) [24].

Exercise steps: Moving in a counterclockwise direction, move your right foot directly to the right into the bottom right square (1b), followed then by your left foot. Now both of your feet are once again in the same square (1c). Now move your right foot straight ahead to the top right square (1d), followed then by your left foot (1e). Now move your left foot directly to the left into the top left square (1f), followed then by your right foot (1g). Now, move your left foot directly backwards to the bottom left square, which is where you first started (1h), followed then by your right foot (1i). Now that you have completed one cycle of the exercise, move to the bottom right square to begin, except now you will repeat these movements going in the opposite (clockwise) direction.

2.6 Knowledge Engineering [26]

Knowledge engineering is a way of acquiring knowledge in which the knowledge engineer serves as an intermediary. Knowledge engineers act as go-betweens when it comes to getting knowledge from specialists. and bring the gained knowledge or skill to be transformed and stored in the knowledge base.

Knowledge Engineering (KE) Process Activities [27]. There are process of Knowledge Engineering as follows:

- *Knowledge Acquisition.*
- *Knowledge Representation.*
- *System Implementation & Refinement.*
- *Verification & Validation.*

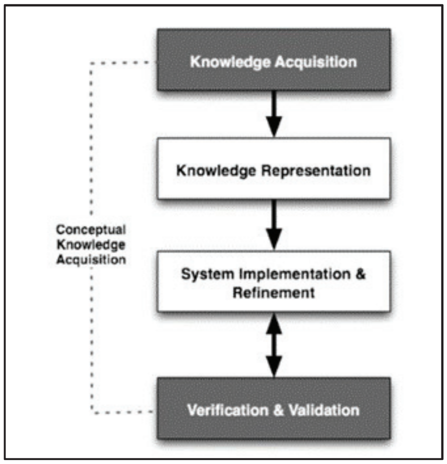

Figure 3 Key components of the KE process. (Adapted from Liou,"Knowledge acquisition: issues, techniques, and methodology", 1990) [28].

2.7 Knowledge Acquisition (KA)

The theories and methods that support KA [29] are drawn from several academic and practical disciplines. Beyond the literature already presented concerning the overall KE process, several academic domains have also addressed various sub-problems associated with KA. Specifically, the disciplines of biomedicine, computer science, cognitive science, education, linguistics, semiotics, and psychology have each contributed to an understanding of the KA process.

Within the overall KE process, which is a sub-process within the broader knowledge engineering (KE) process. KA involves extracting knowledge from existing sources to represent it in a computable format and verifying or validating knowledge-based systems [30]. KA has various applications beyond the biomedical informatics domain [29], including shared database models, ontologies, and human-computer interaction models. Verification and validation methods should be applied iteratively throughout the entire KE process, making them integral components of the KA process [28].

In this research will used the KA technique of structure interview [28], which will explain as follows:

- Structure interview [28]

Interviews, whether conducted individually or in groups, offer a valuable means of gaining insights into the knowledge of domain experts in posture exercise selection or screening research. They can be conducted in an informal manner, fostering a conversational exchange between the interviewer and subjects, or in a formal structure using pre-defined series of questions. The use of interviews in research offers several advantages. Firstly, interviews require minimal resources, making them a cost-effective method. Secondly, they can be completed within a relatively short time frame, enabling efficient data collection. Thirdly, interviews have the potential to provide rich qualitative knowledge, allowing for a deeper understanding of the subject matter. However, it is important to acknowledge certain limitations associated with interviewing techniques. Interviews tend to generate minimal amounts of quantitative data, which may restrict subsequent analysis or quantitative comparisons. The effectiveness of interviews also relies on the ability of subjects to articulate their domain knowledge accurately, which can be challenging if the interviews are conducted out of context or if participants struggle with effective communication. Researchers should be cautious about potential bias introduced through the framing or presentation of questions or topics of interest. This awareness helps ensure the integrity and reliability of the gathered information. For further insights and guidance on interviewing techniques, methodological reviews provided by Boy (1997) [31], Morgan (2004) [32], and Wood (1990) [30] offer more detailed descriptions and considerations.

2.8 Knowledge Representation

When representing knowledge [33, 34] about the system, it is important and necessary to understand about the tool application that must be used. This is the reason why the KR schema must be well structured, explicit, and suitable for different insight levels. Although knowledge representation is widely used and well described the analysis of work to bring knowledge that has been represented by various symbols (symbolic), numbers (numerical), a map (a map), a case (a case), and so on.

In this research used 2 techniques, the first will be frame representation and second is the kinesthetic representation that will explain below:

- The frame representation

A frame is a data structure that provides a structural representation of objects [33]. Object is a recognizable thing; reality that exists in space and time and can be real or abstract [35]. The original definition of a frame is given by Minsky. Most important features of frames are specific representation form, inheritance, class (class–subclass) hierarchy [36]. Using the frame in the KR all the information about the considered object is aggregated into one place. Therefore, frame is used in the system that approaches [30] to acquire and to represent knowledge about the chosen system. The purpose and use of represented knowledge are significant in determining the requirements for knowledge representation [37].

- Kinesthetic representation

Kinesthetic representation [38] is a part-process of knowledge representation or knowledge engineering that focuses on capturing movement or bodily experiences. According to Barfield and Weghorst (1993) [39] kinesthetic representation is the process of capturing and representing movement or bodily experience in virtual environments [38]. This process involves creating a representation of the body and its movements, as well as the environment in which these movements occur.

Kinesthetic representation can be used to represent exercise postures as pictures or videos for the elderly target group to validate exercise. In a study by Huang et al. (2016) [40], kinesthetic representations of exercise postures were created using a motion capture system and displayed to older adults in a virtual environment. The results of the study showed that older adults were able to accurately recognize and perform the exercise postures, indicating that kinesthetic representations can be effective tools for validating exercise postures for elderly populations.

Accuracy and error are important factors to consider when using kinesthetic representations for exercise validation. According to Fuchs et al. (2013) [41], errors in kinesthetic representations can occur due to several factors, including inaccuracies in motion capture systems, limitations in the software used to create the representations, and differences in individual body movements and postures. It is therefore important to ensure that the kinesthetic representations used for exercise validation are accurate and consider the individual differences in body movements and postures of the target population.

Kinesthetic representation is a valuable tool for representing movement and bodily experiences and can be used to create representations of exercise postures for elderly populations. When using kinesthetic representations for exercise validation, it is important to consider the accuracy and potential errors that may occur in the representation process. By taking these factors into account, kinesthetic representations can be effective tools for validating exercise postures and improving the health and well-being of elderly populations.

2.9 Knowledge Validation

Validation [42] is a critical process in the whole knowledge-based system life cycle. A knowledge base incorporated into such systems must be verified or (more generally) validated. There have been many approaches to develop specialized procedures and techniques, aimed at assuring the highest level of knowledge quality.

Despite the still not totally concluded discussions on knowledge validation interpretations, there is a commonly accepted opinion of its importance in the life cycle of knowledge-based systems. Among the software community, validation is interpreted as "building the right product", verification as "building the product right". After Laurent (1992) [43] we assume the validation process can be considered as some determined composition of two kinds of tasks as activities that intend to reach the structural correctness of Knowledge Based (KB) (verification) and activities that intend to demonstrate the KB ability to reach correct conclusions (evaluation). On the other hand, validation refers to different components of a knowledge-based system. We can validate a knowledge base, inference engine, and user interface etc.

There are a lot of approaches defined for verification of a knowledge base. They can be supported by specific techniques to facilitate performance of the procedure, basically by transformation of a KB onto decision tables or trees, some graphical forms or even by activation machine learning techniques [44]. Most of them refer to knowledge bases represented as rules (RB – representative of procedural formalisms), so using the proper KB representation formalism is important. After the transformation of the rules into one of the mentioned indirect forms, completeness and consistency tests are defined for the transformed bases. This mainstream of interests (verification approaches-procedural form of KB) is essential to process to design of KB.

3 Methodology

The research framework shown in Figure 4 comprises three field studies. The first field study focuses on knowledge acquisition, the second on knowledge representation, and the third on knowledge implementation and validation.

3.1 Experiment I: Knowledge Acquisition

This study aims to develop a methodology for selecting exercise postures for elderly individuals. Considering their limited mobility [1], balance issues,

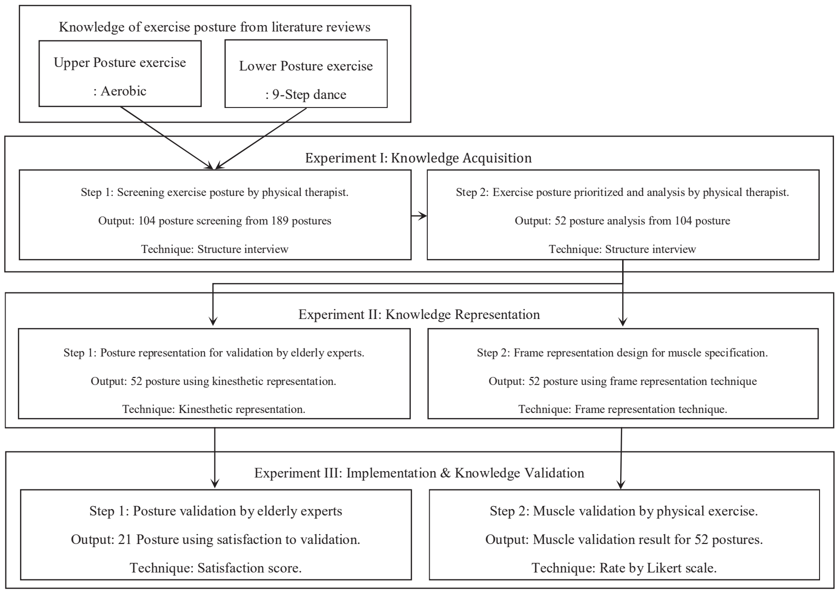

Figure 4 The research framework.

and chronic health conditions, expert knowledge from physical therapists and exercise professionals is utilized to address their specific needs.

This part of experiments comprises two steps: gathering expert knowledge on safe and effective exercise postures for the elderly and evaluating the prioritized postures through feedback from physical therapists. The resulting exercise postures will serve as a reliable and evidence-based resource to enhance physical health and mobility for the elderly, benefiting both healthcare professionals and individuals.

3.1.1 Step 1: Screening exercise posture by Physical exercise

This step was important to identify a large set of postures that could potentially be useful for elderly people. The objective of the step is to select exercises posture from sets of 189 exercises posture, including aerobic and 9 step dance exercises, for a fall prevention program for the elderly, using the interview technique [28, 29] of knowledge acquisition process.

3.1.1.1 *Participants*

The expert group participants in this study consisted of three physical exercise experts from Chiang Mai University, Thailand. These experts were selected based on their knowledge and expertise in the field of physical exercise. They were recruited to assist in selecting safe and effective exercise postures for elderly individuals using structured interviews. To ensure that only qualified experts participated, a purpose-designed questionnaire was used for their selection.

3.1.1.2 *Procedure*

The procedure of this study involved creating a combination of upper and lower exercise postures based on previous research. Specifically, 21 upper aerobic exercise postures were identified from a study by Pornpimol (2019) [16], which consisted of 5 unilateral postures, 13 symmetrical postures, and 3 asymmetrical postures suitable for the upper body. For the lower body, a 9-step dance exercise using 9 types of leg postures was designed and mixed in a matrix, resulting in 189 postures that were deemed suitable for elderly individuals.

To select the most appropriate exercise postures [40], a structured interview technique was used with 3 physical exercise experts from Chiang Mai Fitness Gym, Thailand. These experts were chosen based on their knowledge and expertise in the field of physical exercise. A list of the 189 exercise postures was presented to the experts, who were instructed to select postures that met eight criteria: (1) safety for elderly individuals [15], (2) covering various muscle groups and targeting different parts of the body [16], (3) suitability for elderly individuals with varying physical fitness and mobility levels [21], (4) proven ability to improve balance, flexibility, and cardiovascular health in elderly individuals [45], (5) easy to modify or adapt to meet individual needs and limitations [44, 27], (6) requiring minimal equipment or adaptable to use household items as props [27], (7) avoiding excessive strain on joints or muscles [22], and (8) enjoyable and engaging for elderly participants to encourage adherence to the exercise program [15].

3.1.1.3 *Result*

By utilizing a scoring system based on eight conditions, each with a maximum score of five, the exercise postures were evaluated and prioritized. The results, as shown in Table 1, indicate the following:

104 postures scored between 28 and 40, demonstrating a strong adherence to the criteria and meeting them well. These postures are considered suitable for inclusion in exercise programs for the elderly. Another 54 postures scored between 14 and 27, indicating that they partially meet the criteria but may require further improvement in the future. These postures have potential

but need refinement to ensure safety and effectiveness. 31 postures received scores between 1 and 13, indicating inconsistent and insecure movements. These postures did not meet the criteria and are deemed unsuitable for the elderly population.

In this study, 104 exercise postures were identified as safe and effective for elderly individuals based on expert interviews. These postures target multiple muscle groups, improve balance, flexibility, and cardiovascular health. They can be modified for individual needs, require minimal equipment, and are enjoyable to promote adherence. These findings provide a valuable resource for designing exercise programs for elderly individuals to enhance their overall well-being.

3.1.1.4 *Evaluation/analysis*

The application of structure interview techniques of knowledge acquisition experiment results in the right direction in choosing of posture for elderly to exercise. As conditions were shown in the experimental stage, for example, the combined movements using the Matrix style are suitable for dancing by the elderly. Or how are they related in the upper and lower parts of the posture for dance This will lead to research in the right direction to determine the benefits of choosing the right dance moves. and safe for the elderly. During the interview, notes and voice recordings will be taken. The interview started with an explanation. about the topic and objectives of the research paper first Then, to start the interview, for this research, a group of 3 exercise specialists were interviewed using of 8 to select inner move from the Matrix until the experts are most satisfied. In this experiment, 104 moves that have appropriate movements and can be danced will be selected as shown in the matrix in Table 1.

Table 1 Shows the results of screening posture exercise by physical exercise using the structure interview technique

Level of Accept	Description	Scored	No. of Posture Selected
Accept	Postures that meet the criteria for safety and effectiveness for the elderly.	28–40	104
Require to improved	Postures that require further refinement or modification to enhance safety and effectiveness.	14–27	54
Not accept	Postures that do not meet the criteria and are not suitable for the elderly population.	1–13	31

3.1.2 Step 2: Exercise posture prioritized and analysis by Physical Therapist

3.1.2.1 *Participants*

The expert group participants are 3 Physical therapists from Chiang Mai University, Thailand. In this study this expert group will be selected based on their expertise in designing exercise programs for elderly individuals, as well as their in-depth understanding of the effects of exercise on the body, their knowledge and experience will be used to evaluate the effectiveness and safety of the exercise postures identified in step 1. Physical therapists have specialized knowledge and training in designing exercise programs for individuals with various physical abilities and health conditions. Therefore, they will be interviewed using a structured interview technique to gather their knowledge and feedback on the safety and health condition effects of the exercise postures. Their input will help to ensure that the exercise postures selected are not only effective, but also safe for elderly individuals to perform.

3.1.2.2 *Procedure*

In Step 1, upper and lower body exercise postures were created and combined, resulting in 189 postures. A physical exercise expert group was then involved in a structured interview process to select postures suitable for elderly individuals. The selected postures met safety criteria, targeted various muscle groups, and were enjoyable for the participants.

The purpose of Step 2 is to acquire in-depth knowledge from physical therapists on the selection of exercise postures for elderly individuals. The goal is to ensure that the exercise postures selected are safe and effective for elderly individuals with varying physical fitness and mobility levels, and that they target various muscle groups and different parts of the body. The aim is to identify a set of exercise postures that physical therapists can confidently recommend to elderly individuals seeking to improve their physical health.

To achieve this goal, the study uses a structured interview technique with physical therapists who have expertise in geriatric physical therapy. The interview questions are designed to elicit detailed information about the selection of exercise postures, considering the following conditions as shown in Table 2.

3.1.2.3 *Result*

Table 3 displays the results of posture prioritization and analysis using the structured interview technique with specific criteria in Table 1 by the physical therapist within the context of the knowledge acquisition field study.

Table 2 Shown the condition for physical therapist to prioritize and analysis of posture

Condition	Description	Reference
Effectiveness	What exercise postures would you recommend for improving physical function in elderly individuals based on your expertise and experience as a physical therapist?	[46]
Safety	Do you think the exercise postures identified safe for elderly individuals to perform? Are there any modifications or adjustments that need to be made to ensure safety?	[47]
Health condition	Based on the health conditions of the elderly individuals, what exercise postures do you typically recommend?	[48]
Injury prevention	What exercise postures do you typically recommend for preventing injuries, especially for elderly individuals who may be more prone to falls and other accidents?	[49]
Muscle and body condition	Which exercise postures do you typically recommend for improving muscle strength, balance, flexibility, and overall body condition in elderly individuals?	[49]
Lower and upper body	Can you recommend exercise postures that focus on improving the relationship between the upper and lower body, particularly for elderly individuals who may have trouble with coordination and balance.	[50]

Using a structured interview technique, the 104 exercise postures selected and displayed in Step 1 will be presented to 3 physical therapists with expertise in physical therapy for elderly individuals. The physical therapists will rank each exercise posture based on the criteria in Table 1 for elderly participants. The 52 exercise postures with the highest rankings will be selected and ranked into 3 difficulty levels: easy (20 postures), medium (16 postures), and hard (16 postures), based on the difficulty level of the lower posture from the 9-step dance. The resulting combinations of upper and lower body exercise postures will be used in the intervention program.

3.1.2.4 *Evaluation/analysis*

In this step of experiment using of structure interview technique, participants categorized 104 exercise postures into three difficulty levels based on factors like effectiveness, safety, health condition, injury prevention, muscle with body composition and has harmonious relationship between the upper and lower body. The most grouped postures within each level were identified, and 52 postures were chosen based on participants experience on physical therapy and overall difficulty.

The selected 52 postures were further classified into the following categories: easy (20 postures), moderate (16 postures), and hard (16 postures).

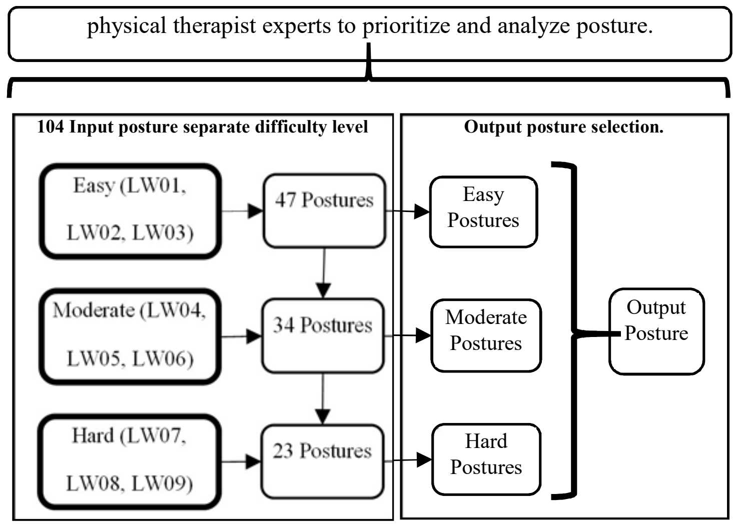

Figure 5 Diagram illustrating the prioritized posture and exercise analysis by the physical therapist.

Table 3 Result of posture prioritization and analysis using structure interview techniques in the knowledge acquisition by th physical therapist experts

Difficulty	Output Posture Selection
Easy Lower posture	20
Moderate Lower posture	16
Hard lower posture	16
Total posture selection	52

The easy postures were those that required minimal strength and flexibility and were suitable for beginners or those with limited mobility. The moderate postures required more strength and flexibility and were suitable for intermediate-level exercisers. The hard postures were the most challenging, requiring advanced strength and flexibility, and were suitable for experienced exercisers or athletes.

3.2 Experiment II: Knowledge Representation design [30]

This part of the experiment consists of two steps. In the first step, the exercise postures will be represented for implementation and validated by elderly experts. In the second step, the exercise muscles will be represented for validation by physical exercise experts.

3.2.1 Step 1: Posture representation design for validation with elderly

3.2.1.1 *Participants*

In this step of study, the expert group will consist of three physical exercise specialists from Chiang Mai University, Thailand. The selection of these participants will be based on their expertise and experience in designing exercises specifically tailored for the elderly population. A purpose questionnaire will be used to identify individuals who possess the necessary qualifications and knowledge in this field. The chosen experts will then participate in the trial to collaboratively design the kinesthetic exercise posture representation.

3.2.1.2 *Procedure*

The primary objective of this research phase is to leverage the principles of kinesthetic representation, a nuanced facet of knowledge representation, to design exercise postures tailored for the elderly. Kinesthetic representation, as articulated by Barfield and Weghorst (1993) [39], zeroes in on capturing and portraying bodily movement or experiences, especially within virtual environments [38]. This encapsulation of the body and its movements offers a novel way to visually represent exercise postures, potentially enhancing the comprehensibility and effectiveness of exercise routines for older individuals.

In the context of this study, the kinesthetic representation will be employed to craft a detailed and intuitive exercise routine consisting of 52 distinct postures. The methodology encompasses:

1. Selection of Postures: Drawing from existing knowledge and studies, such as the one by Huang et al. (2016) [40], we will identify and curate a mix of exercise postures. These will harmoniously blend upper and lower body movements, ensuring comprehensive engagement for the elderly.
2. Movement Cues Development: To further simplify the adoption of these postures, definitive movement cues will be designed. These cues serve as guidance, aiding participants during exercises and ensuring the accurate reproduction of the postures.
3. Preliminary Testing: Recognizing the potential challenges in kinesthetic representation, such as those highlighted by Fuchs et al. (2013) [41], a preliminary evaluation will be conducted. This will ascertain the clarity and simplicity of the kinesthetic representation. Experts, using a Likert scale (spanning 1 to 5), will evaluate and rate the clarity and ease of each posture representation, ensuring that individual differences in body movements and postures of the target group are adequately considered.

Table 4 Result of kinesthetic representation and scored of preliminary tests of the representation

Upper Posture Type	Level of Difficult	Number of Postures Postures to Present	Average of Preliminary Test
Unilateral	Low	10	4.2
Symmetrieal	Moderate	34	4.4
Asymmetrical	Hard	8	4.6

4. Compilation: Based on the evaluations, the final selection of kinesthetic representation exercise postures, accompanied by their respective Likert scale ratings, will be cataloged in Table 4.

Integrating the insights and complexities of kinesthetic representation, this methodology aspires to develop a comprehensive exercise system. This system is designed not just to convey postures clearly but also to align with the distinct physical requirements and understanding capacities of the elderly, facilitating accurate execution and comprehension of movements.

3.2.1.3 *Result*

In the Table 4 presents the results of the kinesthetic representation for exercise postures, specifically focusing on the preliminary test conducted by the physical exercise expert.

The results can be examined by presentation posture numbers categorized by upper type to identify any patterns or trends in the effectiveness of the representation across different exercise types. This analysis allows researchers and practitioners to identify areas where improvements may be needed. The findings from the preliminary test results in Table 4 serve as a basis for further refinement and adjustment of the kinesthetic representation, ensuring that it effectively conveys the intended postures and movements to the elderly participants. These improvements can enhance the overall effectiveness and user experience of the kinesthetic representation, ultimately leading to better outcomes in exercise programs for elderly individuals.

3.2.1.4 *Evaluation/analysis*

The evaluation of the kinesthetic representation exercise postures involved a preliminary test and expert group assessment. Scores from the Likert scale indicated the clarity and ease of following the representations. The expert group provided feedback on understanding, comfort, and accuracy of replicating the movements. Data analysis included descriptive statistics and thematic analysis of qualitative feedback. The evaluation highlighted strengths and weaknesses, guiding refinements of the representations for improved effectiveness. This process ensured that the postures are easily understood, correctly performed, and well-received by the elderly population. The evaluation contributes to enhancing the quality and efficacy of the kinesthetic representation exercise postures for use in exercise programs for the elderly.

3.2.2 Step 2: Frame representation design for muscle specification

In this part of methodology, will be design of knowledge representation [41, 42] for setup of muscle specification using of frame representation by physical exercise expert participants.

3.2.2.1 *Participants*

The expert group participants are 3 Physical exercises from Chiang Mai University, Thailand. They will be selected from the specialists at designing exercises for elderly using a purpose questionnaire.

3.2.2.2 *Procedure*

The procedure for representing of dance posture muscle for expert to define the muscle specification in validation process must gather information by consult with physical exercise experts to identify a set of postures that are effective for targeting specific muscle groups. Document each posture, including its name, description, and the muscle groups it targets. Then organize the information by create a frame for each posture, including the following attributes:

- *Name*: The name of the posture.
- *Description*: A detailed description of the posture design.
- *Muscle groups targeted*: A list of the muscle groups that the posture targets.

Then, the knowledge representation was developed using frame representation to capture the attributes of exercise postures and their muscle specifications. An example of this representation is shown in Table 5, illustrating the differences in attributes among the 52 postures.

3.2.2.3 *Evaluation/analysis*

The use of a frame representation allowed for a structured and organized way to categorize exercise postures into difficulty levels. This method provided a

Table 5 Sample of frame representation of posture for validation of muscle specifications in the posture number1

Name	Upper	Lower	Difficulty	Upper Muscle	Trunk Muscle	Lower Muscle
Posture1	U01	LW01	Easy	Brachioradialis	External Oblique	Gluteus Maximus
				Biceps Brachii	Latissimus Dorsi	Quadriceps
				Triceps Brachii	Rectus Abdominis	Hamstring
				Deltoid		
				Pectoralis Major	Upper Rectus Abdominis	Gastrocnemius
				Trapezius	Lower Rectus Abdominis	

clear and concise way for participants to group postures according to their own criteria and for researchers to analyze the results. The criteria used for posture representation, such as upper posture, lower posture, difficulty, and muscle group, provided a well-rounded approach to evaluating exercise postures. By taking these factors into consideration, the selected postures were more likely to prevent injury in elderly individuals and reduce the risk of falls. Overall, the combination of frame representation, posture representation, and muscle specification provides a comprehensive approach to selecting exercise postures that considers a variety of factors. This can help individuals create a well-rounded and effective workout routine that meets their specific needs and goals.

3.3 Experiment III: Implementation & Knowledge Validation Process [42, 43]

3.3.1 Step 1: Posture validation by elderly experts

3.3.1.1 *Participants*

The one exercise instructor for the elderly is a fitness professional with expertise in working with older adults. Understand exercise science, physical therapy, or a related field. Have a strong understanding of the physiological changes that occur as an age, and how to design safe and effective exercise programs that are tailored to the unique needs and abilities of elderly.

The elderly exercise experts are the expert group from Fa-Ham elderly group (Fa-Ham Elderly group is an elderly club located in Fa-Ham district, Chiang Mai province), will be recruited on the condition that they must exercise at least 2 years before experiments, healthy, and can understand the safety posture of aerobic design for elderly exercise using of purposive questionnaire. The Inclusion criteria of elderly experts are: (1) 60 years or

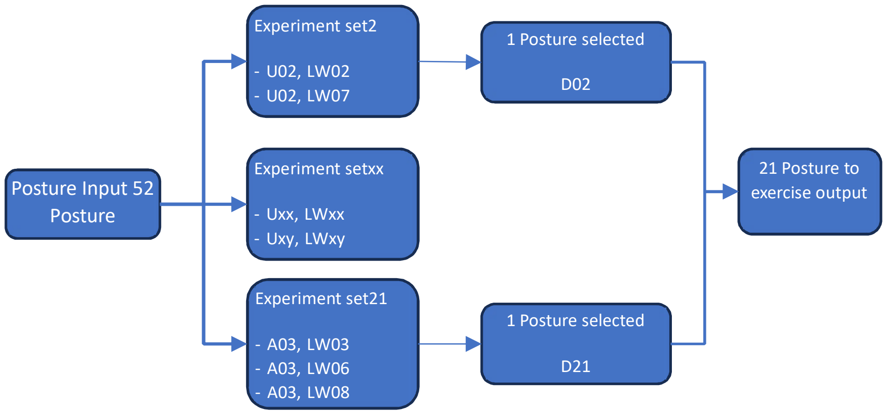

Figure 6 Diagram of Posture implementation for elderly to verify the postures.

older, (2) no history of injuries or diseases that influence balance function, (3) no alcohol consumption 12 hours prior to the experiment. (4) Passed the screening using the Par Q+ test by physical therapist prior to the trial with a score of 7 out of 7 on the test.

3.3.1.2 *Health check. Using 3 procedure as described*

– *PAR-Q+ questionnaire*: The PAR-Q+ (Physical Activity Readiness Questionnaire) is a simple health screening tool that can be used to determine if an individual is ready to start an exercise program. It asks a series of questions about the individual's medical history, current medications, and any symptoms or conditions that may affect their ability to exercise. The doctor can review the individual's answers to determine if they need further medical clearance before beginning an exercise program.
– *Blood pressure check*: The doctor can also perform a blood pressure check to ensure that the individual's blood pressure is within a healthy range. High blood pressure can increase the risk of heart disease and other health problems, so it's important to monitor it before starting an exercise program. If the individual's blood pressure is high, the doctor may recommend lifestyle changes or medication to help manage it.
– *Heart rate check*: The doctor can also check the individual's heart rate to ensure that it is within a healthy range. This can be done using a heart rate monitor or by manually checking the pulse. If the individual's heart rate is too high or too low, the doctor may recommend further testing or modifications to the exercise program to ensure that it is safe for them.

3.3.1.3 *Procedure*

Building on the principles of kinesthetic representation and knowledge validation, our research aimed to design exercise postures specifically for the elderly, drawing on insights from Barfield and Weghorst (1993) [51] and Laurent (1992) [43] to ensure clarity and validity of these postures.

Upon concluding the design phase in Experiment II, our subsequent focus shifted to validation. We curated 52 postures, largely influenced by Huang et al. (2016) [40], to address the holistic needs of the elderly. To enhance accuracy, we introduced distinct movement cues to aid the elderly in emulating these postures. Given the intricacies associated with kinesthetic representation, highlighted by Fuchs et al. (2013) [41], we initiated a preliminary evaluation. In this phase, experts employed a Likert scale to assess the clarity and adaptability of each posture, factoring in the diverse physical prerequisites of the elderly.

Following this evaluation, 21 postures, deemed to have the highest clarity and ease, were selected from the initial set. Their corresponding Likert scale evaluations were then detailed in Figure 7, showcasing the difficulty levels, with Figure 8 illustrating the balance of lower postures chosen by the elderly. The results of the posture selection, segmented into three levels of difficulty, are cataloged in Table 7.

Prior to the experimental phase, we imparted comprehensive exercise instructions to elderly experts. Their subsequent posture tests allowed us to evaluate the precision of their exercise execution. Employing Table 6 as a reference, we measured the satisfaction levels of the participants concerning the exercise routines. This meticulous testing and feedback sequence culminated in the finalization of 21 optimal exercise postures from our initial assortment.

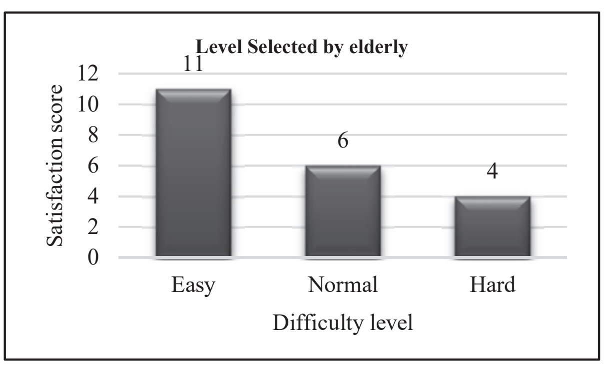

Figure 7 Bar chart showing the balance of easy, medium, difficult levels selected by elderly.

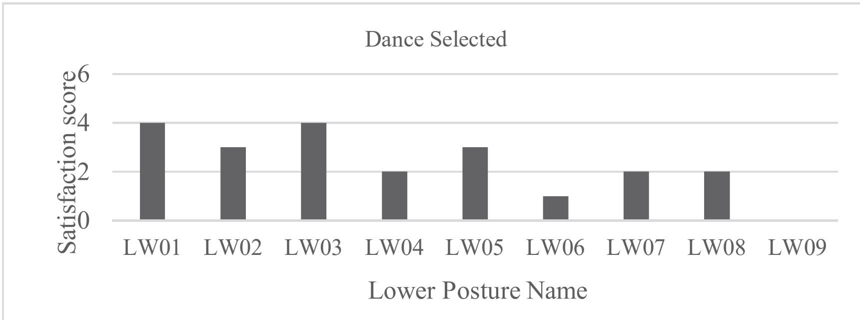

Figure 8 Showing balance of lower postures selected by elderly.

Table 6 Shown the sample result from implementation & validation of exercise posture by elderly experts

Test	Dance	Upper	Lower	Score	Selected	Voted
1	**1**	**U01**	**LW01**	**15**	**1**	75%
	2	U01	LW07	12	0	25%
2	3	U02	LW02	9	0	38%
	4	**U02**	**LW07**	**18**	**1**	63%

Table 7 Shows the selection of moves divided by 3 layers (easy, medium, hard)

Mode	Lower	Selected	Percent
Easy	20	11	55%
Normal	16	6	38%
Hard	16	4	25%
Total	52	21	

3.3.1.4 *Result*

The study results obtained from the process Implementation & validation 52 exercise postures that have processed by kinesthetic representation and implemented with exercise specialists who are elderly people in this step, it was found that 21 exercise positions out of 52 exercise positions were obtained. which is a suitable exercise posture and there are different levels of difficulty as an example shown in Table 6 which will be evaluated and analyzed further.

3.3.1.5 *Evaluation/analysis*

In this study, exercise postures were analyzed to determine appropriate exercise postures for elderly individuals based on their satisfaction ratings.

Advantages and disadvantages were also identified, including difficulty level and safety in each position, to choose the right exercise posture for the elderly. Participants evaluated exercise postures for three levels of difficulty: easy, normal, and hard, and specifically focused on lower body exercises.

The findings of this study suggest that it is important to consider the satisfaction, difficulty level, and safety of exercise postures when designing exercise routines for elderly individuals. By focusing on lower body exercises and evaluating postures at different difficulty levels, a well-rounded exercise routine can be created that provides maximum benefit and reduces the risk of injury. Further research in this area could help to improve exercise programs for the elderly and promote healthier aging.

From voting results, it was found that from the charts and tables for choosing poses divided by easy, medium, and difficult levels, there was a good distribution. A total of 11 out of 20 dance moves were selected, 6 out of 16 heavy dance moves were selected, and 4 out of 16 difficult moves were selected. From the bar chart and table, the moves that were easy also received a lot of points that were selected. and medium posture and poses that are difficult will be chosen less and less accordingly.

The bar chart displaying the balance of lower postures revealed that LW01, LW02, and LW03 were the most selected postures due to their relative ease. Conversely, LW04, LW05, LW07, and LW08 were less frequently selected, with LW04 being the least popular. These postures were considered less appealing due to their repetitive nature and lack of challenge. On the other hand, LW09 was not selected at all due to its difficulty level and the potential danger it posed to elderly participants who may struggle to maintain their balance while performing the move.

3.3.2 Step 2: Muscle validation by physical exercise experts

In this step, the likelihood of movement from the exercise is determined for each muscle frame. representation in step 2 in the validation field study will allow the exercise expert to validate and rate each exercise How does it affect each muscle part.

3.3.2.1 *Participants*

The expert group participants are 3 Physical exercises from Chiang Mai University, Thailand. They will be selected from the specialists at designing exercises for elderly using a purpose questionnaire. Join in this trial to choosing exercise posture using cart sorting technique.

3.3.2.2 *Procedure*

Three physical exercise experts validated the effect of each exercise on the elderly's muscles by examining and validating the choreography. They evaluated the impact on 15 different muscle groups and recorded the effect on each one. The effects on the muscles were then summarized for each of the 21 exercises, based on the muscle representation in the form of a frame, and the results were presented.

3.3.2.3 *Result*

Tables 8–10 illustrated the average score of muscle testing grades from three experts. The result was divided into three parts: arms muscle (Upper limb muscle), trunk muscle (Center muscle), and legs muscle (Lower limb muscle).

As the result shown in Tables 8–10 from the studies, this study has analyzed the focus level of muscles in the upper limb, trunk, and lower limb. Brachioradialis (scored is 4.5) and Deltoid (scored is 4.4) were significantly focused on the upper limb, while all parts in trunk muscles were significantly poor. And the Quadriceps (scored is 4.7) and Hamstring (scored is 4.3) were strongly focused on the lower limb, while Gluteus Maximus (scored is 2.3) and Gastrocnemius (scored is 2.3) were rated as poor. The overall score of the upper limb and lower limb muscles were graded as moderate, while the trunk muscles were graded as strongly poor.

Table 8 Muscle of upper limb result

Muscle of the Upper Limb	Average Score	Muscle Testing Grades
1. Brachioradialis	4.5	Strongly Focus
2. Biceps Brachii	2.8	Moderate
3. Triceps Brachii	2.8	Moderate
4. Deltoid	4.4	Strongly Focus
5. Pectoralis Major	2.4	Poor
6. Trapezius	3.1	Moderate

Table 9 Muscle of trunk result

Muscle of the Trunk	Average Score	Muscle Testing Grades
1. External Oblique	1.6	Strongly Poor
2. Latissimus Dorsi	1.5	Strongly Poor
3. Rectus Abdominis	1.5	Strongly Poor
4. Upper Rectus Abdominis	1.5	Strongly Poor
5. Lower Rectus Abdominis	1.3	Strongly Poor

Table 10 Muscle of lower limb result

Muscle of the Lower Limb	Average Score	Muscle Testing Grades
1. Gluteus Maximus	2.3	Poor
2. Quadriceps	4.7	Strongly Focus
3. Hamstring	4.3	Strongly Focus
4. Gastrocnemius	2.3	Poor

Table 11 Validation outcome for muscle specification

Type of Answer	Expert1	Expert2	Expert3
% who agree	91%	79%	85%
% who disagree	4%	11%	14%
% who don't know	5%	10%	1%

Table 11 presents the validation outcomes on muscle specification validation field study, shown agreement, disagreement and don't know. Based on the experts' comments, the disagreement and don't know responses were related to a misunderstanding of the case problems, mainly because they were ambiguous or ill-defined [29].

For most of the case problems (80%), the experts agreed with the recommendations. The range of variation between the experts is low for the agreements (between 79% and 85%), and higher for the disagreements and "don't know".

4 Discussion

The deployment of knowledge management systems [26] and knowledge engineering methodologies in devising postures tailored for the elderly carries significant implications for both healthcare professionals and researchers. A primary advantage of this methodology is the systematic and structured extraction of knowledge from domain experts. The expertise acquired in this study came from professionals in physical exercise and physical therapy who have vast experience working with the elderly. Such an approach allowed for a comprehensive insight into the elements that influence elderly posture, alongside an understanding of potential advantages and risks associated with various postures.

Moreover, the use of knowledge management and engineering methodologies also presents the capability to articulate knowledge in an organized and significant manner. In this study, the representation of posture knowledge leveraged a knowledge representation [24] framework. This not only facilitated the organization and validation of the knowledge accumulated from domain experts but also provided a lucid and succinct presentation of the information. Such clarity in presentation is instrumental in conceptualizing effective postures for elderly individuals.

By integrating the feedback from both physical exercise specialists and the elderly during the implementation field study, the postures designed through this methodology demonstrate higher relevance and potential acceptance for the target demographic. Engaging these stakeholders ensures the long-term adoption and acceptability of the postures.

One significant concern from the study pertains to the potential bias introduced during the knowledge acquisition phase [29]. Despite the inclusion of experts spanning various fields, the accumulated knowledge largely mirrors the individual opinions and experiences of these experts. Moreover, while the study zeroes in on exercise postures for the elderly, the findings might hold potential applications for other age groups or populations.

Another limitation is the constrained sample size. Although the study comprised six specialists, including physical therapists and physical exercise experts, it risks not capturing the full breadth of the elderly's diverse needs and suggestions. Future studies should contemplate a more expensive and varied participant pool. Incorporating objective measures, like energy expenditure and heart rate, can also fortify the validity and depth of the findings.

While the input from experts is invaluable, the voices of the elderly participants are equally crucial. Their firsthand experiences and feedback can provide a unique perspective on the feasibility and effectiveness of the postures designed. Therefore, it would be beneficial to integrate comments or testimonials from the elderly participants in future studies to provide a more holistic understanding.

Lastly, the inclusion criteria for elderly experts, although comprehensive, focuses heavily on the expert group from the Fa-Ham Elderly group. For wider applicability, it would be beneficial to source participants from various backgrounds and regions.

Overall, employing knowledge management systems and knowledge engineering [28] for the design of postures for the elderly offers an innovative approach to enhancing the physical health of this demographic. As we progress, it's essential to recognize and address the potential limitations while harnessing the benefits of this methodology.

5 Conclusion

In conclusion, the integration of knowledge management systems and knowledge engineering methodologies in posture design for elderly individuals has produced significant findings. Through a comprehensive procedure encompassing knowledge acquisition, representation, and application, this research has pioneered the formulation of postures that are both safe and efficacious, aligning with the specific physical health needs of the elderly demographic. The inclusion of experts from the realms of physical exercise and therapy has not only enriched the foundational knowledge but also enhanced the validity and acceptance of the devised postures. Moreover, the direct input from the elderly ensures that the postures are practical, relevant, and suited for sustained adoption.

The forthcoming phase of the study will incorporate motion analysis technologies [51]. The intention is to integrate the exercise postures developed from the current research into such systems to establish an interactive platform guiding elderly individuals through correct exercise execution. In parallel, the introduction of an advanced dashboard [52] will enable the systematic collection and analysis of data from the motion analysis. This feedback system will serve as a vital resource for Thai healthcare professionals, including exercise specialists and therapists, to enhance their care provision. The shift towards these technological enhancements marks a significant step in improving engagement and adherence, heralding a new era of data-driven approaches in creating tailored exercise routines for the elderly population.

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