

# Application of the Transtheoretical Model to Physical Activity and Health-related Quality of Life Among Older People Living With Frailty in the Community: The Fitness and Nutrition Program for Seniors (FANS) Study Protocol

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## Abstract

**Background:** When the COVID-19 pandemic is combined with frailty, not only are older people's types of activities and willingness to be active limited, but also issues and hidden concerns about health care arise. However, the effectiveness of health promotion strategies incorporating remote care technologies remains to be explored. Therefore, the purpose of this study was to develop a hybrid learning approach based on a fitness and nutrition program for seniors (FANS). Simultaneously, the FANS follows the Transtheoretical Model (TTM) as an overall framework to design blended learning in in-person and telecare modalities for older people living with frailty in the community.

**Methods:** This study is a non-randomized, control-group, pretest–posttest design. A total of 84 older participants living with frailty will be assigned to two groups. The intervention group will receive the 6-month, 9-session FANS through hybrid learning, which includes in-person physical activity (PA) training, nutritional guidance led by a nurse, and group discussions. The official account of the FANS and the group chat will provide individuals with online home practice at the current TTM stage, session time and home practice reminders, video reviews, consultations, and tutoring for telecare. The waitlist control group will maintain regular health promotion activities. Three repeated assessments (one pre-test and two post-training tests conducted after 3 months and after 6 months) will be conducted. The primary outcome measures will include frailty status, PA, and health-related quality of life (HRQoL), and the secondary outcome measures will be health-related data. Statistical analysis will include the Chi-squared test, Independent Sample t-test, and Generalized Estimating Equation (GEE).

**Discussion:** This study will provide evidence that the FANS for older people living with frailty will have more positive and beneficial outcomes than the traditional method. Simultaneously, we hope the FANS will help the older population living with frailty in the community to transform their health difficulties in the future.

**Trial Registration:** NCT05242549. Registered 22 February 2022.

**Keywords:** transtheoretical model, physical activity, health-related quality of life, frailty, older people, fitness, nutrition

## 1. Background

The world has shown a trend toward an aging society, and this trend must be faced now, in the 21st century.

Under the aging society structure, older people living with frailty in the community will face not only huge physical and mental changes (Dent et al., 2017; Zazzara et al., 2019) but also issues and hidden concerns related to community-based geriatric care. The prevalence of the concept of "Aging in Place" has led countries to actively promote relevant community-based health promotion activities. However, the main obstacle at present is the lack of a standard and effective community-based geriatric whole-care model (Mishra & Barratt, 2016). Studies have shown that the strategies of health care for older people living with frailty in the community should be diverse. At the same time, multiple strategies are commonly employed for the prevention and management of frailty. Physical training and nutritional education are the most common elements of diverse health promotion strategies (Haider et al., 2019; Jadcak et al., 2018; Kidd et al., 2019; Zhang et al., 2020). Physical training-based interventions can significantly improve the physical status, physical function, or functions of daily life in the older population living with frailty (Kidd et al., 2019; Puts et al., 2017; Zhang et al., 2020), while also improving the health-related quality of life (HRQoL) of older people living with frailty in the community (Barrachina-Igual et al., 2021; Kapan et al., 2017; Otones et al., 2020).

The American College of Sports Medicine (ACSM) suggests combining behavioral theory and positive feedback strategies when assisting older people with regular activity programs (Pescatello et al., 2014). The Transtheoretical Model (TTM) can guide older people living with frailty to establish behaviors that are beneficial to themselves or modify their current cognitions and behaviors. Through TTM, in addition to triggering their motivation to achieve purposeful changes and maintenance of health-related behaviors, it can also be an instrument to measure their current stage. Currently, few community-based frailty-aging studies have targeted interventional strategies related to physical activity (PA) with TTM, but the results have indicated significantly improved frailty status and physiological function (Nagaia et al., 2018; Wang et al., 2020).

With advances in technology, applied science and technology have begun to be provided to older people in the community. The impact of science and technology on physical function should not be underestimated (Barton et al., 2020). Especially during the pandemic of severe coronavirus disease 2019 (COVID-19), and under the influence of complex factors such as additional restrictions on the scope of activities, the frail state of older people in the community is very likely to increase (Shinohara et al., 2021). A simple and fast solution to this problem could be the provision of geriatric care via technology (Gerotziafas et al., 2021). Despite the advantages of technology-assisted interventions, which cannot be ignored, it is difficult and challenging to design and develop effective health promotion strategies for older people living with frailty in the community (Apóstolo et al., 2018). Thus, there is a need to explore the development of health promotion strategies combined with technology-assisted interventions to help older people living with frailty in the community improve their PA and HRQoL.

To alleviate the problem described above, we have employed the TTM as an overall framework to develop a hybrid learning approach, the Fitness and Nutrition program for Seniors (FANS). The TTM was applied to analyze the process of behavioral change in older people living with frailty at various stages of the intervention, as well as to investigate the influencing factors at various stages of using technology for telecare in geriatric care, and to design blended learning in-person and telecare for older people living with frailty in the community. We hope that older people living with frailty in the community will transform into a driving force for health promotion, setting the goal of a healthy life, improving their PA and quality of life, and bringing about positive changes.

## **2. Research Objectives and Hypothesis**

Our study aims to test two hypotheses:

1. We hypothesized that the TTM as a framework to develop the FANS would positively affect frailty status, PA, HRQoL, and health-related data in older people living with frailty in the community as compared with the waitlist control group.
2. We hypothesized that the recruitment and implementation of the FANS for older people living with frailty in the community would be feasible and have a certain degree of compliance, and also that no adverse events would occur during the intervention.

## **3. Methods**

### *3.1 Research Design*

This study is a non-randomized control-group pretest–posttest design. We will recruit participants from two community-based care centers in the same area with the same nature, but located in the southern and northern regions of the area, to participate in this study. We will decide by lottery which community care center will be

the experimental group for the 6-month FANS and waitlist control group. After obtaining the consent of the care center for this study, we will collaborate with it to publicize the study during the usual activities and courses. In addition, meetings to explain the study will be held at both community-based care centers, and the study will again be explained to the participants individually both to ensure that they are fully informed about the program protocol and to assist the participants to sign the informed consent. The detailed study process is shown in Figure 1. Throughout the trial, two community-based care centers will agree not to participate in any interventional study including PA or a healthy diet. The study is currently ongoing (recruitment began on June 19, 2022, and data collection for the study is expected to be completed by February 2023). This study protocol has been approved by the Fu Jen Catholic University Institutional Review Board (FJU-IRB NO: C110071) and registered with ClinicalTrials.gov (Clinical Trials.gov ID: NCT05242549).

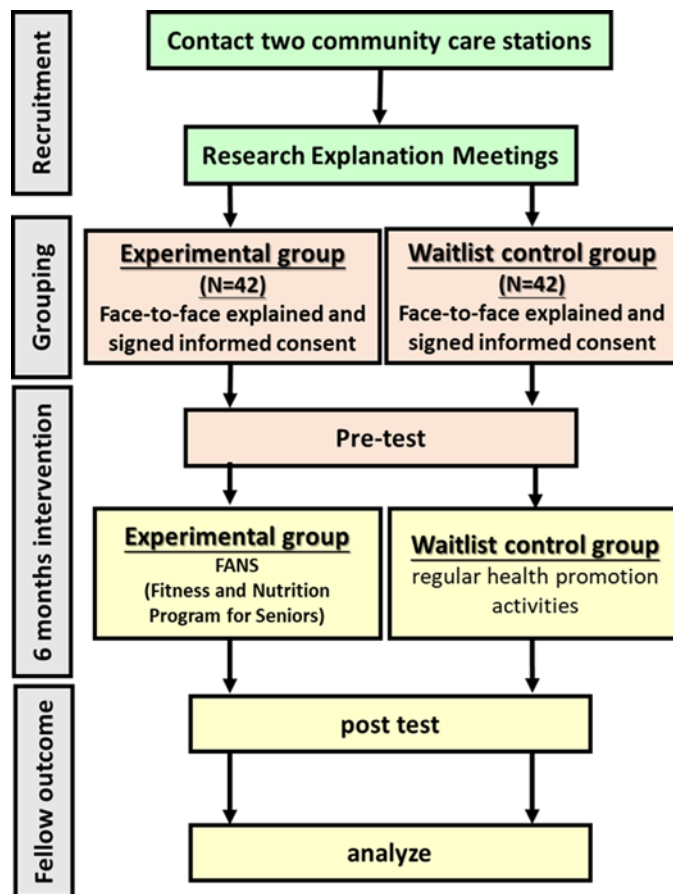


Figure 1. FANS study flowchart

### 3.2 Sample Size

The sample size necessary to achieve the goals of this study was determined through statistical power analysis using G\*Power version 3.1.9.4, calculating repeated measures ANOVA. Based on a prior study that was similar to our study, we planned with an effect size of 0.25,  $\alpha$  of 0.05, power of 0.8, the number of groups set to 2, 7 repeated measurements, and a correlation coefficient between repeated measures for participants of 0.5 (Liao et al., 2019). This study would thus require a total sample size of 74 participants, or at least 37 in each group. Considering a 14% dropout rate, our total sample size was calculated as 84 participants (42 cases in each of the intervention and waitlist control groups).

### 3.3 Participant Recruitment

Participants are eligible for the trial if they are 65 years of age or older with the frailty phenotype of the Cardiovascular Health Study (CHS). Participants who have a diagnosis of acute or chronic disease inappropriate for PA and conditions such as joint or lower extremity surgery within 6 months are excluded. Detailed inclusion

and exclusion criteria are listed in Table 1. This study only includes those who sign the informed consent form prior to the baseline. When participants in the experimental group meet the criteria, they start the intervention phase after completing the pre-intervention baseline data collection. Before the intervention, the researcher assists the participants in the experimental group to complete the installation of the application software program required by the FANS on their mobile phones or tablet computers and to confirm whether they have acquired and can achieve the skills of independent operation. Then the participants receive the blended learning program in both in-person and telecare modalities for a 6-month period.

Table 1. Inclusion criteria and exclusion criteria

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> <li>▸ Aged 65 years or above</li> <li>▸ Frailty according to the cardiovascular health study (CHS)</li> <li>▸ Normal cognitive function and agreement to cooperate with the study interventions and data collection</li> <li>▸ Ability to access the internet with any type of digital device, e.g., personal smartphone, tablet (iPad), or computer (with camera functionality)</li> </ul>	<ul style="list-style-type: none"> <li>▸ Diagnosis of high risk of acute or chronic diseases causing unfit for physical activity, e.g., neurological dysfunction, severe cardiovascular or pulmonary disease, persistent joint pain, or severe musculoskeletal impairment</li> <li>▸ Severe visual impairment</li> <li>▸ Residence in a long-term care facility</li> <li>▸ Participation in an interventional study related to physical activity or nutrition within the six months prior to the study intervention.</li> </ul>

### 3.4 Intervention Group

FANS is a hybrid learning program that combines in-person learning with telecare. The TTM frameworks for FANS intervention design are presented in Figure 2. FANS creates in-person group sessions, and based on the participants' TTM stage, uses telecare to provide online home physical practice and nutrition instruction. Telecare is also used to identify changes in cognition and behavior, while follow-up through telecare is offered to enhance self-efficacy. The strategy aims to achieve behavioral change outcomes by motivating individuals to adopt healthier behaviors. Telecare consultation and counseling techniques are used to assist individuals in moving towards the preparation phase and attaining decision-making equilibrium. Finally, frail older adults in the community reach the action or maintenance phase of the behavior change process through FANS, indicating successful adoption and sustained practice of healthier behaviors. The detailed study rationale and protocol design are listed in Table 2. The contents of FANS include: (1) In-person PA training sessions. (2) In-person nutritional guidance led by a nurse. (3) Online home physical practice and nutrition instruction provided by the mobile app LINE based on the individual's current TTM stage. (4) Using the mobile app LINE to track the attendance rate for home practice in telecare. (5) Providing consultation and counseling about home practice through the mobile app LINE.

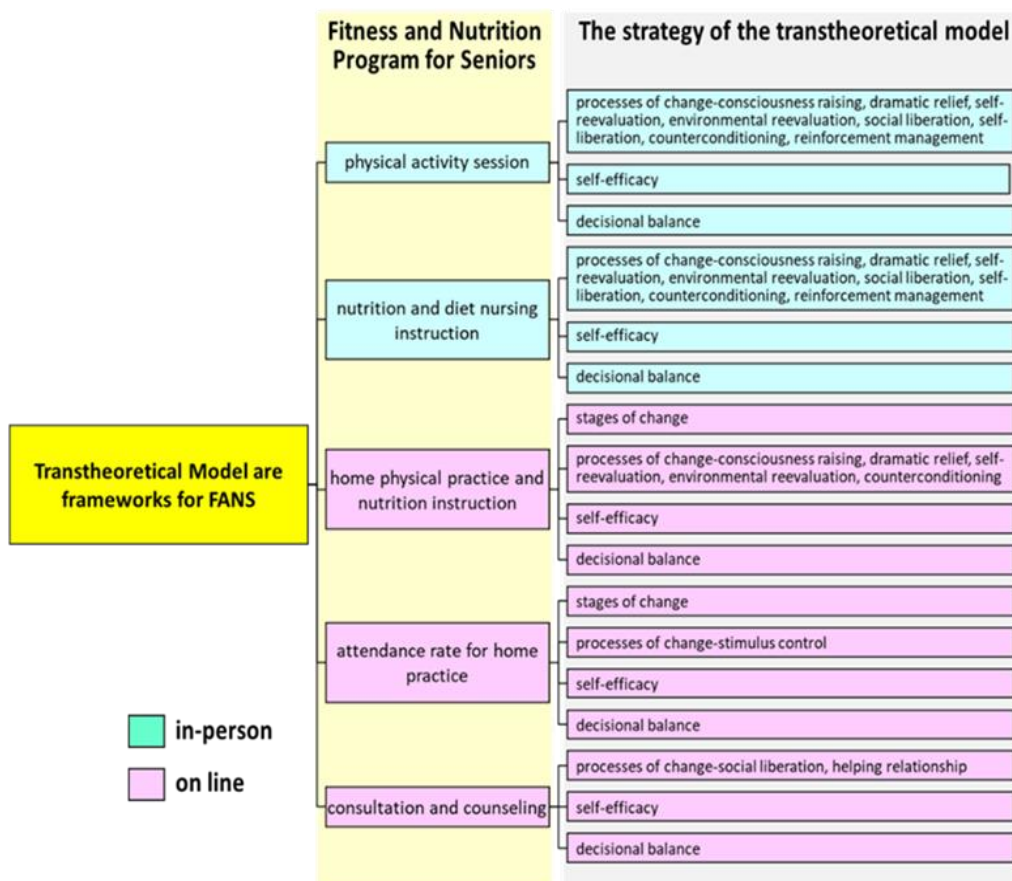


Figure 2. FANS intervention based on the transtheoretical model

Table 2. Effects of Transtheoretical Model-Based FANS Among Older People Living with Frailty in the Community: Study Rationale and Protocol Design

Stages of change (goal)	Processes of change	Self-efficacy	Decisional balance
<ul style="list-style-type: none"> <li>■ Precontemplation</li> <li>■ Contemplation</li> </ul> <i>(The necessity to increase information about FANS.)</i>	<ul style="list-style-type: none"> <li>• Consciousness-raising: provides reasons and consequences for the benefits of FANS to help reduce executive barriers (hybrid learning).</li> <li>• Dramatic relief: advocacy about the consequences of not doing FANS, raising concerns and worries about health (hybrid learning).</li> <li>• Self-reevaluation: Initiate self-focus and start to make positive changes in FANS (hybrid learning).</li> <li>• Environmental reevaluation: Inspire yourself to think about the benefits that FANS can bring to friends, family, or society (hybrid learning).</li> <li>• Social liberation: Encourage the feasibility of increasing self-physical activity and focusing on a balanced and healthy diet with the support of a social environment (hybrid learning).</li> <li>• Self-liberation: Encourage individuals to be willing to accept FANS by believing in themselves (In-person).</li> <li>• Reinforcement management: Provide certificates and verbal rewards when goals are achieved (In-person).</li> </ul>	When progressing through stages of change and continuing to improve, various factors that impede behavior change begin to decrease, leading to an increase in self-efficacy.	When an individual perceives that the benefits of behavior change outweigh the drawbacks, their stage of change will progress.

Stages of change (goal)	Processes of change	Self-efficacy	Decisional balance
<p>■ Preparation (Increase motivation and confidence to participate in FANS.)</p>	<ul style="list-style-type: none"> <li>• Self-reevaluation: Assistance in adjusting FANS practices based on individualized needs (Online).</li> <li>• Self-liberation: An individual declares their willingness to engage in FANS practice In- person).</li> <li>• Helping relationship: Through professional assistance, as well as support, encouragement, and care from peers (hybrid learning).</li> <li>• Stimulus control: Implement telecare to send FANS reminders every day and regularly track compliance with home practices attendance (Online).</li> <li>• Counter conditioning: Provide options for physical activities and healthy diet to assist in adjusting the execution content of FANS (hybrid learning).</li> <li>• Reinforcement management: Provide certificates and verbal rewards when goals are achieved (In-person).</li> </ul>		
<p>■ Action ■ Maintenance (Create a long-term supportive environment for FANS.)</p>	<ul style="list-style-type: none"> <li>• Self-reevaluation: Assistance in regularly reviewing the status after self-acceptance of FANS practices (Online).</li> <li>• Self-liberation: An individual declares their belief that they can sustain FANS practice (In-person).</li> <li>• Helping relationship: Foster a sense of cohesion and shared growth within the group (hybrid learning).</li> <li>• Stimulus control: Implement telecare to send FANS reminders every day and regularly track compliance with home practices attendance (Online).</li> <li>• Counter conditioning: Help people experience the joy and sense of achievement that come from the positive changes gained through the long-term execution of FANS (hybrid learning).</li> <li>• Reinforcement management: Provide certificates and verbal rewards when goals are achieved (In-person).</li> </ul>		

Therefore, training workshops for teachers and staff will be held prior to the implementation of the FANS. The Content Validity Index (CVI) score of the workshop course content is 0.99. The PA training presenter is a licensed professional sports coach with multi-sport certifications. The presenter of the Nutritious Diet Nursing Instruction holds a master's degree in Gerontology Nursing and has been certified for credit in sports nutrition. The FANS comprises a total of 9 in-person lessons, each lasting 90 minutes. In the first month, the experimental group will have four in-person lessons at weekly intervals. In-person lessons will be held once every month for 5 months. The in-person group lessons include a 50-minute PA training session conducted by a licensed professional sports coach, a 20-minute nutrition and diet nursing instruction conducted by a nurse, and a 20-minute group discussion and sharing session. The PA training session begins with joint activities for the extension and mobility of the main joints as a warm-up, followed by muscle strength and balance training as the core of the course. Muscle strength training focuses on weight and resistance training for the upper and lower limbs to improve overall muscle strength, while balance training includes the application of core muscle coordination and dynamic and static balance functions and requires coordination and sensory processing during the process. Finally, simple relaxation exercises are included at the end of the PA training session to reduce body temperature, promote blood return and increase metabolism, and achieve physical repair by maintaining muscle length and elasticity. Nutrition and diet instruction is carried out through group lectures. The main content includes nutrients related to nutrition required for advanced age, dietary recommendations for six types of food per day, the key points of the senior nutrition nursing guidance, and the effects of PA and nutrition on frailty. It is expected that the in-person lessons will enhance the overall awareness of older people living with frailty and contribute to changes in motivation and behavior. The course video of each in-person lesson will be placed on

the FANS official account in the mobile communication application LINE for viewing at any time.

If there are special circumstances such as social distancing restrictions due to the COVID-19 pandemic during the intervention period, the in-person lesson will be replaced with a teleconference in LINE at home and at the original scheduled time. To maintain the overall fidelity of this study, we will count the intervention fidelity data and special conditions every month during the implementation of the overall intervention measures. To establish and maintain fidelity in study and practice, the attendance at the in-person lessons will be recorded by check-in procedures.

The telecare component of the FANS will be provided by creating a FANS official account and a FANS e-group in LINE. The FANS official account and FANS e-group will provide: 1. online home practice content appropriate for participants' current TTM stage and message sending; 2. a short message service to remind participants to do PA at home and follow a nutritious diet every day; 3. one-by-one consultations and coaching; 4. real-time communication in the LINE e-group to address participants' immediate issues; 5. a point system for the home-based PA and nutritious diet for the following adherence level; and 6. the URL of a Google form to follow up on the TTMstage and the participants' satisfaction in the experimental group every month. The online home practice will be based on the current TTM stage of the participants. By designing three different online home practice interventions for the behavioral process, we apply cognitive change skills and behavioral change skills. Details of the study process are shown in Figure 3.

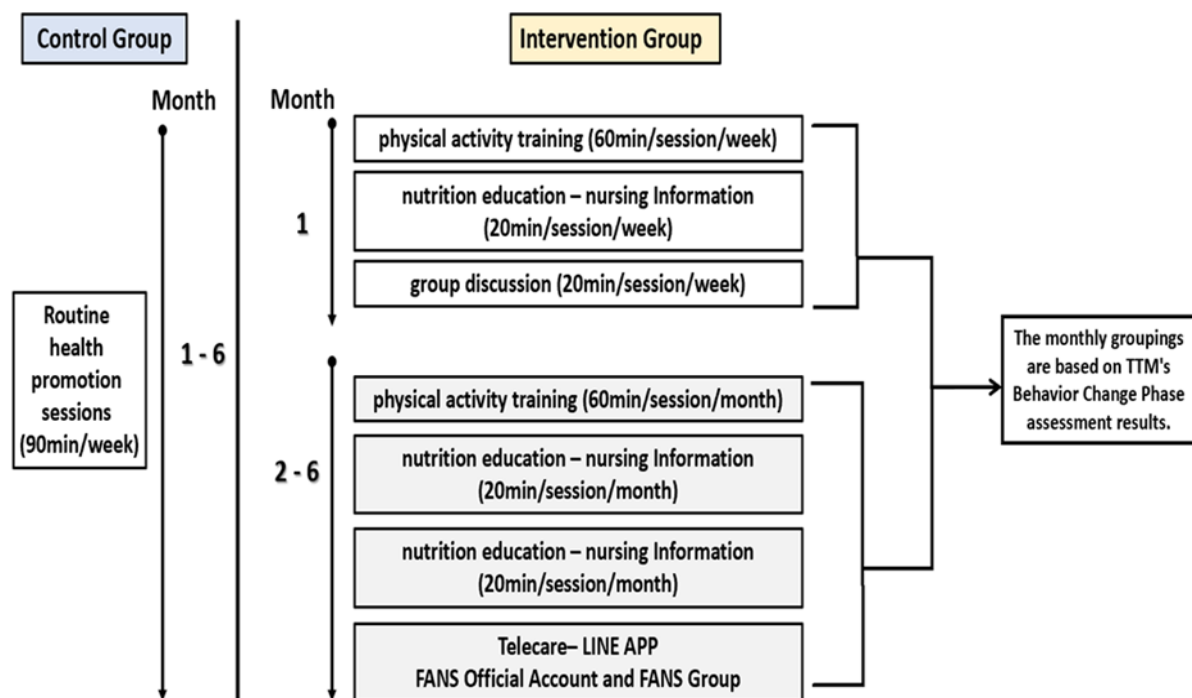


Figure 3. Overview of the study procedure

### 3.5 Waitlist Control Group

The control group will continue to receive the usual health promotion activities. If the control group asks relevant questions, only general advice will be given due to ethical considerations. This means that no information about the TTM-based FANS will be provided.

### 3.6 Outcome Measures

#### Socio-Demographic Profile

The demographic variables are based on the study purpose and structure and were chosen with reference to the relevant literature for the relevant set. The 9 variables are as follows: 1. Date of birth; 2. Biological sex (male / female); 3. Education level (illiterate / elementary school / high school / college degree or above); 4. Marriage

type (unmarried / married / divorced / widowed); 5. Residential status (living alone / non-living alone); 6. History of smoking (yes / no); 7. History of drinking (yes / no); 8. Perceived economic situation (no economic pressure / slight economic pressure / moderate economic pressure / great economic pressure); and 9. Comorbidities (myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic lung disease, rheumatic disease, ulcer disease, mild liver disease, diabetes, chronic complications of diabetes, hemiplegia or paralysis of the lower body, kidney disease, malignant tumors including leukemia and lymphoma, moderate or severe liver disease, metastatic cancer, acquired immunodeficiency syndrome).

### **Primary Outcomes**

#### 1. Frailty

The cardiovascular health study (CHS) will be applied to assess frailty status, defined as unintentional weight loss of > 5.0 kg or 10% during the past year (shrinking); grip strength of < 26.0 kg in men or < 18.0 kg in women (weakness); agreement with one of the following two statements from the Center for Epidemiologic Studies Depression Scale (CES-D): "I felt too tired to do anything" or "I lacked the motivation to do anything" for at least 3 days in the past week (exhaustion); walking slower than 0.8 m/s (slowness); and PA < 3.75 MET/h in men or < 2.5 MET/h in women (low PA). Participants meeting three or more of the criteria will be classified as frail, and those who meet one or two, as prefrail (Chen et al., 2020; Chittrakul et al., 2020; Liao et al., 2019; Sadjapong et al., 2020; Yu et al., 2020).

#### 2. PA

The assessment of PA will include the Short Physical Performance Battery (SPPB), grip strength, and the Timed-up-and-go test (TUG), and the International Physical Activity Questionnaire (IPAQ) will be used to calculate the weekly activity levels of participants to show the metabolic equivalent of task (MET) (Chen et al., 2020; Liao et al., 2019; Watanabe et al., 2020; Yu et al., 2020).

#### 3. HRQoL

HRQOL will be assessed with the 12-Item Short Form Survey (SF-12) (Haywood et al., 2005). It considers participants' health characteristics and study design (Chittrakul et al., 2020; Nagaia et al., 2018; Sadjapong et al., 2020). The internal consistency is around 0.70–0.925 (Halvorsrud & Kalfoss, 2007). The correlation coefficient between the 12-item Short Form Health Survey (SF-12) and the original 36-item Short Form Health Survey (SF-36) is as high as 0.94–0.97 (Gandek et al., 1998).

### **Secondary Outcomes**

#### 1. Kinanthropometric Measures

Kinanthropometrics will be assessed using body mass index (BMI), which is calculated by measuring body height (meters) and body weight (kg). Additionally assessed at the same moment are the calf circumference and mid-upper arm circumference.

#### 2. Falls Efficacy

The efficacy of falls will be assessed using the Short Falls Efficacy Scale International (FES-I). This scale comprises 7 items assessing functional activities such as dressing and undressing, bathing, standing up or sitting down from a chair, climbing up and down stairs, walking up or down a slope, and leaving the home for social activities. The weighted score is determined according to the degree of fear of falling. A higher score indicates greater fear of falling in daily life. The Cronbach's alpha for internal consistency is reportedly 0.89 (Helbostad et al., 2010).

#### 3. Pain Intensity

The intensity of pain will be assessed using the Visual Analogue Scale (VAS), with 0 mm meaning no pain intensity and 100 mm indicating the highest pain intensity. Movement from left to right on the VAS indicates that the pain intensity gradually increases.

#### 4. Activity of Daily Living

Activities of daily living will be assessed using the Instrumental Activities of Daily Living (IADL) scale. This 8-item scale is used to evaluate such activities as shopping, housework, money management, food preparation, transportation, making phone calls, washing clothes, and taking medication. The weighted score is determined by the life functional level. Higher scores mean better function.



### ***Intervention Group Outcomes***

#### **1. Adherence level during the intervention**

The level of adherence to in-person lessons will be calculated as attendance for each lesson. The level of adherence to home practice will be applied via telecare and tracked using monthly accumulated points.

#### **2. Behavioral change stages and satisfaction with the FANS**

The behavioral change stages and satisfaction will be assessed using the FANS Behavior Change Stages and Satisfaction scale. This scale has two components: behavior change stages and satisfaction. The components of the behavior change stage were adopted from the Questionnaire for Stage of Exercise Change (Marcus, Rossi, et al., 1992; Marcus, Selby, et al., 1992). The items assess stages of change in PA status and daily nutrition diet for older people living with frailty in the community. Satisfaction with the overall program, PA training, nutrition and diet satisfaction are all included. Satisfaction will be assessed using the VAS. The CVI score of the FANS Behavior Change Stages and Satisfaction scale is 0.99.

In the event of an unexpected or adverse occurrence occurring during the FANS interventions, the principal investigator is notified promptly, and the adverse event is reported to the study team. One registered nurse from the study team will take care of trial participants who have experienced harm as a result of their participation.

#### ***3.7 Data Collection and Analysis***

To ensure the fidelity of the FANS intervention, this study will recruit individuals qualified in administering outcome measures of functional fitness in older adults to participate and complete the workshop. The first data (T0), including socio-demographic profile, primary outcome, and secondary outcomes, will be collected at the two community care sites, respectively. The primary outcome and secondary outcomes will be remeasured during the third month of the intervention and at the end of the intervention. During the intervention period, the attendance of the experimental group will be tracked at in-person lessons. In addition, the experimental group will be followed for adherence to home exercises, behavioral change stages, and satisfaction in FANS through the mobile app LINE every month. Appendix 1 shows the research evaluation and research process timeline.

Workshops provide training for every member of the trial's measurement personnel. Standard operating procedures and operational principles are followed throughout the data collection process. All consent and paper-based acquired data will be kept in locked filing cabinets for maximum security. Staff members who have undergone training will independently enter the data from the coded questionnaire items. The collected data will be saved in a password-protected computer folder. Data published will not include personally identifying information about participants. The researcher will be in charge of data administration and will have access to the entire dataset. The only person who can view the coded data is the study moderator. Reports of unfavorable FANS-related incidents from participants will be kept on file.

Data will be processed in SPSS 22.0 for statistical analysis. In descriptive statistics, categorical variables will be presented as amounts and percentages and continuous variables as means and standard deviations. Before the intervention, the differences between the two groups will be analyzed by applying the Chi-squared test for categorical variables and the Independent Samples t-test for continuous variables to examine the homogeneity and underlying differences between the two groups before the intervention. Then the Generalized Estimating Equation (GEE) will be applied to analyze the PA and HRQoL at 3 months and 6 months after the intervention to examine group differences. This approach will examine whether data collected at 3 and 6 months post-intervention interacts with groups on health-related data, PA, and HRQoL (Liang & Zeger, 1986; Zeger & Liang, 1986). By combining intention-to-treat analyses with specialized strategies for managing multiple imputations for missing data, we were able to eliminate possible bias related to variations in outcomes between individuals who were lost to follow-up and those with complete data.

### **4. Discussion**

At present, there is an urgent need to provide older people with a healthcare model oriented to reducing frailty. Factors due to frailty, such as loss of muscle strength, decreased exercise capacity, reduced physical function, and fatigue, can be reversed by increased PA. The research on older people living with frailty in communities around the world has successively used strategies such as exercise training and nutrition education to improve physical function, prevent or slow down the adverse consequences of frailty, and increase the ability to live independently (Kidd et al., 2019). Although there is much evidence for improving PA in frail older people, designing interventions that are significantly effective in reducing frailty is extremely challenging. A health care program for older people living with frailty in the community should be designed to include dynamic PA based on each individual's physical fitness level and health status. Such a program will significantly improve their

health and yield substantial results (Apóstolo et al., 2018). Furthermore, improved HRQoL will result from exercise intervention for older people living with frailty. Similarly, the application of multiple strategies can improve the HRQoL for older people living with frailty in the community (Barrachina-Igual et al., 2021; Chittrakul et al., 2020). Therefore, multiple healthcare strategies should be designed, including exercise and long-term follow-up health status for older people living with frailty in the community, to achieve the goal of improving and maintaining their quality of life.

Frailty has a causal relationship in the older population. Choosing a theory for the study of the elderly will support the design of interventions to prevent and improve frailty outcomes (Melnik & Morrison-Beedy, 2018). More than one factor affects the PA and quality of life of older people living with frailty in the community. Based on the literature, applying the TTM can achieve changes in the behavioral stages of older people in the community (Nagaia et al., 2018; Wang et al., 2020). When the TTM leads to staged changes in preparing for healthy lifestyle behaviors in the older people living with frailty in the community, cognitive and behavioral changes occur over time at different stages. Simultaneously, in the process in which the change occurs, the self-efficacy of believing that individuals can make behavioral changes is as important as the decision balance that values the good and the bad of change, which lasts until the behavior is completely changed and the new behavior continues (Prochaska & Velicer, 1997). Applying the TTM to develop health promotion strategies that fit the individual's status can reduce and overcome contextual barriers for older people living with frailty in the community.

In the face of changing times and the continuous aging of the population, applying technology to reduce the cost of human resources is a modern trend and new type of care strategy. Telecare can strengthen the advantages of the ideas and practices of "aging in place," has the ability to make up for the lack of face-to-face care, and reduce the use of human resources and associated costs. Therefore, telecare, such as communication technology, computer technology, or Internet technology, is being applied to improve the delivery of geriatric care (Marston et al., 2020). In particular, the COVID-19 pandemic has brought unprecedented new challenges to geriatric care in the community. Currently, it is an urgent issue to formulate a complete and appropriate healthcare strategy. Asian countries such as Taiwan and Singapore have collaborated with the mobile communications application LINE to disseminate information on the COVID-19 pandemic and provide pandemic-related public health education. The advantages of communication technology are being applied to reduce the spread of the pandemic and some adverse effects of the pandemic, such as social distancing restrictions or home isolation policies (Ting et al., 2020). Therefore, the health strategy must adopt home-follow strategies, technology assistance, and telecare to strengthen its function and enable older people living with frailty to live independently in the community. When older people living with frailty receive immediate support and continuous care in the community, it will help to ensure that they can safely achieve the goal of "aging in place" (Karlsen et al., 2017).

#### **List of abbreviations**

CVI: Content Validity Index

FANS: Fitness and Nutrition Program for Seniors

HRQoL: Health-related Quality of Life

PA: Physical Activity

TTM: Transtheoretical Model

VAS: Visual Analogue Scale

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#### **Declarations**

#### **Ethics approval and consent to participate**

The study was approved by and performed in accordance with the relevant guidelines and regulations by the Institutional Review Board of Fu Jen Catholic University (Date: 2022.01.06/FJU-IRB No.: C110071). All participants provided their written informed consent to participate in this study.

#### **Consent for publication**

Not applicable.

### Availability of data and materials

Not applicable.

### Competing interests

All the study authors have no relevant financial or non-financial interests to disclose. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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### Authors' contributions

All authors contributed to the study's conception and design. C-J H, and P-S L. had the initial idea and developed the original study plan. N-F M, and J-K. supported the development and implementation of the interventions. P-S L, and J-K. are responsible for developing the content of the protocols and organizing training workshops. P-S L. wrote the paper. N-F M. helped to write the text. C-J H. critically revised the text for its content. All authors critically revised the draft manuscript and approved the final paper.

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Appendix 1. Study process lines: summary of schedule of enrollment, interventions, and assessments

	STUDY PERIOD								
	Enrolment	Pre-intervention, Baseline	Post-intervention, 1-5 months						Close-out
TIMEPOINT**	$-t_1$	0	$t_1$	$t_2$	$t_3$	$t_4$	$t_5$	$t_6$	$t_x$
<b>ENROLMENT:</b>									
Eligibility screen	X								
Informed consent	X								
Staff Member roll	X								
<b>INTERVENTIONS:</b>									
Intervention: FANS		X	←—————→						
<b>ASSESSMENTS:</b>									
Socio-Demographic Profile		X							
<b>Primary Outcomes</b>									
Frailty		X			X				X
Physical Activity		X			X				X
Health-related quality of life		X			X				X
<b>Secondary Outcomes</b>									
kinanthropometric measures		X			X				X
Falls Efficacy		X			X				X
Pain Intensity		X			X				X
Activity of Daily Living		X			X				X
<b>Intervention Group Outcomes</b>									
Behavioral change stages and satisfaction in FANS			X	X	X	X	X	X	

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