PHYSICAL FITNESS LEVELS AMONG COMMUNITY-DWELLING IN ONGKHARAK DISTRICT, NAKHON-NAYOK PROVINCE

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PHYSICAL FITNESS LEVELS AMONG COMMUNITY-DWELLING IN ONGKHARAK DISTRICT, NAKHON-NAYOK PROVINCE

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BY

JINTANA TANYONG

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Aging reduces levels of physical fitness leading to disability among the elderly and appropriate exercise programs are advantageous in reducing the risk of immobility. This study evaluated the effects of prescribed individual home-based progressive exercise programs among elderly participants in the Ongkharak district of the Nakhon-Nayok Province and composed of three phases. Phase One involved the investigation of the test-retest reliability of the Senior Fitness Test (SFT) included the following: (1) arm curl test; (2) chair stand test; (3) six-minute walk test (6MWT)/two-minute step in place test (2MST); (4) back scratch test; (5) chair sit and reach test; (6) eight-ft up-and-go test; and (7) body mass index. A high test-retest reliability for all tests (ICC .89-.98, n=10) was also found. The evaluations of the reliability of 2MST, ten-meter 6MWT (6MWT-10m) and thirty-meter 6MWT (6MWT-30m) for assessing cardiopulmonary endurance among the elderly showed a high test-retest reliability (ICC .91-.93, n=30). In terms of validity, there was a moderate to high correlation (r=.71-.86, p<.1) in the percentage of heart rate reserve (%HRR) but only a moderate correlation for a rating of perceived exertion (RPE) (r=.40-.58, p<.01) to 6MWT-30m were found. In Phase Two, the results from the 190 participants (one hundred and 21 females, 64.2+2.6 year) found that all physical fitness levels were different between genders, (p<.05) except upper body strength. In Phase Three, 61 participants from Phase Two, ranked in the 75th percentile of lower in cardiopulmonary endurance and lower body strength physical fitness levels were included and randomly assigned to two groups. The exercise group completed an eight-week individualized home-based progressive exercise programs including strength, endurance, flexibility, and balance exercises. The results after four weeks indicated that the exercise group achieved significantly higher results compared to the control group in the arm curl test, the chair stand test, the 2MST, the chair sit and reach test, and 8-ft up-and-go test (p < .05). There was no significant between-group difference in the back scratch test. Similar results were also found at eight weeks. In conclusion, the eight-week individualized home-based progressive exercise prescribed based on physical fitness levels were shown to be effective in improving strength, cardiopulmonary endurance, lower body flexibility, and balance. Further studies are required to promote physical fitness among the elderly, especially for the purpose of upper flexibility.

Keyword : Physical fitness test, Elderly people, Exercise training

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CHAPTER 1
INTRODUCTION

Background

The proportion of the elderly population to the world population is continuously growing. In 2012, out of the total population of 7,058 billion, there were 565 million people aged 60 years or older, representing 8 percent of world population[1]. Furthermore, advancements in the areas of medicine and public health care have been helping prolong life in elderly people, thus greatly widening the ratio of the aging population, as compared to other demographic groups. As the result, the number of elderly was projected to increase nearly three times during a 30-year period from 6 million (10%) in 2005 to 16 million people (25%) in 2035 [1].

Biologically, aging reduces one's physical fitness, leading to the decline in functions of body systems (such as the cardiovascular system, respiratory system, musculoskeletal system, and nervous system) and the increase of comorbidity (metabolism disease, heart disease and lung disease) and sedentary lifestyles[2]. In addition, the major health problems faced by the elderly is the decreased in physical functions[1, 3]. Typically, physical functions depended on muscle strength, muscle flexibility, exercise endurance, agility/dynamic balance, and body composition[4]. Accordingly, there is a critical need for periodic assessments of basic health data of the elderly in order to promote the health condition among these individuals. Moreover, the lower physical activity levels of a person aged 53 years or older is statistically associated with the higher rate[5].

One of the most important components of elderly's independent functioning in daily life is physical fitness. This includes both simple and complex daily life activities such as walking, climbing stairs, standing up from the floor, performing tasks of daily living (such as combing hair, putting on socks and shoes) [6]. To ensure that an elderly person receives a comprehensive physical fitness, Senior Fitness Test (SFT) is used for tests in upper/lower body strength, cardiopulmonary endurance, upper/lower flexibility, agility/dynamic balance and body mass index (BMI) [6]. SFT has been shown to be a good reliable and valid assessment of exercise effectiveness among elderly [6]. The SFT for the upper and lower body strength is performed through the arm curl test and 30-s chair stand test, respectively. For upper and lower flexibility tests, the back scratch test and chair sit-and-reach test are performed, respectively. The agility/dynamic balance is performed via 8-ft up-and-go test. The body mass index is calculated from one's weight and height. And the cardiopulmonary endurance is conducted through the six-minute walk test (6MWT) or the alternative cardiopulmonary endurance test, 2-minute step in place test (2MST), if space is limited [6]. The measurement of cardiopulmonary endurance is important as it associates directly with the endurance to perform daily activities, and the poor test result can indicate the poor physical fitness in other areas, such as lower body strength and agility/dynamic balance. As a standard, the 6MWT utilizes walkways of different lengths, e.g. 20 meters, and 30 meter [7]. Ng et al. (2013) found that there is no significant difference between the lengths of walkway (10, 20, and 30 meter) in terms of Rating of Perceived Exertion (RPE) and heart rate (HR) in elderly [8]. However, the 2MST may be more appropriate for elderly due to the use of repetition movements. Therefore, the present study was investigate the heart rate, Rating of Perceived Exertion, and blood pressure among community dwelling elderly during the 6MWT-10m, the 6MWT-30m, and the 2MST.

In Ongkharak district (in 2013), there are 7,438 people who are over 60 years old (12% of total population) with more than 70% of them having comorbidity [9]. Examples of comorbidity in elderly are hypertension, diabetes mellitus, dyslipidemia, and chronic lung diseases. Therefore, an appropriate physical performance test is required to assess the level of physical activity in order to maintain and improve the physical fitness and health conditions specific to this group of population. In addition to having high reliability and validity, the physical fitness test must properly take into account of the availability and limitation of facilities, equipment, and other resources. And most importantly, the test must cover the physical fitness components of the elderly.

Therefore, the aims of study were investigated appropriate physical fitness test in community dwelling elderly, and evaluate physical fitness of elderly, consequently design appropriate exercise program to maintain or increase health of elderly.

Research question

Phase I

Is the 2MST and 6MWT-10m reliable, and valid in community-dwelling elderly?

Phase II

What is the physical fitness level of community-dwelling elderly in Ongkharak district determined by SFT?

Phase III

Does the community-dwelling elderly who performs 8 weeks home-based progressive exercise program have a physical fitness level different from the control group?

Objectives of the study

Phase I

Primary objective:

To investigate percent heart rate reserve and dyspnea level response to 2MST compare to 6MWT-10m and 6MWT-30m in community-dwelling elderly.

Secondary objectives:

1. To investigate test retest-reliability of Senior fitness test.

2. To investigate test retest-reliability of 2MST, 6MWT-10m and 6MWT-30m in community-dwelling elderly.

Phase II

Primary objective

To determine physical fitness level of the community-dwelling elderly in Onkharak, Nakhon-Nayok and subsequently categorize the elderly to below-average and average from above average physical fitness based on 25th and 75th percentile as suggested by Rikli and Jones (1999).

Secondary objective:

To determine gender and age effect of physical fitness level of community-dwelling elderly in Ongkharak, Nakhon-Nayok.

Phase III

To determine changes in physical fitness level community-dwelling elderly who performed 8 weeks individualized home-based exercise program.

Hypotheses of the study

Phase I

1. The validity of percent heart rate reserve and RPE level have higher than 0.7 in 2MST compare to 6MWT-10m in community-dwelling elderly using 6MWT-30m as a reference test

2. Modified SFT Thai-version has high test retest-reliability (ICC>0.8)

3. 2MST, 6MWT-10m and 6MWT-30m have high test retest-reliability (ICC>0.8)

Phase III

The physical fitness level in community-dwelling elderly who performed 8 weeks individualization home-based progressive exercise program is improved.

Significance of the elderly

This study was investigate appropriate the physical fitness test in community-dwelling elderly and was receive information of physical fitness level of elderly in Ongkharak districts by SFT. This physical fitness level can be used as a guideline for individualized home-based progressive exercise program in elderly, therefore, design appropriate exercise program to maintain or increase health of elderly.

Keywords

Senior fitness test, reliability, validity, community-dwelling elderly, individualized home-based progressive exercise program

Conceptual Framework

The conceptual framework of this study is presented in figure 1. This conceptual framework is composed of three groups categorized by independent level of

Ongkharak elderly in Nakhon-Nayok Province, factor affecting the decline of physical performance, five component of functional test, and R1, R2, and R3 that are first, second, and third research questions.

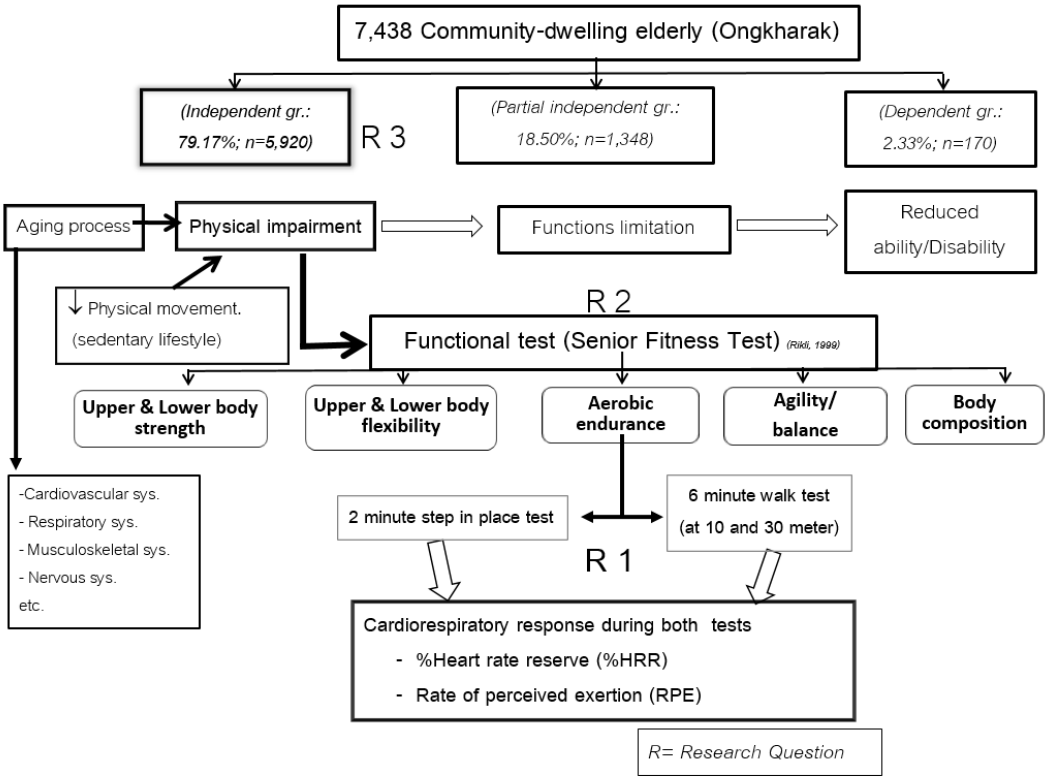


Figure 1 Conceptual framework

CHAPTER 2
REVIEW OF THE LITERATURE

Systematic change in elderly

The reductions in age-related physical fitness are often attributed to the decline in functions of the body system, the increased in comorbidity, and the sedentary lifestyles. The body system which likely suffer the declined in major functions due to aging include the cardiovascular system, the respiratory system, the musculoskeletal system, and the nervous system [2, 10].

Cardiovascular system

Alterations of the heart decrease stroke volume, cardiac output, and muscle contractility. They are also responsibility for the degeneration of the conduction system, cardiac hypertrophy, and inability to control of vasoconstriction. These changes may induce dysrhythmias and reduced blood flow to the coronary arteries, thus, causing dizziness on light-headedness when standing up (impaired blood pressure response to standing) [11, 12].

Respiratory system

As a result of aging, the respiratory tract and lung tissue become less elastic. Along with mucus accumulation and reduced cilia activities, these conditions often lead to the lower rate of airflow. The respiratory muscles also weaken and undergo atrophy, thus, reducing the ability to breathe deeply. Moreover, shortness of breath and fatigue can occur more frequently due to a ventilation/perfusion mismatch (decreased gas exchange) and a decreased in the oxygen partial pressure (PO_2). In elderly, the vital capacity can decrease approximately 50% while there is a 1% decrease in maximum oxygen uptake (VO_2 max) per years, resulting in limited exercise capacity and increased exertion [2, 10].

Musculoskeletal system

The number of blood vessels, myoglobin, and mitochondria decrease with age, affecting the ability of slow fiber muscle function and, in turn, reducing the endurance for physical activities. Additionally, an elderly may suffer from the loss of muscle mass, size, and strength. To further worsen the condition, this generalized atrophy of all muscle is often replaced by fat deposits. Furthermore, when calcium is lost and bones dense, osteoporosis and a reduction of weight bearing capacity are likely to occur, ultimately leading to the possibility of spontaneous fracture [10].

Nervous system

A person of old age may suffer the alterations in central and peripheral nervous system, consequently, having an effect on body functions. The decline in the nervous system includes decrease of the total number of neurons, brain shrinkage, reduction of neurotransmitter level, loss of myelin, and autonomic nervous system dysfunction. There can also occur major impairments in memory, hearing, balance, vision, and smell [2, 10].

The decline of these body systems may limit functions and lower the physical fitness. As the level of physical activities among elderly tends to decrease due to the sedentary lifestyles and comorbidity, maintaining and improving physical activities are of prime importance not only to reinforce physical fitness of an aging person but also to help reduce medication use, when viewed from a social perspective.

Physical fitness test for elderly

There are many physical fitness tests in elderly, but, in order to have the tests appropriate to the elderly in any given community, one must consider the level of difficulty, the cost, and the duration required. The tests should also include assessments of the physical fitness performance in these five areas: muscle strength, flexibility, cardiopulmonary endurance, agility/dynamic balance, and body composition measurements [4].

In order to effectively assess physical function for elderly, Rikli and Jones (1999) developed a functional ability framework indicating a progressive relationship between physiological performances, functional performance (muscle strength, cardiopulmonary endurance, flexibility, agility/dynamic balance, and body composition) can result in a physical impairment which can lead to a functional limitation (such as walking, stair climbing, and standing up from a chair) and a decrease in common activities (such as personal care, shopping, and housework) or a disability in the long run [13].

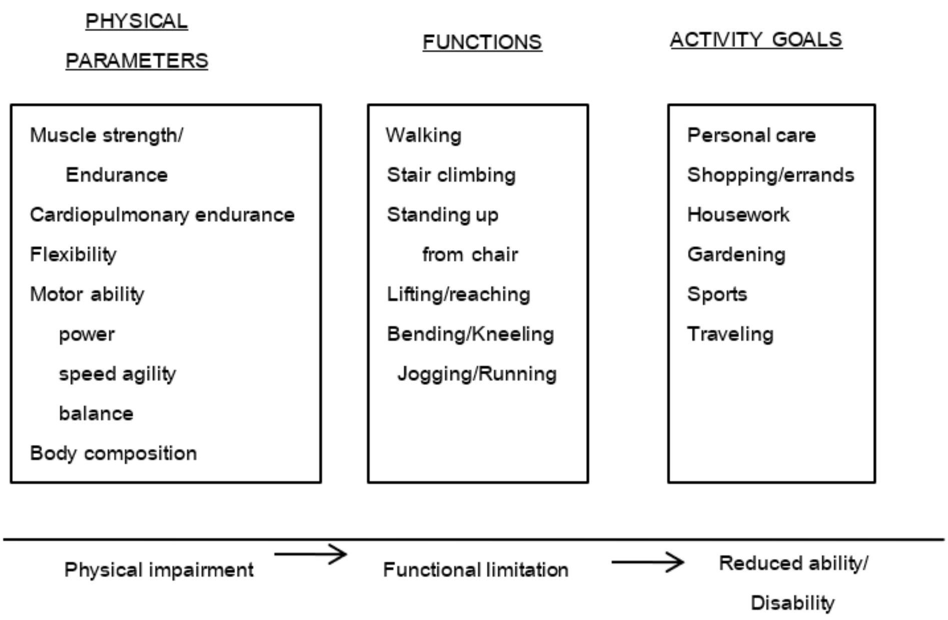


Figure 2 Functional ability framework

Based on the functional ability framework above, Rikli and Jones (1999) developed the Fullerton Fitness Test as a recommended SFT to evaluate the physical performance in elderly. The SFT consists of 30-second chair stand, arm curls, chair sit-and-reach, back scratch, 6MWT or 2MST, 8-ft up-and-go and height and weight measurements (Table 1) [14].

Table 1 Senior fitness test item selected

Physical fitness parameter	Test items
1. Body strength	
Upper body strength	Arm curl
Lower body strength	30-s chair stand
2. Cardiopulmonary endurance	6-minute walk test
Alternative cardiopulmonary endurance	2-minute step test
3. Body flexibility	
Upper body flexibility	Back scratch
Lower body flexibility	Chair sit-and-reach
4. Motor agility/dynamic balance	8-ft up-and-go
5. Body Mass Index	Height and weight

Each of the five physical fitness performance is reviewed in order to explain its importance toward health, evaluate measurement tools other than SFT, and determine the exercise to improve the physical fitness as followed:

1. Cardiopulmonary endurance in elderly

Cardiopulmonary endurance is the capacity to perform heavy muscle and dynamic activities for a prolonged period [15]. Natural aging in humans is associated with a progressive decrease in cardiopulmonary endurance, which contributes to decline in daily activities. Cardiopulmonary endurance depends on the functional state of the skeletal muscle, cardiovascular, and respiratory system. It is measures by VO_2 max, which indicates the ability of cells to take up and utilize oxygen in produce energy during maximal activity [15]. The VO_2max can be evaluated by direct and indirect methods.

Measurement of cardiopulmonary endurance

Gas analyzer is the direct method and the gold standard of cardiopulmonary endurance measurement. However, this method has several shortcomings as it is expensive and time consuming. And, most of all, the gas analysis may not be appropriate for elderly because it is required to be conducted during a maximal exercise test. On the other hand, an indirect method involves a submaximal exercise test, which incorporates several tests, such as walking, cycling, and step tests. It can easily be seen that the walk test (6MWT) and step test (2MST) are appropriate for elderly in a community (14) because they are simple, safe, inexpensive, and easy to conduct (14).

The 6MWT is a simple, useful and objective to measure the functional capacity (7). The test requires a subjective to walk as far as possible in six minutes. It was modified from the 12-minute walk test (12MWT), which was developed for testing lung disease, in a study by Butland et al. (1982). The study found that walking for six minutes has better correlation with 12-minute walk than that of any other duration (16).

In 2002, American Thoracic Society (ATS) issued guidelines for the 6MWT in order to minimize errors and ensure safety. ATS recommended 6MWT as an evaluation of the physical capacity in patients with lung or cardiac disease during the per- and post- treatment, health elderly, and those with predictive mortality risk. Specifically, ATS advised the use of the 30-meter standard walkway and the total time of not more than 15 minutes, which includes the time to perform 6MWT, to rest, and to measure vital signs (blood pressure, whole body fatigue, blood oxygen saturation, dyspnea, and heart rate) before and after the walk test (7).

The test-retest reliability when comparing 2-day, 1-week, and 2- week 6MWT in healthy elderly was found to have high reliability intraclass correlation coefficients (ICC) ranging from 0.91 to 0.96 (3, 17, 18). In addition, test-retest reliability of 6MWT in patient with heart failure was also high (ICC = 0.88-0.91) (19).

The setup and pattern of 6MWT can vary depending on the course, the walkway length, the number turn, the instruction, the encouragements, and the number of trials required. Ng et al. (2013) found that the walkway length (10 m., 20 m., and 30 m.) had a significant effect on the distance achieved in 6MWT [8]. Encouragements also played a crucial role in increasing the distance [20]. However, the turning direction and walkway length had no significant effect on the post-test heart rate, RPE, and oxygen saturation[8]. Moreover, the shape of walkway, whether it be rectangular, elliptical, or circular, also did not yield any effect on the results of 6MWT [3, 18, 21-24].

As a substitute for 6MWT, the two-minute step-in-place test (2MST) was recommended by Rikli and Jones (1999). The test was originally developed for an exercise endurance assessment in elderly and included as a part of Fullerton's Functional Fitness Test or SFT. 2MST is appropriate to be performed by an elderly because of its repetitive movements, in which induce less anticipation in elderly. In addition, 2MST requires a simple protocol and smaller area, thus, making this test suitable for a facility whose space is limited. The only movement of 2MST to be performed is to step in place for two minutes, in which the height of each step is indicated by a mark on the wall, where the raised kneecap aligns horizontally with the iliac crest. Moreover, the subject with a balance disability is allowed to hold on to a chair or a rail for support while performing the test. The number of times when the right knee reaches the mark in two minutes is then recorded as the result of the test [6, 14].

The intraclass reliability of 2MST ranges from 0.90 to 0.95 in elderly [14, 25]. The criterion validity of 2MST shows a moderate correlation (r= 0.73) correlation with one-mile walk time in 24 male and female elderly subjects (mean age = 69.6, SD=6.5) [26]. Moreover, there is also a moderate correlation (r=0.74) between 2MST scores and incremental treadmill test in 25 male and female elderly subjects (mean age = 72.1, SD=6.2), with the exercise capacity measured at 85% maximum heart rate on the incremental treadmill test [27].

Rikli and Jones (1999) evaluated 2MST in the community-dwelling elderly who had no symptoms of chronic heart failure, chest pain, dizziness, angina during exercise conditions, and severe hypertension, i.e. having blood pressure above 160/100 mm Hg. The study measured the normal range of 2MST in the elderly aged between 60 and 94 years old. It was found that the cardiopulmonary endurance in male was higher than that of female in the same age range, while the cardiopulmonary endurance decreased with increasing age [(22)].

Johnston (1998) found that the average RPE during 2MST was 13.9, while that of the 6MWT was 13.6 [(27)]. However, in the study of 32 hypertensive elderly females (65.4±5.4 year old) by Perosa and Holanda (2009), there was a low correlation (r=.36) between the number of steps in 2MST and the distance walked in 6MWT [(28)].

Although Rikli and Jones (1999) recommended 2MST as an alternative exercise endurance test[(6)], there has not been any study investigating the heart rate, dyspnea, and blood pressure response between 10-meter and 30-meter 6MWT and 2MST.

2. Muscle strength (Upper and Lower body strength)

The loss of muscle strength in elderly is an effect of a generalized atrophy of muscle tissues whose mass is being replaced by fat deposits due to prolonged inactivity. As the muscle strength is reduced due to aging, so is the agility and the ability to balance [(29)], often leading to falling [(30)], and, ultimately, the risks of disability [(31)]. Generally, the isometric, concentric, and eccentric strengths start to decline at the age of approximately 40 years old and quickly deteriorate after the age of 65-70 years old. The lower body strength tends to decrease at a faster rate than the upper body strength. In addition, the muscle power declines faster than the muscle strength [(32)]. However, strength trainings can help increase neural adaptation after 1-2 weeks and skeletal muscle hypertrophy after 3-4 weeks [(33-35)].

Measurement of muscle strength

There are numerous instruments that can be used as tools for the muscle strength assessment in elderly, such as chest press, dumbbell, elastic bands, handheld dynamometer, isokinetic dynamometer, leg press, pull down, and manual muscle testing. These instruments measure either upper or lower muscle strength with different reliability and validity [(36)]. For the elderly in the community, the functional fitness tests recommend the 30-second arm curl test [(22)] for the upper body strength and the five times chair stand test [(37)] and the 30-second chair stand test for the lower body strength [(22)].

For the 30-second arm curl test for the upper body strength assessment, SFT modifies the procedure from that originally proposed by Osness (1996) with two changes [(38)]. First, the weight for women's test is changed from four pounds (1.8 Kg.) to five pounds (2-3 kg.) because the five-pound weight for women tends to be about 60 percent of that for men [(39)]. Second, the hand-arm position is changed from the handshake grip to the palm-up during flexion because the position is more effective in terms of the biceps tendon muscle action [(38)]. In addition, it was found that there are moderate to high correlations (r=0.84 for men and 0.79 for women) between the SFT's arm curl test and the combination of biceps, chest, and upper back exercises. The composite measure shows to have a significance, and the validity of the SFT's arm curl test confirms the reflection of overall upper body strength [(14)].

The functional performance test tool for the lower muscle strength assessment is the sit-to-stand test with the parameters of five times, ten times, and 30 seconds. The test requires a participant to stand up from a sitting position on a standard chair for a set number of times [(36)]. Or within a time limit. The five times sit-to-stand test (FTSST) is normally used in special conditions, such as for people after a stroke, people with arthritis, and in older adults. However, FTSST has a floor effect [(6)] because a subject must complete the number of times (five for FTSST) in order to receive a score [(6)]. Instead of setting the number of times, SFT developed the 30-second chair stand test in order to discriminate the ability of the test subject. Several studies found that the 30-

second chair stand test is a good field-test assessment of the lower body strength in elderly because of the high correlation when compared to laboratory tests, such as knee extensor strength, knee flexor strength, and leg press strength [40, 41].

3. Muscle flexibility (Upper and Lower body flexibility)

Flexibility is defined as the range of movement or motion (ROM) of a single or multiple joints. In elderly, ROM is first limited by the decline in the skeletal muscle strength and the connective tissue elasticity around the joint [32]. The decreasing ROM in both upper and lower extremities can lead to a development of a physical impairment, a reduction of the amount of daily activities, and a progression of disability [42]. The muscle flexibility is crucial in maintaining a good posture, performing tasks in daily living (e.g., putting on socks and shoes, picking up objects from the floor, rising arm on overhead, combing hair), reducing the risk of musculoskeletal injuries, and preventing falls. Poor flexibility could result in impaired mobility and functional limitation [42]. As people age, flexibility (age 70 yr.) reduces significantly in hip, spine (20%–30%), and ankle (30%–40%), especially in female [32]. In male, starting at the age of 71 years old, the decline of flexibility in shoulder abduction accelerates at the rate of 0.80 degree/year, whereas the onset of the decline (0.74 degrees/year) in female is 63 years. For hip flexion, the rate of decline is 1.16 degrees/year in male, starting at 71 years, and 0.66 degrees/year linearly in female [43].

Measurement of muscle flexibility

The most common tests for the lower body and lower back flexibility are sit-and-reach test, toe touch test, modified sit-and-reach test, unilateral sit-and-reach test, back-saver sit-and-reach test, and chair sit-and-reach test [44-47]. Most of these flexibility tests require the participant to be seated on the floor, except the chair sit-and-reach test. Since most elderly find it too difficult to stand up from the floor, SFT recommends the chair sit-and-reach test for the lower body flexibility assessment [6]. The study found that there is a high correlation (r=0.92 for men; r=0.96 for women) between the chair sit-and-reach test and the back-saver sit-and-reach test in elderly[47].

Furthermore, the test also measures the hamstring flexibility, which is a safe and socially acceptable alternative to the traditional floor sit-and-reach test in elderly [47].

The upper body flexibility is measured through a range of motion of the shoulders. In SFT, the back scratch test is used for the upper body flexibility assessment, which involves a measurement of the distance between the two middle fingers across the back, with a continuous scale being used for scoring [6, 14]. The back scratch test was developed from Apley scratch test, which requires the participant to reach behind the head with one hand and then attempt to touch the opposite scapula. Unlike the back scratch test, the distance between the middle fingers is not measured since it involves one hand at a time [48].

4. Motor agility/dynamic balance in elderly

The combination of agility (involving speed and coordination) and dynamic balance (maintaining postural stability while moving) is important for common mobility tasks, such as walking. The balance is essential in reducing the risk of falls and the loss of independence [49]. Falls are the major cause of mortality and morbidity in older adults, with approximately 40% of adults over the age of 64 suffering falls during the 12-month follow-up period [50]. In addition, 28% to 35% of falls each year occur among community-dwelling adults over 64 years. The risk of falls rise sharply with age, in which adults over the age of 80 years having the highest risk when compared to other age groups [51]. Moreover, the lower body strength also contributes to the risk factor of falls [30].

Measurement of motor agility/dynamic balance

Berg Balance Scale (BBS), timed up and go (TUG), balance screening tool (BST), and Fullerton Advanced Balance Scale (FAB) have been observed to show a good reliability, validity, and practically for the motor agility/dynamic balance assessment in elderly [52]. However, TUG is found to be more suitable than other tests because TUG is short in duration, simple, and quick to prepare. It is also widely used as a clinical performance-based measurement of lower body functions, mobility, fall risk, and the indicated dynamic balance level [53]. Statistically, TUG possesses both excellent inter-rater (ICC=0.98-0.99) [54-56] and intra-rater reliability (ICC=0.97-0.98) [3, 54, 55]. However, to increase the feasibility of conducting the agility and dynamic balance test due to the limited area, particularly in the home setting [14], SFT proposed the change from 3-meter TUG [55] to 8-foot (2.44-m) TUG. Among the community-dwelling elderly, the 8-foot TUG proves to have a good test-retest reliability (ICC = 0.94) and discriminate between the physically active and sedentary groups, as well as the male and female groups [25].

5. Body composition in elderly

Body composition consists of fat and lean body mass (such as muscle, bone and water), which is an indicator of health status. Aging decreases total body water, skeletal muscle organ mass, and bone mineral, while total body fat increases [57].

Measurement of body composition

There are several tools that can be used to measure the body composition, such as BMI, waist circumference (WC), skinfold thickness, and bioelectrical impedance analysis (BIA) [15, 58]. BMI and WC are simple and easy to apply since an extensive training is not required, and equipment used is less expensive. Evidently, BMI and WC are widely used for body composition measurement than skinfold thickness and BIA [58, 59]. Body mass index assesses body composition by calculating body weight relative to body height [58]. It is defined as a person's weight in kilograms divided by the square of body height in meters and expressed in units of kg/m^2. It is the most common measurement of obesity [15, 58-60].

Table 2 Classification of BMI

Category	Criteria BMI
$\geq$50 kg/m^2	Obese Type III (super obese)
40.1-50 kg/m^2	Obese Type II (morbid obese)
30-40	Obese Type I (Obese)
$\geq$30 kg/m^2	Obese
25-29.9 kg/m^2	Pre-obese
23-24.9 kg/m^2	Overweight
18.5-22.9 kg/m^2	Normal
17-18.49 kg/m^2	Mild underweight
16-16.9 kg/m^2	Moderate underweight
$\leq$16 kg/m^2	Severe underweight

The high and low levels of BMI (18.5-22.9 kg/m^2) in normal person are significantly associated with increasing mortality [61, 62], while the higher BMI in elderly is associated with an increase in functional limitations [63-65]. In addition, high BMI can also indicate the increased risk of metabolic diseases, such as hypertension, dyslipidaemia, cardiovascular disease, and diabetes mellitus [66-69].

Waist circumference is a measurement of the distribution of body fat in abdomen [58], which is strongly associated with morbidity (Diabetes Mellitus, cardiovascular disease), and mortality [67, 70]. WC is measured at the level of the area between the top of the iliac crest and the lower edge of the last rib in the medial auxiliary line. In South Asia, China, and Japan, the cut-off is reportedly at 80 cm and 90 cm for female and male, respectively [59].

Fitness performance scores of community-dwelling elderly

Most of the studies evaluated SFT as physical fitness tests in elderly [22, 71-73]. There are few studies evaluated tests other SFT [21] (Table 2.3).

Table 3 Summary of physical fitness tests research (normative data)

Studies	Participants		Physical Fitness Tests						
	Group	Age Mean ± SD or age range	Upper body strength (Mean ± SD)	Lower body Strength (Mean ± SD)	Cardiopulmonary endurance (Mean ± SD)	Upper body flexibility (Mean ± SD)	Lower body Flexibility (Mean ± SD)	Agility/ dynamic balance (Mean ± SD)	Body composition (Mean ± SD)
Rikli and Jones 1999	community-dwelling **American** elderly N=7,183 (Female: 5,048, Male: 2,135)	Female: 73.3 ±7.6 Male: 73.4 ±7.4 (60-94 years)	30-s ACT (reps.) Male: 17.9±12 Female: 14.3±4.5	30-s CST (reps. of stands) Male: 14±4.6 Female: 12±4	2MST (steps) Male: 93±25 Female: 83±25 6MWT (m.) (Rectangular course: 45 m.) Male: 536.7±118.8 Female: 485±108.8	Back scratch (cm.) Male: (-4.4) ± (+4.6) Female: (-1.7) ±(+3.6)	Chair sit-and-reach (cm.) Male: (-0.6) ±(+4.4) Female: (+1.2) ± (+3.4)	8-foot-up-and-go (sec.) Male: 5.6±1.8 Female: 6.2±1.9	BMI (kg/m^2) Male: 26.6±4 Female:25.8±4.17
Macfarlane et al. 2006	community-dwelling **Chinese** elderly N= 1,038 (Female =766, Male = 272)	Female: 73.6±7.1 Male: 73.6±6.7 (60-96 yrs.)	-	30-s CST (reps. of stands) Male: 11.8± 4.3 Female: 9.9±4.2	-	-	-	-	-

Table 3 (Continues)

Studies	Participants		Physical Fitness Tests						
	Group	Age Mean ± SD or age range	Upper body strength (Mean ± SD)	Lower body Strength (Mean ± SD)	Cardiopulmonary endurance (Mean ± SD)	Upper body flexibility (Mean ± SD)	Lower body Flexibility (Mean ± SD)	Agility/ dynamic balance (Mean ± SD)	Body composition (Mean ± SD)
Chen et al. 2009	community-dwelling Taiwanese N= 1,104 F (501) M (603)	60-92 years	grasp test (Kg.) Male: 29.2±7.5 Female: 18.1±5	30-s CST (stands) Male: 13.9±4.7 Female: 12.9±4.2	2MST (steps) Male: 89.8±21.7 Female: 89±21.2 3-min step tests with preset cadence (in number of steps) Male: 61.1±15 Female: 61.5±15.2	-	Chair sit-and-reach (cm.) Male:(-2.3) ± (+12.9) Female: 4.9 ± 9.8)	open eyes stand on right foot (sec.) Male: 14.7±16.1 Female: 13.4±15.1	BMI (kg/m2) Male: 24.1±3.1 Female: 24.4±3.5
Gusi et al. 2012	community-dwelling Spain elderly N= 6,449 (Female = 5,610, Male = 839)	(60–89 yrs.)	Hand grip (kg.) Male: 61.6 ±16.3 Female: 40.1 ±9.5	-	6MWT (m.) (Oval course: 20m.) Male: 402.1 ±102.7 Female: 394.9 ±93.4	Back scratch (cm.) Male: (-18) -(+15.1) Female: (-11) -(+12.1)	Chair sit-and-reach (cm.) Male: (-2.9) ± (+12.6) Female: (+1.4) ± (+11.1)	TUG (sec.) Male: 8.42 ±3.33 Female: 8.55 ±3.02 Functional reach (cm.) Male: 27.2 ±9.2 Female: 25.8 ±8.1	BMI (kg/m²) Male: 29.56±4 Female: 30.91±4.56 WHR Male: 0.98±0.07 Female: 0.88±0.07 Body fat (%) Male: 33.9±5.9 Female: 42.1±5.6

Table 3 (Continues)

Studies	Participants: Group	Participants: Age Mean ± SD or age range	Physical Fitness Tests: Upper body strength (Mean ± SD)	Lower body Strength (Mean ± SD)	Cardiopulmonary endurance (Mean ± SD)	Upper body flexibility (Mean ± SD)	Lower body Flexibility (Mean ± SD)	Agility/ dynamic balance (Mean ± SD)	Body composition (Mean ± SD)
Marques et al. 2013	independent-living elderly, Portuguese N= 4,712 (Female = 3,121, Male = 1,591)	(65–103 yrs.)	30-s ACT (reps.) Male: 16.7 ±6.1 Female: 15.6 ±6	30-s CST (reps. of stands) Male: 13.8 ±5.5 Female: 13.1 ±5.5	6MWT (m.) (Rectangular course: 45 m.) Male: 404.7 ±151.3 Female: 455.4 ±168.4	Back scratch (cm.) Male: (-20) ±15 Female: (-15.6) ±14	Chair sit-and-reach (cm.) Male: (-15.6) ± (+14) Female: (-7.1) ± (+11)	8-foot-up-and-go (sec.) Male: 8.5 ±6 Female: 9.6±7.8	BMI (kg/m²) Male: 27.4±3.8 Female: 28.2±4.5 WC (cm.) Male: 98.3±11.8 Female: 94.3±11.8
Thaweewannakij et al, 2013	community-dwelling Thai elderly N= 1,030	(60-90 yrs.)	-	FTSST (sec.) (Mean) Male: 12.9-14.2 Female: 13.2-17.1	6MWT (m.) (Rectangular course: 6 m. X 4m.) (Mean) Male: 306.6-389.6 Female: 256.3-366.1	-	-	TUG (sec.) (Mean) Male: 9.2- 11.9 Female: 9.9-13.4 BBS (scores) (Mean) Male: 52.2-54.7 Female: 50.1-54.1	-

Six studies evaluated physical fitness as follow: upper body strength assessment performed by 30-second arm curl test (30-s ACT) [22, 73], and hand grip [72, 74]; lower body muscle strength assessment performed by five time sit-to-stand test [21] and 30-second chair stand test (30-s CST) [22, 74]; cardiopulmonary endurance performed by 6MWT [21, 22, 72, 73], 2MST [22], and two-and three-minute step tests with present cadence [74]; upper body flexibility assessment performed by back scratch test [22, 72, 73]; lower body flexibility assessment performed by chair sit-and-reach test [22, 72-74]; agility/dynamic balance assessment performed by 8-foot up and go test [22, 73]; 3-meter timed up and go test [21, 72], berg balance scale [21], functional reach [72], and open-eye stand on right foot [74]; and body composition assessment performed by BMI [22, 72, 73], WC [73, 74], percent body fat [72], and waist-to-hip ratio (WHR) [72].

These six studies of normative physical fitness level found that all components of the fitness level declines with aging (Table 3). Expectedly, male physically performed better than female [21, 22, 71-73]. These studies preferred to follow SFT for the assessment of the physical fitness level. However, 2MST was performed in only few studies [22, 74]. According to Chen et al. (2009) [74], three-minute step test with pre-set cadence was found to result in fewer number of steps than 2MST. Moreover, participants did not have any difficulty completing 2MST, while only 76-83% of the participants were able to complete the three-minute step test with pre-set cadence, due to the task (stair-climbing exercise) being more complicate than that of 2MST. Therefore, 2MST is more suitable for elderly than three-minute step test with pre-set cadence.

When compared the physical fitness level among population (Spain, Portuguese, and Thai populations) from different geographical areas, the American population performed better than the rest in cardiopulmonary endurance (6MWT), upper body flexibility (back scratch), and lower body flexibility (chair sit and reach test) [21, 22, 72, 73]. However, the Portuguese population performed better than the Americans in the area of the agility/dynamic balance (8-foot up and go test). For the upper body strength (30-s ACT), all populations performed at about the same physical fitness level. For the lower body strength (30-s chair stand test), Hong Kong and Chinese populations performed more poorly than the Portuguese and American counterparts. Lastly, all populations were assessed to have higher BMI than the normal range. Therefore, normative physical fitness data can yield different results depending on the race and daily activities among each population group.

For the Thai population, a study was conducted but did not cover all of the normative physical fitness parameters. The data of the parameters tested showed that the Thai population performed more poorly than the American, Portuguese, and Spanish populations. Therefore, it is interesting to conduct more comprehensive measurements of physical fitness tests among Thai elderly in the future.

For the Thai population, a study was collected but did not cover all normative physical fitness parameters [(21)]. The data of the parameters tested (6MWT and time up and go test) shown that the Thai population performed more poorly than the American [(22)], Portuguese [(73)], and Spainish populations [(72)]. Therefore, it is interesting to conduct more comprehensive measurements of physical fitness tests among Thai elderly in the future.

Exercise for elderly

The American College of Sports Medicine (ACSM) recommends the periodic assessment of physical fitness in elderly. There are five components of health related to the physical fitness: muscular strength, flexibility, aerobic capacity, balance, and body composition [(4)]. This information below compares various exercise prescriptions in order to find exercises suitable for the community-dwelling elderly [(6, 49, 75-86)].

1. Improving muscle strength

The ACSM/AHA[(75)] and several studies[(6, 76)] recommends the exercise prescriptions (Table 4) of resistance exercise to improve muscle strength for older adults. This exercise is progressive resistance training program (8–10 exercises involving the major muscle groups such as gluteus, quadriceps, hamstrings, pectorals, latissimus dorsi, deltoids, and abdominals of 8–12 repetitions each), arm curl exercise, 30-chair stand exercise, elastic exercise bands, stair climbing, standing squat, and other strengthening activities that use the major muscle groups. The exercise program consists of moderate (5–6) to vigorous (7–8) intensity (a modified Borg scale of 0-10) or 40-50% of 1 repetition maximum (1RM) (very light to light load for beginning older persons and for beginning sedentary persons) and 60-70% of 1RM (moderate to hard load for novice to intermediate adult exercisers). Progression is by increasing repetitions at first, and then by increasing the resistance. This exercise compose of 2-4 sets are recommended for strength of most elderly and 2-3 minutes of rest between multiple set training, (20-30 minutes/day) at least 2 day/weeks.

Table 4 Exercise prescriptions to improve muscle strength for the elderly

Variable	Recommendation
Mode	Arm curl exercise, 30-chair stand exercise, elastic exercise bands, weight training, standing squat[3]
Frequency	Major muscle groups should be trained 2-3 days/week with a 48-hour rest between sessions for muscle groups[2]
Duration	20 to 30 minutes
Intensity (Strength)	8 to 10 exercises (major muscle, e.g. gluteals, quadriceps, hamstrings, pectorals, latissimus dorsi, deltoids, and abdominals)[1] 40-50% of 1RM or very light to light load for beginning older persons and for beginning sedentary persons[2] 60-70% of 1RM or moderate to hard load for novice to intermediate adult exercisers[2]
Repetitions	10 to 15 repetitions (RPE 5-6)[1] 8-12 repetitions to improve strength in most adults to fatigue[2] 15-20 repetitions is recommended for increased muscular endurance[2]
Sets	At least 1 set for elderly[1] Single set training for novice and older adults[2] 2-4 sets are recommended for strength of most adults[2] $\leq$2 sets for muscular endurance[2]
Progression	Increasing the number of repetitions at first, and then by increasing the resistance[1]
Rest	2-3 minutes of rest between multiple set training[2]

Note: [1](Balady, et al. 2000), [2](Garber, et al. 2011), [3](Rikli and Jones 2013), 1 RM = 1 Repetition Maximum

Muscle strength could be improved by progressive resistance strength training exercises in healthy and chronic condition in elderly (79). Moreover, the yoga exercise(80), dancing (81), and dynamic exercise (Tai Chi) (76, 82, 83) improved muscle strength in elderly. However, these exercises are general functional exercise, required training and should be group exercise practice under supervision. Many studies showed that the individualized home-based exercises (strengthening exercise)[87], and functional exercise (standing and sitting on a chair, climbing stairs, and a 15-minute walk)[88] improved muscle strength for the elderly. SFT Manual recommended self-exercise which simple task, safety, and individualized specific functional on daily activities exercise for component of physical fitness at home setting to improve body muscle strength, and similar to exercise prescription in Table 4 [6]. The important muscle groups for strength training exercise recommended for elderly included hip extensor, knee extensor, ankle plantar flexors, dorsiflexors, biceps, triceps, shoulder, abdominals, and back extensor muscle [6].

2. Improving cardiopulmonary endurance

The ACSM/AHA [75] and several studies [6, 76, 77] recommended the exercise prescriptions (Table 5) of exercise to improve cardiopulmonary endurance for the older adults. This aerobic exercise is walking (the most common type of activity), jogging, stair climbing, cycling, combined arm and leg ergometry, running, machine-base, dancing, and endurance game. This exercise is moderate to vigorous intensity aerobic exercise, at least 20–60 min/day, and 3-5 day/week. Progression is by increasing duration, frequency, and intensity.

Table 5 Exercise prescriptions to improve cardiopulmonary endurance for the elderly

Variable	Recommendation
Mode[#]	Walking, jogging, stair climbing, cycling, combined arm and leg ergometry, running, machine-base, dancing and endurance game.[1, 3] Continuous or intermittent exercise involving the major muscle groups of the body [1, 2]
Frequency	3-5 days/wk. at 60 to 80% HRR or 70 to 85% HRmax [1] 3-7 day/wk. for hypertension patient[1] 4-6 day/wk. or daily at low to moderate intensity for diabetes patient[1] Exercise performed at a moderate intensity should be undertaken most days of the week[1]
Intensity	55/65% to 90% of MHR (40/50% to 85% VO2max or %HRR)[1] 40-70% VO2max for hypertension patient [1] 50-85% VO2max for diabetes patient [1] Moderate intensity (somewhat hard) Moderate to vigorous intensity is recommended (40-59 to 60-89% VO_2max or %HRR) [2] Pedometer step count for 2,000 – 7,000 steps per day[2]
Duration	20-60 minutes for healthy adult[1, 2] 20-30 minutes for adult with the risk of both cardiovascular and orthopedic injuries (excluding time spent warming up and cooling down) [1] 30-60 min for hypertension patients[1] 20-60 min/session for diabetes patients[1]
Progression	Gradually progression for duration, frequency and/or intensity (if reasonable), attaining desired goal[2] Increased exercise duration rather than intensity[1]

Note: [1](Balady, et al. 2000), [2](Garber, et al. 2011), [3](Rikli and Jones 2013), VO_2max= Maximal Oxygen Consumption; HR=Hart Rate; HRR=Heart Rate Reserve; MHR = Maximum Heart Rate

[#]The SFT recommendation of walking for older adult, walking can be improved cardiopulmonary endurance and easy practice every day. The walking can lower body exercise and dynamic balance.

*Moderate intensity includes exercises that are light to somewhat hard, or RPE of 12-13/20 or 3-4/10.

**Vigorous exercise includes exercises that are somewhat hard to very hard, or an RPE of 14-17.

Cardiopulmonary endurance exercise improves functions of the heart, lungs, and blood vessel, which related to physical performance of activities of daily living such as walking, jogging, and stair climbing. Interval-walking training (IWT) has been developed as a novel free-living training modality that consists of 5 or more sets of 3 minutes of low-intensity walking (40% of VO_2peak) followed by fast walking (70% of VO_2peak) for 3 minutes, that were monitored by accelerometry [89]. The IWT improved cardiopulmonary endurance (VO_2peak) in patients with diabetes mellitus[89], and decreased cardiovascular risk factors in middle age older subjects[84, 86]. However, these exercises required training and monitored for walking intensity by accelerometry. Another study investigated that the moderate intensity walking exercise at fairly light and somewhat hard of RPE score (11-13/20 score) improved exercise capacity in healthy adult [90]. The moderate intensity walking exercise is recommended by SFT manual that simple, safety, and individualized specific functional exercise for component of physical fitness at home setting to improve cardiopulmonary endurance, and similarly exercise prescription in Table 5.

3. Improving body flexibility

The flexibility exercise could be performed before or after cardiorespiratory/strength training exercise. The ACSM/AHA [75] and two studies [76, 77] recommended the exercise prescriptions (Table 6) of exercise to improve muscle flexibility for older adults. This flexibility exercise is activities that maintain or increase flexibility using sustained stretches to the point of slight discomfort or feeling of tightness in muscle (static flexibility, 10 to 30 seconds) for each major muscle groups and joints, 2-4 repetitions of each stretching at least 2 day/weeks.

Table 6 Exercise prescriptions to improve body flexibility for the elderly

Variable	Recommendation
Mode	Static flexibility Exercises should be prescribed for every major joint (hip, back, shoulder, knee, upper trunk, and neck regions) [1]
Frequency	≥2-3 days/week of stretching the major muscle groups; greater gains will be attained if done daily[1,2]
Intensity	Stretch to the point of slight discomfort or feeling of tightness in muscle[1,2]
Duration	10-30 seconds of static stretching holds for most elderly[1, 2]
Pattern	2-4 repetitions of each stretching[2]

Note: [1](Balady, et al. 2000), [2](Garber, et al. 2011)

Upper and lower body flexibility in elderly were improved by Yoga exercise(80, 91, 92), and dancing(81). However, these general exercises were required training by under supervision. Many studies investigate that the functional flexibility exercises such as sit and reach (93), static calf stretching program (94, 95) improved body flexibility in elderly. SFT manual (6) recommended self-exercise to improve body flexibility, and similar to exercise prescription in Table 6.

4. Improving agility and dynamic balance

The ACSM/AHA (75) and four studies (6, 76-79) recommended the exercise prescriptions (Table 7). These exercises are walking on unstable surfaces, walking at different speeds, crossover stepping, and strength training exercises that is simple to advance exercise. The exercise program is 20-30 min/day (3 times/day) at least 2 day/weeks. Progression is by increasing the number of repetitions or duration.

Table 7 Exercise prescriptions to improve agility and dynamic balance for the elderly

Variable	Recommendation
Mode	Any exercises that improve balance, agility, coordination and gait, particularly for older adults to improve/maintain physical function and to prevent falls such as walking on unstable surfaces, walking at different speeds, crossover stepping[2,3] Strength training exercises for the muscle groups required for basic mobility skills[4]
Frequency	≥2-3 days/weeks[2, 4] 3 times/day[4]
Intensity	Simple to advance exercise[4]
Duration	≥20-30 min/day may be needed[2]
Progression	Increasing the number of repetitions or duration[4]

Note: [1](Balady, et al. 2000), [2](Garber, et al. 2011), [3](Rikli and Jones 2013), [4](Clegg, et al. 2014)

Exercise programs (balance training, strengthening exercise, flexibility, and endurance) could be used to prevent injuries caused by falls and reduced the rate of falls leading to medical care in older adults [(49)]. Yoga [(92)], and Dynamic balance exercise (Tai Chi) [(76, 82, 83, 85)] could improve balance control, flexibility and cardiovascular fitness in healthy elderly and patients with chronic condition. In addition, Tai Chi Chuan is effective in reducing falls and blood pressure in the elderly [(83)]. However, these exercises were under supervised and required training by trainer. In previous studies showed that functional exercises such as the stand up and step ups[(96)], sit to stand practice, and weight transference and reaching [(97)] can improve balance and reduce the rate of falling in elderly. SFT manual [(6)] recommended self-exercise which individualized specific functional exercise for component of physical fitness at home setting to improve agility/dynamic balance, safety, and similar to exercise prescription in Table 7.

International Exercise Recommendations in Older Adults (ICFSR): Expert Consensus Guidelines in 2021 stated that “Exercise advice should be individualized, referenced to the intended outcomes, and personalized regarding the modality, frequency, duration, and intensity including practical implementation solutions and behavioural support systems to monitor outcome and provide feedback"[98]. Therefore, the term "individualized home-based progressive exercise" was applied in the present study following this concept. It is the exercise program consisted of mobility, balance, and function, tailored to an individual based on his/her present physical performance and allowed for the time that each person is ready to exercise at home[99].

Demographic data of Ongkharak elderly

Ongkharak is a district in the Nakhon-Nayok Province that has 7,438 elderly (over 60 years old). This district is subdivide into 11 Tambon. These subdistricts are Phra Achan (n=915), Bueng San (n=746), Sisa Krabue (n=974), Pho Thaen (n=595), Bang Sombun (n=444), Sai Mun (n=734), Bang Pla Kot (n=929), Bang Luk Suea (n=538), Ongkharak (n=150), Chum phon (n=653), and Khlong Yai (n=730). The approximate independent elderly is 79% (n=5,920) [9]. Therefore, these elderly should receive the appropriate physical fitness assessment for health promotion and prevent disability. However, the Sports Authority of Thailand [100] reported normal data of physical fitness using different protocol from Rikli and Jonse 1999 [22]. In addition, the SFT [14] was developed appropriate for elderly and useful. Therefore, the aims of the present study was investigate the heart rate, RPE, and blood pressure response during 2MST and 6MWT. Moreover, this research was study physical fitness in elderly people at Ongkharak district uses by SFT, that to guidelines select a proper exercise to improve physical fitness for the elderly at Ongkharak district.

CHAPTER 3
METHODOLOGY

This thesis is based on three studies; one methodology research (phase I), one cross-sectional study (phase II), and one randomized controlled trial (phase III). The research methodology investigates the reliability and validity of 2MST to 6MWT-10m by 6MWT-30m, which is a referent test for the elderly community dwellings. The cross-sectional study determines the physical fitness level of community-dwelling elderly people in Ongkharak district using the SFT. The randomized controlled trial evaluated changes in physical fitness level for community-dwelling elderly people who performed an 8-week home-based exercise program.

Phase I:
Correlation of physiological response between 2MST and 6MWT-10m and 6MWT-30m in community-dwelling elderly

1. Research design

This study was an observational reliability, and validity (Methodological research) aimed to determine the test-retest reliability of SFT, test-retest reliability of cardiopulmonary endurance (2MST, 6MWT-10m and 6MWT-30m) and convergent validity of %HRR and RPE level response to 2MST compare to 6MWT-10m using 6MWT-30m as a reference test.

2. Participants

Participants was volunteers, community-dwelling elderly, living in Ongkharak district, Nakhon-nayok Provide. The Participants selected are 30 in number with age group 60 to 69 years of both sexes. Participants were admitted based on the following criteria: (1) age 60 to 70 years, (2) were male and female, (3) able to walk 6 minutes with or without the use of an assertive device (walker and cane), and (4) stable hemodynamic; resting heart rate at 60 to 100 beats/minute and blood pressure at 90/60 to 159/109 mmHg. Participants were excluded if they meet following criteria (1) have the medical diagnosis of lung diseases, heart failure, unstable angina, recent myocardial infarctions, aortic aneurysm, and aortic stenosis, (2) unstable hypertension (>160/110 mmHg), (3) severe weight-bearing pain (rated > 5/10 on the visual analog pain scale), (4) severe visual or hearing impairment, and (5) severe orthopedic problems that limited walking or marching ability. Participants were compensated healthy present for their participation.

The sample size of the community-dwelling elderly of the correlation study was calculated by the following equation [101].

$$n = \left(\frac{Z_{\alpha} + Z_{\beta}}{Z_{(r)}} \right)^2 + 3$$

The sample size calculate for reliability study

When: $Z\alpha = 1.96$ ($\alpha = 0.05$)

$Z\beta = 0.84$ ($\beta = 0.8$)

Expecting r in the present study is set at 0.9 and error is 0.084.

Then, $P_0 = 0.9$, $P_1 = 0.9 \pm 0.084$

$$Z_{P0} = \tfrac{1}{2} \ln \left[\frac{1+0.9}{1-0.9} \right] = 1.47$$

$$Z_{P1} = \tfrac{1}{2} \ln \left[\frac{1+0.984}{1-0.984} \right] = 2.41$$

$Z_{(r)}$ was calculated from formula $Z_{P0} - Z_{P1} = 0.94$

$$n = \left[\frac{1.96 + 0.84}{0.94} \right]^2 + 3$$

Thus, the sample size in reliability study was 12 participants. Null hypothesis r was at least 0.5. The sample size calculate for validity study.

When: $Z\alpha = 1.96$ ($\alpha = 0.05$)

$Z\beta = 0.84$ ($\beta = 0.8$)

Expecting r in the present study was set at 0.8 and error is 0.1275.

Then, $P_0 = 0.8$, $P_1 = 0.8 \pm 0.1275$

$$Z_{P0} = \frac{1}{2} \ln \left[\frac{1+0.8}{1-0.8}\right] = 1.098$$

$$Z_{P1} = \frac{1}{2} \ln \left[\frac{1+0.9275}{1-0.9275}\right] = 1.640$$

$Z_{(r)}$ was calculated from formula $Z_{P0} - Z_{P1} = 0.542$

$$n = \left[\frac{1.96 + 0.84}{0.542}\right]^2 + 3$$

$$n = 29.7$$

Thus, the sample size in validity was 30 participants. Null hypothesis r was at least 0.5.

Consequently, the sample size in reliability and validity studies are 30 participants. Null hypothesis r was at least 0.5.

3. Outcome Measures

3.1 Test-retest reliability for SFT

The physiologic and anthropometric measures were assessed. Systolic blood pressure, diastolic blood pressure, height, weight, and body mass index were measured for each participant. BMI was calculated as height (in meters) squared divided by weight (in kilograms).

Functional fitness was assessed using the SFT, which consisted of the total score for each test.

3.2 Test-retest reliability for cardiopulmonary endurance (2MST, 6MWT-10m and 6MWT-30m)

The physiologic and anthropometric measures were assessed. Systolic blood pressure, diastolic blood pressure, height, weight, percent oxygen saturation, chronic disease (hypertension, diabetes mellitus, dyslipidemia) and BMI were measured for each participant. BMI was calculated as height (in meters) squared divided by weight (in kilograms).

Cardiopulmonary endurance was assessed by 2MST, 6MWT-10m and 6MWT-30m for test-retest reliability, which consisted of the number of step for 2MST, distance of 6MWT. Cardiopulmonary endurance was assessed by 2MST, 6MWT-10m and 6MWT-30m for validity. Heart rate at after tests

4. Material and research tools

The materials used in t is study included the followings.

1. Folding chair placed against a wall with a 17 in. (43 cm.) seat height
2. 5 lb (2.3 kg) and 8 lb (3.6 kg) dumbbells
3. 18 in. (45 cm.) ruler
4. Tally counter
5. Masking tape
6. Stopwatch
7. Tap measure
8. Cone
9. Automatic blood pressure
10. Pulse oximeter

5. Procedure

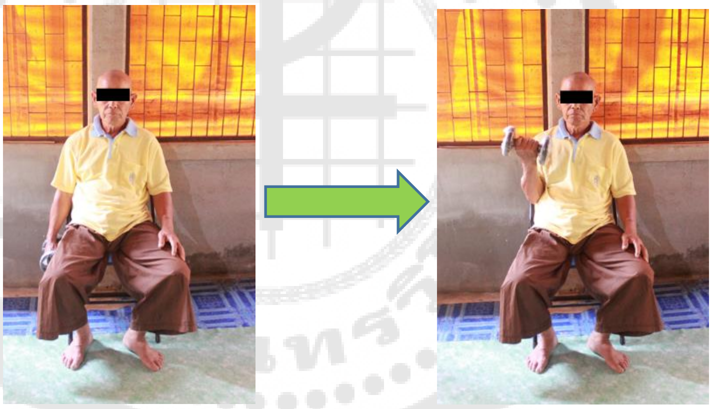
The aims and details of the study were read to the participants, and informed consent was obtained from each subject. Participants were interviewed and assessed for baseline demographics and health status using a questionnaire.

5.1 Test-retest reliability for SFT

Test-retest reliability for SFT were determined at the same time of day for each participant with each test scheduled 2 to 5 days apart. The tests separate to 3 time, first time for familiarly of all tests and measure SFT score at 2 and 3 time.

Their blood pressure, heart rate, and RPE were measured and the physical performance test[6] was administered. The protocol for this test was designed to evaluate physical fitness related to the independent functioning of upper and lower strength, cardiopulmonary endurance, upper and lower flexibility, and balance. Blood pressure, heart rate, and RPE were measured after each test for each subject. The tests were carried out as established by Jones and Rikli, 2013 details as follows:

1. The arm curl test (ACT) was designed to assess upper body strength. Participants were asked to perform as many bicep curls as possible in 30 seconds, using a 5-pound dumbbell for females and an 8-pound dumbbell for males. Scoring was based on the total repetitions completed in 30 seconds.

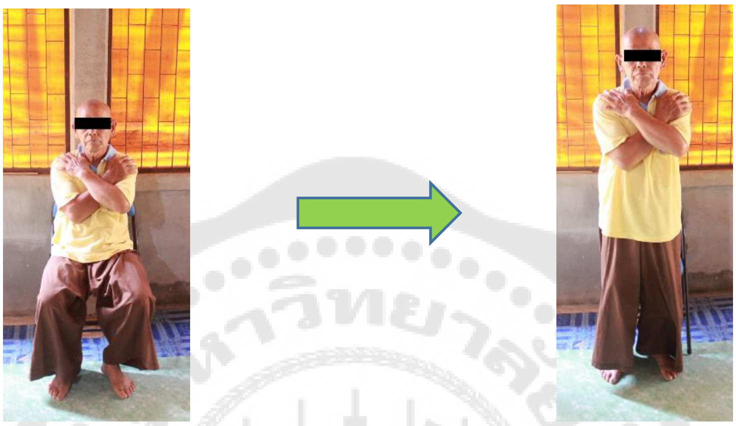


A B

Figure 3 A-B Upper body muscle strength assessment

(30-Second arm curl test)

2. The 30 second chair stand test was designed to assess lower body strength. Participants were asked to sit on the chair with arms crossed over their chest, and they were encouraged to complete as many stand-ups as possible in 30 seconds. Scoring was based on the total repetitions completed in 30 seconds.



A B

Figure 4 A-B Lower body muscle strength assessment

(30-second chair stand test)

3. The back scratch test was designed to assess upper body flexibility. Participants were asked to touch the fingers of opposing hands behind their back. The most flexible side of an individual was used for assessment. The distance in centimeters between opposing hands' fingers was measured. A negative score was given if the fingers did not reach the opposing hands' fingers, whereas a positive score was given if fingers reached beyond the opposing hands' fingers.

Figure 5 Upper body muscle flexibility assessment

(Back scratch test)

4. The chair sit and reach test was designed to assess lower body flexibility. Participants were asked to sit on the edge of a chair with the left knee bent at 90° and the left foot flat on the floor while keeping the right knee straight and the right leg extended forward. Participants were instructed to attempt to touch their toes using both hands. The most flexible side of an individual was used for assessment. The distance in centimeters between the fingers and toes was measured. Overlap of the fingers was measured in positive increments, while the distance between untouched fingers was measured in negative increments.

Figure 6 Lowe body muscle flexibility muscle flexibility assessment

(Chair sit-and reach test)

5. The 8-foot up and go test was designed to assess agility and dynamic balance. Participants were asked to sit on the chair. After a signal, the participants stood up and walked as quickly as possible around a cone set 8 feet away from the chair and then sat back down on the chair. Scoring was based on the total time elapsed to complete the test in seconds.

Figure 7 Agility/dynamic balance assessment (8-Foot up-and go test)

6. The 2MST was designed to assess cardiopulmonary endurance (alternative cardiopulmonary endurance). Participants were asked to step in place, raising the knee to a height halfway between the hip bone and the kneecap. Scoring was based on the total number of times the right knee reached the proper height in 2 minutes.

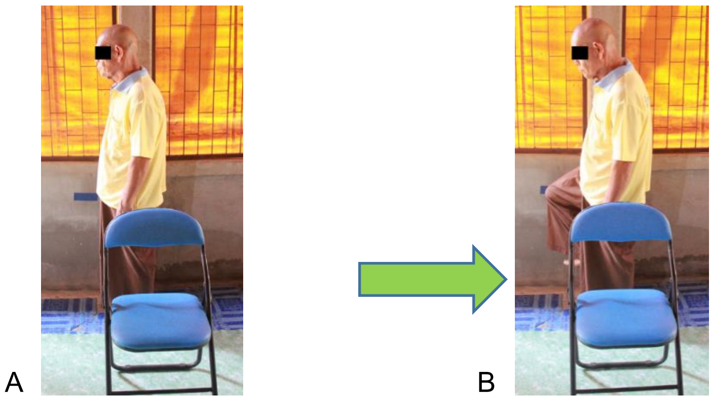


Figure 8 A-B Cardiopulmonary endurance assessment

(2-Minute step in place test)

7. The 6MWT was designed to assess cardiopulmonary endurance. The tests were conducted along a straight corridor with 10 m. walkways. Colored adhesive markers were taped at each end and at 1-m intervals. The orange traffic cone was placed before the destination 50 centimeters at each end. The participants were instructed to walk as quickly as possible within 6 minutes to cover as much ground as possible. They were able to stop for rest as needed, but the time was not stopped. During the test, an assessor walked alongside the participants to ensure their safety and inform them of every minute of time left [7].

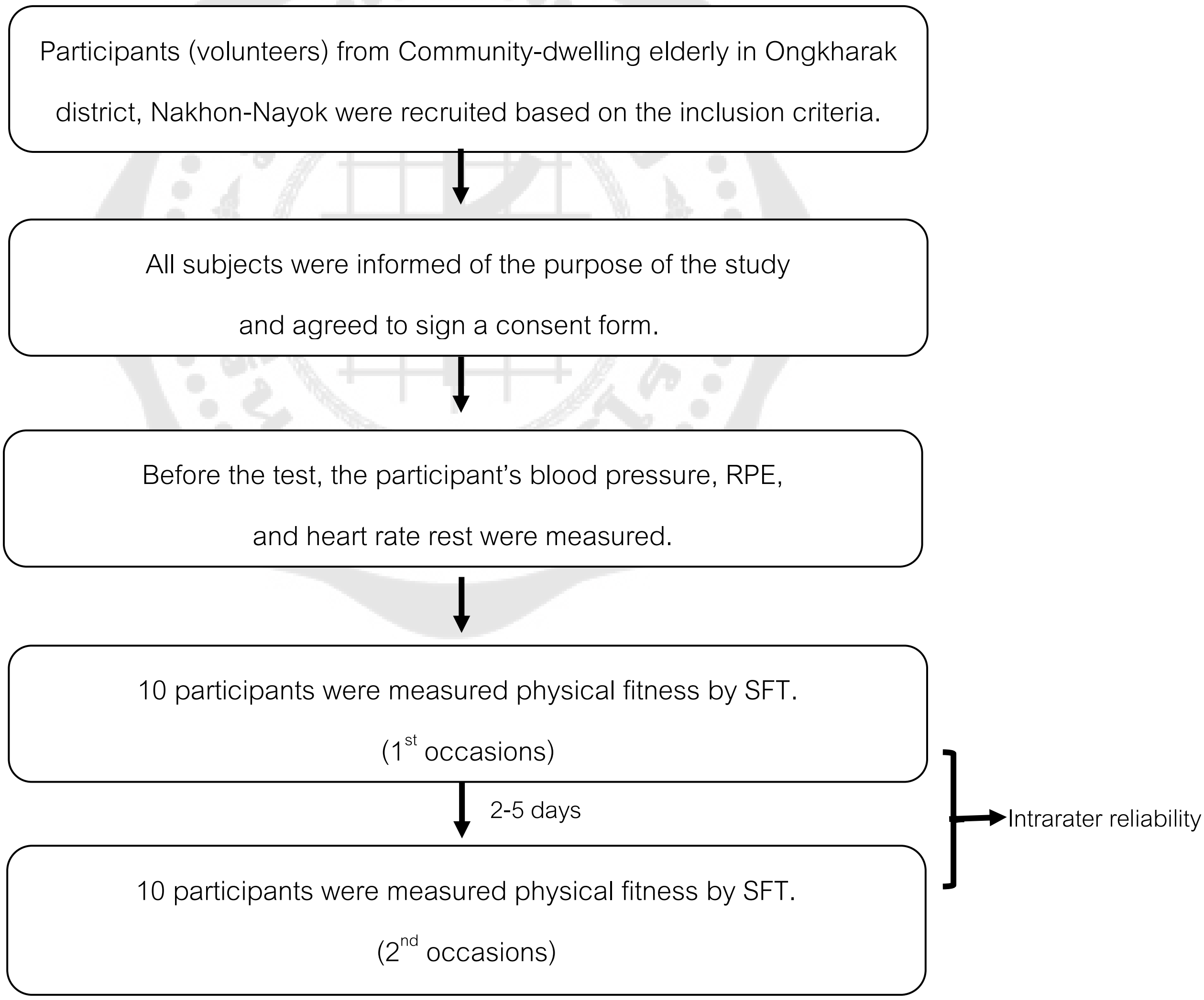


Figure 9 Procedure of test-retest reliability for SFT

5.2 Test-retest reliability for cardiopulmonary endurance (2MST, 6MWT-10m and 6MWT-30m) and validity

The procedure of test-retest reliability for cardiopulmonary endurance and validity was divide to 3 tests. Each participant performed three trials (2MST, and 6MWT-10 m and 6MWT-30m.) in a random sequence determined by simple random sampling: envelops concealed. This was to reduce random error [102]. After that, the blood pressure, heart rate, and RPE was measured before the tests.

Heart rate was measured before and every 20 seconds for 2MST and every minute for 6MWT. The percent intensity exercise is measured using the percent of heart rate reserves (%HRR). Dalleck and Kravitz (2006) showed that %HRR is correlated with the %VO2max (*r* = 0.99)[103]. The percent of heart rate reserves of the elderly was calculated using Kavonen's Method formula [104]:

%HRR = (HR exs-HR rest) x 100/(HR max – HR rest)

When; Maximum heart rate (HR max) = 220 – age

Exercise heart rate (HR exs) is heart rate average at 5 minute and at 6 minute for 6MWT, and at of 1 minute and 2 minute for 2MWT of steady state heart rate (steady state heart rate is two heart rate within 5 beats/min) [104].

Dyspnea and overall fatigue was evaluated using the 10 points RPE (0 = no exertion at all, 10 = maximal exertion) before, during, and immediately after testing. Zamunér et al., (2011) showed that RPE is correlated with the oxygen consumption (*r* = 0.86) and is correlated with HR (r= 0.86) [105]. Blood pressure was measured at before and immediately after testing.

6-minute walk test and 2-minute step in place test

The 6-minute walk test was designed to assess cardiopulmonary endurance. The tests were conducted along a straight corridor with 10 and 30 m. walkways. Colored adhesive markers were taped at each end and at 1-m intervals. The orange traffic cone was placed before the destination 50 centimeters at each end. The participants were instructed to walk as quickly as possible within 6 minutes to cover as much ground as possible. They were able to stop for rest as needed, but the time was not stopped. During the test, an assessor walked alongside the participants to ensure their safety and inform them of every minute of time left. After the test, the participants were measured for BP, RPE, HR and total walking distance [7].

The 2-minute step in place test was also designed to assess cardiopulmonary endurance. Participants were asked to step in place while raising their knees to a height halfway between the hip bone and the kneecap. Scoring was based on the total number of times the right knee reached the proper height. After the test, the participants were measured for BP, RPE, HR and the total number of times the right knee reached the proper height. This test follows by Jones and Rikli 2013.

The first time, the participants practiced to become familiar with the walkway, equipment, and instruction. Subsequently, the reliability study of three tests (6MWT-10m and 6MWT-30m, and 2MST) was performed on two different occasions (2 to 5 days apart) [22].

All three trials for validity were completed on the same day with a rest until the heart rate reached the same baseline (HR is different less than ±5 bpm) [104] before each test and between trials in order to minimize any interference effect of the a previous trial.

Participants (volunteers) from Community-dwelling elderly in Ongkharak district, Nakhon-Nayok were recruited based on the inclusion criteria.

↓

All subjects were informed of the purpose of the study and agreed to sign a consent form.

↓

Before and after the test, the participant's blood pressure, RPE, and heart rate rest were measured.

↓

Randomized sequence of 6MWT-10m and 6MWT-30m, & 2MST using simple random sampling: envelops concealed (Group A or Group B or Group C)

↓

Group	Order of tests		
	1	2	3
A (n=10)	6MWT-30m	6MWT-10m	2MST
B (n=10)	6MWT-10m	2MST	6MWT-30m
C (n=10)	2MST	6MWT-30 m	6MWT-10m

↓

30 participants were measured cardiopulmonary endurance (1^{st} occasions)

↓ 2-5 days

30 participants were measured cardiopulmonary endurance (2^{nd} occasions)

Intrarater reliability (step and distant)

Validity (Heart rate reserve and RPE)

Figure 10 Procedure of reliability and validity for cardiopulmonary endurance

6. Data Analysis

Results was reported as means $\pm$ standard deviation. Characteristic of participants were analyzed using descriptive statistics. The Intraclass correlation coefficient (ICCs; ICC 3,1: Intra-rater reliability) was used reliability for SFT and cardiopulmonary endurance test. This study was used Pearson product moment correlation to convergent validity the peak heart rate reserve and RPE achieved between 2MST with 6MWT-10m and 6MWT-30m. $P \leq 0.05$ was considered statistically significant.

Phase II:

Study of physical fitness in community dwelling elderly in Ongkharak Nakhon-Nayok

1. Research design

This study was a cross-sectional study aimed to investigate the physical fitness levels of SFT: arm curl test (upper body strength); 30 second chair stand test (lower body strength); 2 minute step in place test (cardiopulmonary endurance); back scratch test (upper body flexibility); chair sit and reach test (lower body flexibility); 8-foot up and go test (agility and dynamic balance) and body composition (body mass index and waist circumference) in a sample of 191 participants (60-69 years of age).

2. Participants

Participants was volunteers, community-dwelling elderly, living in Ongkharak district, Nakhon-nayok Provide. Participants were age 60 to 69 years and both male and female. The inclusion and exclusion criteria were the same as phase I. All subjects were informed of the nature and purpose of the study and sign consent form before began.

The sample size of the elderly of this phase II was calculated using following equation (Stratified random sampling) [106];

$$n = \frac{z^2_{1-\alpha/2}\sum_{h=1}^{L}[N_h^2 P_h(1-P_h)/w_h}{N^2 d^2}$$

When: n = number of sample size

$Z_{1-\alpha/2}$ = 0.05, $Z_{1-\alpha/2}$ = 1.96

Nh = Total number of population units in each stratum

Ph = The ratio of weight in each stratum

Wh = The stratum weight (Nh/N)

N = number of elderly population (5,920)

d = Errors of precision at $\pm$3 percentage

n $=1.96^2(1738885.50) / (5920)^2 (0.03)^2$

$= 3.84(1738885.50) / (35046400)(0.0009)$

$= 6677320.32 / 31541.76$

n = 211.69

Calculate number of samples from this formula is 212 participants. Then sample size calculates in each stratum from allocation of a sample to strata using formula follow:

When: n = number of samples

n_h = the sample size in each stratum

N_h = the population size in each stratum

N = the total population size

Thus from this formula is sample size from each of the elderly in 11 Tambon in the Amphoe Ongkharak [9] (Table 8).

Table 8 The sample size in each stratum of 11 Tambon in the Amphoe Ongkharak

Stratum	Tambon name	Population's size	Samples size (n_h)
1	Bang Sombun	314	11
2	Bueng San	611	22
3	Pho Thaen	538	19
4	Sai Mun	610	22
5	Sisa Krabue	537	19
6	Bang Pla Kot	895	32
7	Phra Achan	854	31
8	Bang Luk Suea	492	18
9	Chumphon	619	22
10	Khlong Yai	300	11
11	Ongkharak	150	5
Total		N = 5,920	n = 212

3. Outcome measures

The physiologic and anthropometric measures were assessed. Systolic blood pressure, diastolic blood pressure, height, weight, and body mass index were measured for each participant. BMI was calculated as height (in meters) squared divided by weight (in kilograms).

Functional fitness was assessed using the SFT, which consisted of the total score for each test.

4. Material and research tools

The materials used in this phase II study (for measure physical fitness level) included same phase I.

5. Procedure

The tests of SFT were carried out as established by Jones and Rikli, 2013 details as phase I (5.1 test-retest reliability for SFT). Physical fitness test including arm curl test (upper body strength); 30 second chair stand test (lower body strength); 2 minute step in place test (cardiopulmonary endurance); back scratch test (upper body flexibility); chair sit and reach test (lower body flexibility); 8-foot up and go test (agility and dynamic balance) and body composition (body mass index and waist circumference). Body composition was designed to assess body mass index, as an individual's weight relative to height. Waist circumference was measured between the top of the iliac crest and the lower margin of the last palpable rib in the mid-auxiliary line.

Participants (volunteers) from Community-dwelling elderly in Ongkharak district, Nakhon-Nayok were recruited based on the inclusion criteria.

↓

All subjects were informed of the purpose of the study and agreed to sign a consent form.

↓

Before and after the test, the participant's blood pressure, RPE, and heart rate rest were measured.

↓

Physical fitness level measurement

Physical fitness parameter	Test items
1. Body strength	
Upper body strength	Arm curl
Lower body strength	30-s chair stand
2. Cardiopulmonary endurance	2-min step test
3. Body flexibility	
Upper body flexibility	Back scratch
Lower body flexibility	Chair sit-and-reach
4. Motor agility/dynamic balance	8-ft up-and-go
5. Body mass index	Height and weight
	Waist circumference

Figure 11 Procedure of physical fitness levels measurement

6. Data Analysis

Results were reported as a means ± standard deviation. Characteristic of participants were analyzed using descriptive statistics. Description statistic (percentile ≤

25 is below-average, and percentile > 75 is above average of physical fitness)[22] evaluated the data of physical fitness tests. $P \leq 0.05$ consider statistically significant.

Phase III:

Effect of physical training on physical fitness in community dwelling elderly.

1. Research design

This was a randomized, controlled. The order of this section follows the CONSORT statement for reporting randomized controlled trials [107].

2. Participants

The participants were volunteers, all live in community dwelling elderly, Ongkharak, Nakhon-Nayok. The inclusion and exclusion criteria of the present study was the same in phase II.

Participants were recruited from community dwelling in Nakhon-nayok area, Thailand. Individuals 60-69 years of age and physical fitness level of cardiopulmonary endurance and lower body strength at least 75 percentile were eligible to participate in this study, because the elderly have legs lose muscle faster arms and both performance relationship with activities of daily living.

Furthermore, individuals were excluded for this study if they had severe orthopedic problems that limit their walking or marching abilities, medical diagnosis of heart and lung diseases, unstable hypertension (>160/110 mmHg), severe weight-bearing pain (rated > 5/10 on the visual analog pain scale), and severe visual or hearing impairment.

One hundred and ninety-one participants were evaluated for eligibility. Eighty-five participants not meeting inclusion criteria were excluded. Then, 106 participants were separated by simply randomized sampling (Lottery) method that divided to exercise group (E): 37 participants (16 males, 21 females), and control group (C): 40

participants (19 males, 21 females), respectively. Twenty-nine participants were not allocated because they did not show up on the beginning date.

Sample size was calculated from the study of Matsuda et al, 2010 that investigate effectiveness of exercise in elderly by physical fitness test [87]. The significance level was set at alpha level 0.05. The power level was set at 80%. Sample size for this study was calculated using following equation:

$$n = \frac{2(Z_\alpha + Z_\beta)^2 \sigma^2}{\Delta^2}$$

When: σ Pool variances of 30-sec. chair stand = 3.3

Δ Mean difference of 30-sec. chair stand (pre - posttest) = 2.4

α 0.05, Z_α = 1.96

β 0.20, 1- β = 0.80, Z_β = 0.84

From above calculation, the sample size in the present study is 30 participants in each group. For this study was plus 40% dropout [87]. This dropout was calculated using following equation[108]:

When: n = Sample size (30 participants/group)

n_{new} = New sample size

L = %Droupout rate (40%)

Therefore, the new sample size for the present study is 42 participants in each group.

3. Outcome Measures

All subjects were informed of the purpose of the study and sign consent form. Participants were interviewed and assessed for baseline demographics such as age, sex comorbidity and health status by questionnaire. After that, the blood pressure, heart rate, and RPE were measured. Consequently, the physical performance test [109] was administered. This test protocol was designed to evaluate the physical fitness related to independent functioning: upper and lower strength, cardiopulmonary endurance, upper and lower flexibility, motor agility and dynamic balance, and body composition. Blood pressure, heart rate, and RPE were measured after each test for each subject.

Physical fitness level of participants from both groups were assessed using SFT. These tests required less time or equipment and was designed to be conducted in community settings. Participants were received instruction to before testing. The physical fitness tests were arm curl test, 30 second chair stand test, 2 minute step in place test, back scratch test, chairs sit and reach test, 8-foot up and go test, body mass index and waist circumference that details as follows phase I.

4. Materials and research tools

The materials used in this phase II study (for measure physical fitness level) included same phase I.

5. Procedure

The exercise group performed exercise to improve physical fitness item. This exercises that recommendation from guideline for elderly and performed 8 weeks individualized self-home base exercise program.

Exercise group (individualized home-based exercise program)

The exercise group performed the progressive exercise program for 8 weeks. Progressive exercise involves the gradual increase of stress placed upon the body during exercise training regarding manipulation of frequency, duration, intensity, and type of exercise [104]. The 8-week progressive individualized home-based exercise program that included progressive strength training, cardiovascular/aerobics, flexibility, and balance exercises three days per week. A physical therapy professional supervised the program. Participants marked the exercise dates in their diary. Details of the progressive exercise program follows by Jones and Rikli 2013 [6].

1. **Muscle strengthening of upper and lower body**

Progressive resistive strength training of the upper body involved wall push-up exercise and the lower body sit to stand exercise.

Wall push-up exercise (exercise to improve upper lower body strength) (Fig. 12): The participant faced the wall; distance from the wall was equal to the length of the straight-arm. The participant bent the arm and moved slowly toward the wall and pushed-up the body away from the wall [6].

Sit to stand exercise (exercise to improve lower body strength) (Fig. 13): The participant stood with feet one shoulder–width apart in front of a chair. The back of the chair rested against the wall for safety. The participant sat down to on the chair slowly, bringing both arms forward to balance the movement [6].

The number of repetitions for each exercise was set at the higher number tested by the arm curl test (upper body strength test) and the 30-second chair stand test (lower body strength test) for each participant. Progression was increased every 2 weeks for 2 repetitions and increased by 1 set every 2 weeks [104, 110]. Participants were exercised in range of rate perceive of exertion for at 5-6/10 (participants can speak as a word)[104, 110].

Figure 12 Wall push-up exercise

(Exercise to improve upper lower strength)

Figure 13 Sit to stand exercise

(Exercise to improve lower body strength)

2. Cardiopulmonary endurance training

Progressive cardiopulmonary endurance training involved marching exercise (Fig. 14)[6] similar to the 2MST. The participant stood beside a chair with feet one shoulder–width apart while holding the chair for safety. The time of the marching exercise started at 20 minutes per day at the first 2 week[104] with the duration being increased by 5 min at 2-week intervals[111]. This marching exercise could be performed continuously or as two sets for the time assigned per day based on the rating of perceived exertion $\leq$ 5-6/10, which indicates that the participants can still speak while exercise[110].

Figure 14 Marching exercise

(Exercise to improve cardiopulmonary endurance)

3. Muscle flexibility of upper and lower body

The flexibility exercise for the upper body was the shoulder and upper-arm stretch and for the lower body, it was the standing calf stretch exercise [6].

Shoulder and upper-arm stretch exercise (exercise to improve upper body flexibility) (Fig. 15): The participant stood with feet one shoulder–width apart and held the towel with both hands behind the back [6].

Standing calf stretch exercise (exercise to improve lower body flexibility) (Fig. 16): The participant faced against the wall and stood length of straight-arm away the wall. The participant then stepped forward and bent the knee down toward the wall while keeping the other leg straight and the foot on the floor. The participants felt stretching at the calf of the back leg [6].

This flexibility exercise included the upper-arm stretch and the standing calf stretch, which applies sustained stretches to the slight discomfort point or tightness feeling in muscles and was held for 15 seconds for each exercise. Participants performed this exercise five times per set on each side at three sets per day [104, 110].

Figure 15 Shoulder and upper-arm stretch exercise

(Exercise to upper body flexibility)

Figure 16 Standing calf stretch exercise

(Exercise to improve lower body flexibility

4. Balance training

The balance exercise was the one leg stand. (Fig. 17). The participant stood beside a chair with feet one shoulder–width apart while holding the chair for safety. The participant lifted the leg from the floor and held it up to 30 seconds [112]. In the first 2 weeks, participants performed this balance exercise eight times per set for one set per day for each side. The exercise was progressively increased to 10 repetitions for the 3^{rd} and 4^{th} weeks and then to 12 repetitions for the 5^{th} to 8^{th} weeks [104, 110]. The time of elevating one leg depended on each participant's ability [110].

Figure 17 One leg stand exercise (Exercise to improve balance)

Table 9 Individualized progressive exercise protocol

Weekly	Week 1-2	Week 3-4	Week 5-6	Week 7-8
Wall push up [a]	+2 /set, 1 set/day	+4 /set, 2 sets/day	+6 /set, 3 sets/day	+8/set, 4 sets/day
Sit to stand [a]	+2 /set, 1 set/day	+4 /set, 2 sets/day	+6 /set, 3 sets/day	+8/set, 4 sets/day
Marching	20 min/day	25 min/day	30 min/day	35 min/day
One leg stand	30s X 8/set 1 set/day	30s X 10/set 2 sets/day	30s X 10/set 3 sets/day	30s X 10/set 4 sets/day
Shoulder and upper-arm stretch [b]	5 /set on each side 3 sets/day			
Standing calf stretch [b]	5 /set on each side 3 sets/day			

Note: [a]The number of repetitions for strengthening exercise was set at the highest number tested by the arm curl test and the 30-second chair stand test, then 2 repetitions/sets were added every 2 weeks.

[b] Perform sustained stretches to the point of slight discomfort, or feeling of tightness in muscles, hold for 15 seconds.

Control group (information health knowledge)

Control group participants maintained their lifestyles with performed usual medical care and information about health, self-care, including knowledge about good nutrition and basic knowledge about the pathophysiology convenient for dyslipidemia, diabetes mellitus, and hypertension.

Physical Therapist' role during follow-up

During the first 4 weeks of follow-up, the individualized home-based exercise group was visited weekly. This visit was to prescript the progression of exercise and inquire about the negative effects of exercise. During the last 4 weeks, participants was visited at every two weeks while getting a phone call once a week [(113)]. The total time of exercise at 8 weeks was 24 time. The dropout was recommended at less 20%. Therefore, this total time to exercise at least 20 times was conduct the analysis. The intention-to-treat was use the last observation carried forward (LOCF) method for missing data [108, 114].

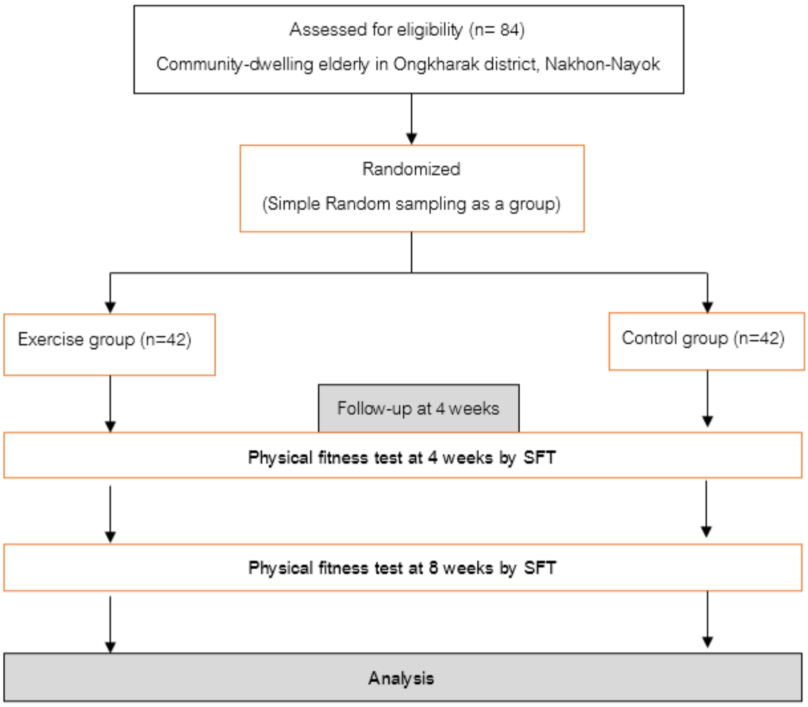


Figure 18 Procedure of phase III

6. Data Analysis

Results reported as means ± standard deviation. Characteristic of participants was analyzed using descriptive statistics. One way ANOVA repeated was determine between groups difference in the performance of the physical fitness tests and before-after tests. $P \leq 0.05$ consider statically significant.

CHAPTER 4

FINDINGS

Phase I: The percent heart rate reserve and dyspnea level responses to 2MST compare to 6MWT-10m and 6MWT-30m in community-dwelling elderly

1. Test retest-reliability of modified senior fitness test Thai-version

The analysis of test retest-reliability of modified senior fitness test Thai-version was based on 10 community dwelling older adults. Ten elderly included 2 men and 8 woman with healthy range of BMI, and normal blood pressure (Table 10).

Table 10 General characteristics of the subjects (N = 10)

Variables	Mean $\pm$ SD
Age (years)	67.5 $\pm$ 6.7
BMI (kg/m^2)	24.8 $\pm$ 5.4
Systolic pressure (mmHg) (at rest)	130.6 $\pm$ 16.1
Diastolic pressure (mmHg) (at rest)	80.6 $\pm$ 9.1

Seven tests of physical fitness test was high test-retest reliability (ICC = 0.89-0.98) (Table 11).

Table 11 Test-retest reliability data of physical fitness test

Tests (n = 10)	Test day 1 (mean ± SD)	Test day 2 (mean ± SD)	Test-retest Reliability
Arm curl test (rep.)	11.5 ± 3.3	12.5 ± 2.7	0.89
Chair stand test (rep.)	12.3 ± 3.1	12.3 ± 2.7	0.91
2 Minute step in place test (rep.)	69.4 ± 14.0	72.3 ± 15.7	0.96
6 Minute walk test (10m.) (m.)	325.8 ± 105.6	304.3 ± 81.5	0.98
Back scratch test (cm.)	-8.5 ± 5.0	-8.7 ± 5.7	0.97
Chair sit and reach test (cm.)	4.0 ± 3.4	4.0 ± 2.7	0.96
8-foot up & go test (sec.)	6.9 ± 1.7	7.1 ± 1.6	0.92

2. Reliability and validity of 2MST and 6MWT

2.1 Test-retest reliability of 2MST and 6MWT

Thirty elderly subjects were recruited for the study. Demographic, anthropometric and physiological characteristics, including age, gender, BMI, vital signs and comorbidity of reliability of 2MST and 6MWT are presented in Table 12. The thirty elderly subjects included 20 men and 10 women with a healthy range of BMI, normal blood pressure and percentage O_2 saturation (Table 12). Most participants expressed having hypertension as well as hypertension with diabetes mellitus and dyslipidemia. The subject group was not found to have individual diabetes mellitus (Table 12).

Table 12 Demographic characteristics of the subjects (N = 30)

Gender (Male: Female)	20: 10
Age (years) (mean ± SD)	64.0 ± 2.8
BMI (kg/m^2) (mean ± SD)	24.6 ± 3.8
Systolic pressure (mmHg) (mean ± SD)	133.3 ± 14.4
Diastolic pressure (mmHg) (mean ± SD)	81.5 ± 7.8
%O2 sat. (mean ± SD)	97.7 ± 0.8
Chronic disease (n)	16
Hypertension	5
Diabetes mellitus	0
Dyslipidemia	2
Hypertension+ Diabetes mellitus+ Dyslipidemia	5
Hypertension+ Dyslipidemia	4

The 2MST and 6MWT-10m and 6MWT-30m shoed very high test-retest reliability, with ICC more than 0.91 (Table 13).

Table 13 Test-retest reliability of 2MST, 6MWT-10M, and 6MWT-30M

Tests	**Test 1 (mean ± SD)**	**Test 2 (mean ± SD)**	**Test-retest reliability**	**95% CI**
2MST (step)	64.1 ± 12.4	67.9 ± 14.1	0.93	0.85 - 0.97
6MWT-10m (distance)	347.5 ± 45.8	355.1 ± 44.0	0.91	0.80 - 0.96
6MWT-30m (distance)	401.6 ± 40.0	406 ± 42.5	0.93	0.86- 0.97

2.2 Validity of 2MST and 6MWT

The 2-minute step in place test showed the most average percent heart rate reserve, followed by 6MWT-30m and 6MWT-10m respectively (Table 14).

Table 14 %HRR (Mean ± SD) of 2MST, 6MWT-10M, AND 6MWT-30M

Test	Mean ± SD	Min-Max
During test		
2MST (step)	29.8 ± 9.8	15.7-51.5
6MWT-10m (distance)	18.5 ± 5.8	10.0-32.1
6MWT-30m (distance)	21.2 ± 8.0	9.4-39.0
Post-test		
2MST (step)	37.6 ± 10.5	21.4-59.3
6MWT-10m (distance)	21.2 ± 6.2	11.0-36.5
6MWT-30m (distance)	24.1 ± 7.5	13.2-38.1

The measure of percent heart rate reserve (%HRR) for 2MST and 6MWT-10m correlated positively with 6MWT-30m, both during and post-test more than 0.71 (p=0.01) that post-test of 6MWT-10m was the most correlated positively with 6MWT (30-m.) (r=0.86; p=0.01) at post-test (Figure 19).

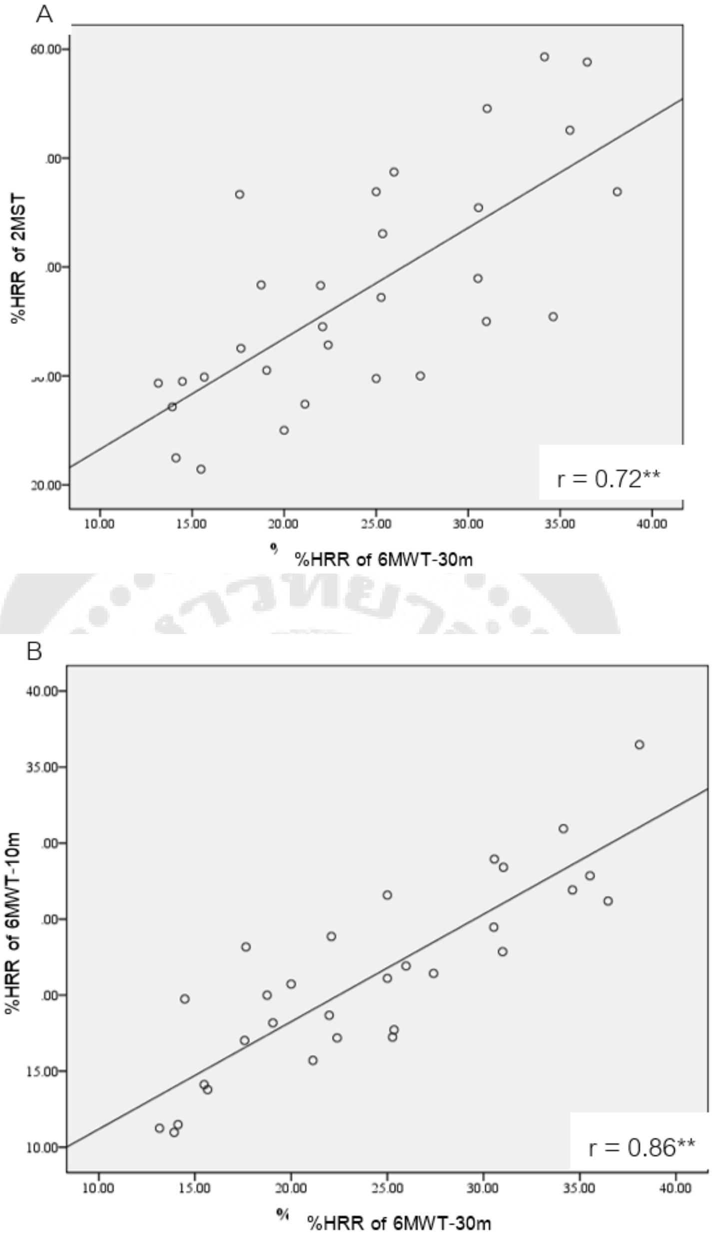


Figure 19 The correlation plots of %HRR for post-test

(A, 6MWT-30M and 2MST; B, 6MWT-30M and 6MWT-10M. (***p*= .01)

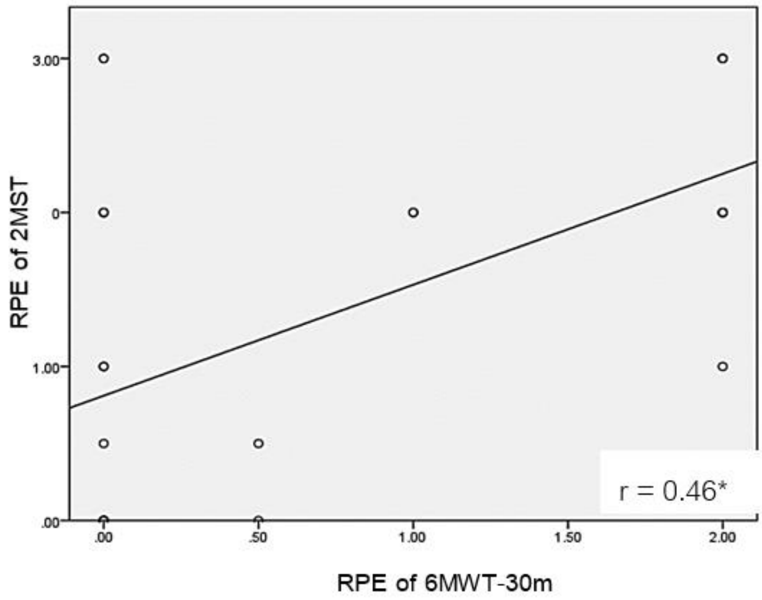
RPE for 2MST and both 6MWT ranged from nothing to weak for perceived exertion, except 2MST (post-test), which had a maximum of moderate perceived exertion. The RPE average of 2MST had low correlation with 6MWT-30m, both during testing and post-test. Further, 6MWT-10m had low correlation with 6MWT-30m both during testing and post-test (Table 15). In addition, RPR of 2MST and 6MWT-10m had low positively correlation with 6MWT-30m, both during testing and post-test (Figure 20).

Table 15 RPE (Mean + SD) of 2MST, 6MWT-10M, and 6MWT-30M

Test	Mean + SD	Min-Max
During test		
2MST (step)	0.7 + 0.8	0-2
6MWT-10m (distance)	0.2 + 0.6	0-2
6MWT-30m (distance)	0.1 + 0.4	0-2
Post-test		
2MST (step)	1.3 + 1.1	0-3
6MWT-10m (distance)	0.5 + 0.7	0-2
6MWT-30m (distance)	0.6 + 0.9	0-2

Note: * RPE 0-10 scale

A



B

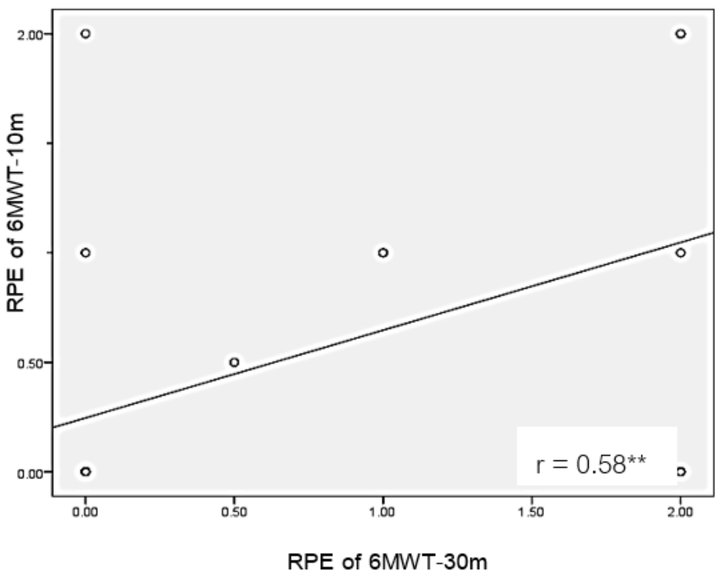


Figure 20 The correlation plots of RPE for post-test (A, 6MWT-30M and 2MST; B, 6MWT-30M and 6MWT-10M (*p<.05, **p=.01)

Phase II: physical fitness level of the community-dwelling elderly in Ongkharak district

Physical fitness level of the elderly

The demographic characteristics of the study sample are listed in table 16. Of the 191 participants, 63.4% and 36.6% were female and male respectively. The participants ranged in age from 60 - 69 years, separated into two groups, male and female. The age of the groups, female and male were 64.4±2.7 and 64.0±2.6 years old, respectively. A total of 72.8%of the participants lived in a house with a partner. There were no significant between-group differences in the baseline characteristics, but females were pre-obese (25.7±4.5) and male were overweight (24.1±3.3). All participants suffered from chronic diseases composed of hypertension, diabetes mellitus, dyslipidemia, and combined diseases (hypertension, diabetes mellitus, and dyslipidemia). The group of males was no underlying diseases at 41.1%. The group of females was highest in two combined diseases at 38.8%. The major occupation of participants was farmers with income more than 10,000 baht per month. In addition, other occupations were work as employees (labor), housekeeping, merchant, fishery, cook, and contractor. The status of participants was single, married, widowed, and divorced with the highest number married at 72.8%.

The physical fitness scores (table 17) showed significant gender difference for all tests ($p<0.05$) except arm curl test. The chair stand test showed higher statistical significance of scores for males than females for both groups (14.8±3.2 and 12.9±3.1, $p < 0.001$). For the 2-minute step in place test scores, males showed higher statistical significance than females for both groups (70.5±14.3 and 62.3±15.3, $p < 0.001$). In the chair sit and reach test scores, females showed higher statistical significance than males for both groups (16.9±8.9 and 12.0±9.6, $p < 0.001$). In the back scratch test scores, females showed higher statistical significance than males for both groups (-20.6±15.0 and -14.3±12.7, $p = 0.002$). In the 8 foot up and go test scores, males showed higher statistical significance than females for both groups (7.5±1.6 and 7.0±1.1, $p < 0.05$).

Table 18 shows the 10^{th}-, 25^{th}-, 50^{th}, 75^{th}, and 90^{th}-percentile score equivalents for each test item for men and women groups. Below average physical fitness level is below the 25^{th} percentile, while more than the 75^{th} percentile shows above average physical fitness level, and the 25^{th} – 75^{th} percentile is normative data of physical fitness level(22). The 25^{th} – 75^{th} percentile, the arm curl test were 13.0 – 17 repetitions in males and 12.5 – 17 in females. The chair stand test was 12.0 – 17 and 11.0 – 14.0 repetitions in males and females, respectively. The 2 minute step in place test were 61.0 – 81.0 and 52.5 – 72.5 repetitions in males and females, respectively. The chair sit and reach test were 6.8 – 18.3 and 11.0 – 23.0 centimeters in males and females, respectively. The back scratch test were (-32.3) – (-12.5) and (-24.5) – (-2.5) centimeters in males and females, respectively. The 8 foot up and go scores were 6.0 – 7.6 and 6.5 – 8.3 seconds in males and females, respectively.

Table 16 General characteristics of participant in phase II study (60-69 Years)

Characteristics	Both group	Male	Female	P-value
Number of participants [b]	191	70 (36.6)	121 (63.4)	N/A
Age (yrs.) [a]	64.2 ± 2.6	64.4 ± 2.7	64.0 ± 2.6	0.318
BMI (kg/m^2) [a]	25.0 + 4.2	24.1 + 3.3	25.7 + 4.5	0.003*
Waist circumference (cm) [a]	87.3 + 12.0	87.7 + 9.5	87.8 + 11.1	0.771
Systolic pressure (mmHg) [a]	134.2 + 16.2	136.2 + 16.1	133.1 + 16.2	0.215
Diastolic pressure (mmHg) [a]	81.3 + 10.2	83.4 + 10.2	80.1 + 10.0	0.033*
Heart rate (b/m) [a]	78.6 + 10.5	77.8 + 10.8	79.1 + 10.3	0.434
%O2 sat. [a]	97.6 + 0.9	97.7 + 0.9	97.5 + 1.0	0.333
Number of underlying disease [b]				
0	55 (28.8)	29 (41.1)	26 (21.5)	0.002*
1	44 (23.0)	20 (28.6)	24 (19.8)	
2	61 (31.9)	14 (20.0)	47 (38.8)	
3	31 (16.2)	7 (10.0)	24 (19.8)	
Occupation [b]				
Famer	78 (40.8)	30 (15.7)	48 (25.1)	0.000*
Work of employee (labor)	37 (19.4)	19 (9.9)	18 (9.4)	
Housekeeping	55 (73.8)	11 (5.8)	44 (23.0)	
Merchant	16 (8.4)	7 (3.7)	9 (4.7)	
Fishery	1 (0.5)	1 (0.5)	0 (0.0)	
Cook	3 (1.6)	1 (0.5)	2 (1.0)	
Contractor	1 (0.5)	1 (0.5)	0 (0.0)	

Table 16 (Continued)

Characteristics	Both group	Male	Female	P-value
Income per month [b]				
<5,000 bath	56 (29.3)	12 (6.3)	44 (23.0)	0.012*
5,000 – 10,000 bath	99 (51.8)	45 (23.6)	54 (28.3)	
>10,000 bath	36 (18.8)	13 (6.8)	23 (12.0)	
Status [b]				
Single	10 (5.2)	2 (1.0)	8 (4.2)	0.007*
Married	139 (72.8)	61 (31.9)	78 (40.8)	
Widow	35 (18.3)	5 (2.6)	30 (15.7)	
Divorce	7 (3.7)	2 (1.0)	5 (2.6)	

[a] The data are presented using mean ± SD, and the data comparisons were executed using the two-sample t-test.

[b] The data are presented using the number of subjects and percentage, and the data among the groups were compared using the chi-square test.

*p<.05

Table 177 Physical fitness score of participants in phase II study (60-69 Years)

Variables	Overall (n=191)	Male (n=70)	Female (n=121)	P-value
Arm curl (reps.)	15.0 ± 3.3	15.3 ± 3.5	14.8 ± 3.2	0.338
Chair Stand (no. stands)	13.6 ± 3.3	14.8 ± 3.2	12.9 ± 3.1	<0.001**
2-min step (no. steps)	65.3 ± 15.4	70.5 ± 14.3	62.3 ± 15.3	<0.001**
Back scratch (in.)	-16.6 ± 13.9	-20.6 ± 15.0	-14.3 ± 12.7	0.002**
Chair sit-and-reach (cm.)	15.1 ± 9.5	12.0 ± 9.6	16.9 ± 8.9	<0.001**
8-ft up-and-go (s)	7.3 ± 1.4	7.0 ± 1.1	7.5 ± 1.6	0.007**

[a] The data are presented using mean + SD, and the comparisons of male to female data were executed using the two sample t-test.

**p<.001

Table 18 Gender-group percentiles for men and women in phase II study (60-69 Years)

Physical fitness percentile	Overall (n=191)	Male (n=70)	Female (n=121)
Arm curl (reps.)			
10th	11.0	10.1	11.0
25th	13.0	13.0	12.5
50th	15.0	15.0	15.0
75th	17.0	17.0	17.0
90th	20.0	20.0	19.0
Chair Stand (no. stands)			
10th	10.0	11.0	9.0
25th	11.0	12.0	11.0
50th	13.0	14.5	13.0
75th	16.0	17.0	14.0
90th	18.0	19.0	17.0
2-min step (no. steps)			
10th	45.0	51.2	42.2
25th	55.0	61.0	52.5
50th	65.0	68.5	63.0
75th	75.0	81.0	72.5
90th	86.0	93.6	83.0

Table 18 (Continued)

Physical fitness percentile	Overall (n=191)	Male (n=70)	Female (n=121)
Back scratch (cm.)			
10th	-34.0	-40.8	-31.0
25th	-26.0	-32.3	-24.5
50th	-16.0	-22.5	-15.0
75th	-5.0	-12.5	-2.5
90th	2.0	2.9	2.0
Chair sit-and-reach (cm.)			
10th	3.6	1.0	4.0
25th	9.0	6.8	11.0
50th	15.0	11.5	17.0
75th	22.0	18.3	23.0
90th	27.0	24.0	28.0
8-ft up-and-go (s)			
10th	5.7	5.6	5.9
25th	6.3	6.0	6.5
50th	7.2	7.0	7.3
75th	8.1	7.6	8.3
90th	9.0	8.4	9.4

Phase III: Effect of 8 weeks individualized home-based exercise program in community-dwelling elderly

Effect of 8 weeks individualized home-based exercise program

A total of 191 participants were initially considered for recruitment. After screening using the inclusion and exclusion criteria, the eligible 106 participants were allocated using a sealed envelope cluster random sampling method to exercise group (n = 51) and control group (n = 55). Prior to the first assessment, 14 were excluded from the exercise group and 15 were excluded from the control group due to participants' personal reasons. At the starting of intervention, there were 37 individuals in the exercise group and 40 individuals in the control group. After 4 weeks there were 6 dropouts (16.2%) in the exercise group and 10 (25%) in the control group due to personal reasons and health problems not related to the intervention. The final sample at 8 weeks were 31 in the exercise group and 30 in the control group as indicated in Figure 21

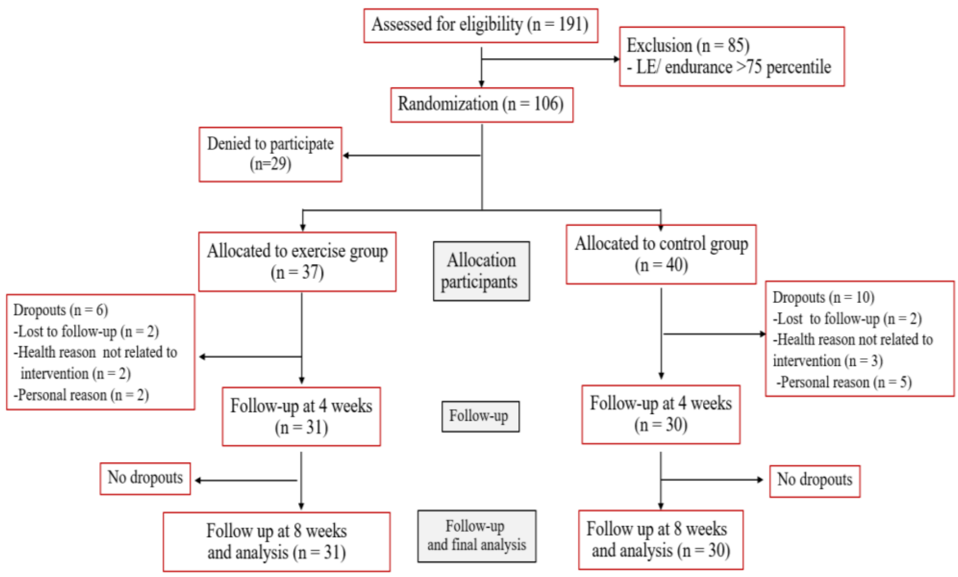


Figure 21 Flow chart of participant recruitment and trial design

Demographics of the participants were presented as mean ± standard deviation as shown in Table 19. There were no significant differences between the exercise and control groups in all baseline characteristics and physical fitness levels.

The average number of exercises per week recorded by the exercise group were 4.5 (SD =0.7) with the range of 4-7 times per week. No adverse effect of exercise was found.

Repeated measures ANOVA was conducted to examine the effects of exercise on physical fitness test levels. Data showed in Table 20. There were significant different improvements ($p>0.05$) in the exercise group compared to the control group in week 4 and week 8 in arm curl test [$F_{(5,177)} = 18.915$, $p = 0.000$], chair stand test [$F_{(5,177)} = 15.003$, $p = 0.000$], 2MST [$F_{(5,177)} = 20.549$, $p = 0.000$], chair sit & reach test [$F_{(5,177)} = 5.7779$, $p = 0.005$], and 8-foot up & go test [$F_{(5,177)} = 10.057$, $p = 0.001$]. No significance between groups in back scratch [$F_{(5,177)} = 1.093$, $p = 0.908$] was found at all time points.

Table 19 Demographics of the subjects, Means ± SD (range)

variable	Control group (n=30)	Exercise group (n=31)	p-value
Age [a] (year)	64.5 ± 2.6	64.0 ± 2.3	.375
Weight [a] (kg)	61.9 ± 10.3	59.0 ± 10.1	.320
Height [a] (cm)	157 ± 9.5	155 ± 9.5	.381
Body Mass Index [a] (kg/m^2)	25.1 ± 4.1	24.9 ± 4.5	.775
Waist circumference [a] (cm)	89.8 ± 9.6	86.2 ± 9.8	.149
Gender: female [b]	16 (53.3)	16 (51.6)	.893
Vital Signs [a]			
Systolic pressure (mmHg)	133 ± 16.9	133 ± 18.1	.914
Diastolic pressure (mmHg)	81.2 ± 9.8	81.2 ± 12.1	.993
Heart rate (bpm)	80.7 ± 12.9	77.8 ± 8.7	.304
% Oxygen saturation	97.6 ± 0.9	97.3 ± 1.0	.127
Number of underlying diseases [b]			
0	6 (20)	10 (32.3)	.731
1	9 (30)	8 (25.8)	
2	6 (20)	7 (22.6)	
3	9 (30)	6 (19.4)	

[a] *The data are presented using mean ±SD, and the data comparisons were executed using the two sample t-test.*

[b] *The data is presented using the number of subjects (%), and the data among the groups were compared using the chi-square test.*

Regarding changes comparing three time points, no significant change was found in the control group for all outcomes. There were significant improvements in the exercise group from baseline to week 4 in all outcomes. Significant improvement from week 4 to week 8 were found only in arm curl and chair stand tests. Data shown in Table 20.

Table 20 Changes in physical fitness score from baseline (week 0) to end of the study

Tests	Control group (n=30)	Exercise group (n=31)	F test	*p* value [a]
Arm curl (no. of reps.)			F (5, 177) = 18.915	0.000**
Baseline	13.7 ± 2.6	13.5 ± 2.6		
4-week	14.2 ± 2.5	16.9 ± 2.2**[b]		
8-week	14.7 ± 2.1	18.1 ± 2.3**[b]		
Chair Stand (no. of stands)			F (5, 177) = 15.003	0.000**
Baseline	11.8 ± 2.1	12.1 ± 1.8		
4-week	12.1 ± 2.0	14.5 ± 2.2**[b]		
8-week	12.5 ± 2.3	15.5 ± 2.5**[b]		
2-min step (no. steps)			F (5, 177) = 20.549	0.000**
Baseline	57.3 ± 9.8	60.3 ± 8.6		
4-week	54.0 ± 13.5	72.1 ± 11.3**[b]		
8-week	55.2 ± 12.9	75.87 ± 10.8**[b]		

Table 20 (Continued)

Tests	Exercise (n=31)	Control (n=31)	F test	*p* value [a]
Chair sit-and-reach (cm.)			F (5, 177) = 5.779	0.005*
Baseline	11.4 ± 8.4	12.3 ± 9.8		
4-week	12.4 ± 11.8	19.8 ± 6.7*[b]		
8-week	13.3 ± 8.4	19.4 ± 6.4*[b]		
8-ft up-and-go (sec.)			F (5, 177) = 10.057	0.001*
Baseline	7.9 ± 1.2	7.6 ± 1.2		
4-week	7.7 ± 1.6	6.4 ± 1.1*[b]		
8-week	7.6 ± 1.3	6.3 ± 0.9*[b]		
Back scratch test (cm.)			F (5, 177) = 1.093	0.908
Baseline	-13.7 ± 12.0	-18.9 ± 12.2		
4-week	-14.8 ± 10.6	-12.8 ± 14.4		
8-week	-14.8 ± 10.3	-13.4 ± 12.4		

Note. The data were presented using mean ±SD.The details of statistical analysis results were presented in Appendix

[a] *The data comparison between the groups were analyzed using the analysis of variance with repeated measures and adjusted by cluster.*

[b]*The data compared to baseline*

**p<0.05, ** p<0.001*

No significant differences were found between 4-week and 8 week.

CHAPTER 5
DISCUSSION AND CONCLUSION

Phase I: The percent heart rate reserve and dyspnea level responses to 2MST compare to 6MWT-10m and 6MWT-30m in community-dwelling elderly

The test-retest reliability of the modified senior fitness test Thai-version found high test retest-reliability. The reliability and validity of 2MST and 6MWT-10 m was compared to the standard test, the 6MWT-30m. The results showed high test retest-reliability. The validity of the 2MST and 6MWT-10 m, when compared to 6MWT-30 m using %HRR was found to have significant correlation. In addition, the RPE of 2MST and 6MWT-10m when compared to the 6MWT-30m after testing showed a low level of correlation.

1. Test retest-reliability of the modified senior fitness test Thai-version

The results showed that modified senior fitness test Thai-version has high test-retest reliability (ICC > 0.89) similarly to previous studies (ICC = 0.84-0.98). [3, 18, 47, 115-118] Our method and subject were similar to these studies that subjects were elderly (over 60 year old) and also the second and third times for test-retest reliability were performed on two different occasions 2 to 5 days apart.

2. Reliability and validity of 2MST and 6MWT

In order to determine the proper cardiopulmonary endurance test for the elderly that can be applied in limit space. Therefore, the present study tested the reliability and validity of two tests (2MST and 6MWT-10m.) when comparing with 6MWT-30m. as reference test. Three tests showed similar exercise intensity when using two variables, including %HRR and RPE. %HRR is expansive considered to be equivalent to %VO_2max which related to oxygen consumption reserve for exercise prescription purposes.

Positive correlation (r>0.7) of %HRR level used in present study to determine the validity of the 2MST and 6MWT-10m, when compared to 6MWT-30m suggested that these three tests were comparable. This result was similar to the study of Rikli and Jones (1998), which carried out a comparison test for SFT and criterion measurement. In their study, positive correlation between 6MWT and time on treadmill to 85% predicted maximum heart rate (r= 0.78) were found. The results found in present study was accepted and indicated moderate correlation.[115, 119] Percent heart rate reserve is used to demonstrate exercise intensity because it showed high correlation with VO_2 max.[120] The advantage of using %HRR in present study was its suitability for field testing in the community. As a consequence, 2MST, 6MWT-10m, and 6MWT-30m were comparable in exercise intensity when using %HRR.

Present study showed that the correlation between 2MST and 6MWT-10m with 6MWT-30m was 0.71 to 0.74 for during and post-test except for the correlation between 6MWT-10m and 6MWT-30m, which was found to be 0.84 for post-test. This could be due to 6MWT-10m and 6MWT-30m having the same walkway patterns and using the same total test. The present study showed that the %HRR intensity of 2MST was higher than 6MWT (29.8-36.7 and 18.5-24.1 respectively). However, the exercise intensity of each test (2MST, 6MWT) resulted in Very light to Light intensity (Very light intensity = <20%HRR, Light intensity = 20<40%HRR).[120]

RPE was used in the present study to determine exercise intensity, which can be subjective. RPE is usually used for monitoring exercise tolerance and impending fatigue during exercise.[104] However, the present study found low correlation (r=0.4-0.58) of RPE between 2MST and 6MWT-10m with 6MWT-30m. RPE has limitations in low exercise intensity and led to floor effect for RPE scale response. The elderly group in the present study, when tested with 2MST and 6MWT, represented the low RPE scale (mean

$\pm$ SD = 0.6 $\pm$ 0.2/10 scale of CR-10 point). RPE may be insufficient for monitoring light intensity exercise response in elderly people. Other evaluation methods for dyspnea on exertion that could be applied for such low intensity exercise may include talk test or a respiratory rate monitoring.

The present study found that the modified senior fitness test Thai-version was reliable. Both 6MWT-10m and 2MST showed reliability and validity when compared with a standard 6MWT-30m, suggesting that 2MST and 6MWT-10m could be used as an alternative to 6MWT-30m. Therefore, the modified senior fitness test Thai-version can be applied in the Thai elderly.

The 2MST uses a repetitive pattern, is easy, requires less area and time, which is suitable for an elderly community because elderly people with declining nervous system function may struggle with recognition and anticipatory postural adjustment.[121] However, 2MST is not appropriate for elderly people who have knee pain or have hip pain while high stepping. In addition, 6MWT-10m is not suitable for elderly people who experience dizziness during walking and turning because 6MWT-10m uses more walking turns.[8] Therefore, 2MST was used in phase II for cardiopulmonary endurance assessment for the elderly.

Phase II: physical fitness level of the community-dwelling elderly in Ongkharak district

Physical fitness level of participants

In phase II, the present study determined the age – specific normative physical fitness scores of a population of Thai community-dwelling elderly in Ongkharak district. All participants were able to complete the full battery of fitness tests and these tests can be considered appropriate for this population. However, in some studies, not all [22, 122] participants were able to complete all the fitness tests (more than 80% of the participants were able to complete the full battery of fitness). These studies were for 60 - 84 or 60 - 94 year olds. In our assessment, the 60-69 age group samples were active participants. The general characteristics of BMI, the males are mostly in the normal range and females are predominantly in pre-obese range.

The chair sit and reach scores, which measures lower body flexibility were higher than in the previous study[22, 122, 123]. The score at the 75th percentile (22.0 centimetres) in this study was higher than Rikli 1999 (5.0 centimetres)[22], Zhoa 2021 (6.0 centimetres)[124], Chen 2009 (10.3 centimetres)[123], and Chung 2016 (7.38 centimetres)[125]. In addition, the present study produced average physical fitness level which considerably US elderly.[22] This may reflect factors such as the way of life in Thai culture like sitting on the floor and occupational (such as planting shrubs) of Thai elderly.

Conversely, the chair stand scores assess lower body strength, this test score at the 75th percentile (16 number steps) in the present study was lower than that reported by Chen 2009 (17 number stands)[123], Rikli 1999 (16.5 number stands)[22], and Marques 2013 (18 number stands)[126], Zhoa 2021 (19 number stands)[124], and Chung 2016 (20 number stands)[125] .

The arm curl used to assess upper body strength, the test score at the 75th percentile (17 repetitions) in present study was lower than that reported by Rikli 1999 (18.5 repetitions)[22], Zhoa 2021 (24 repetitions) [124], Chung 2016 (18 repetitions)[125], and Marques 2013 (21 repetitions)[126].

The 2MST assess cardiopulmonary endurance, the score at the 75th percentile (75 number steps) in present study was lower than that reported in Rikli 1999 (107 number steps)[22], Zhoa 2021 (108 number steps) [124], Chung 2016 (106 number steps)[125], and Chen 2009 (104 number steps)[123] by approximately 30 step. This may indicate that the cardiopulmonary endurance of the elderly subjects in the present study was lower than those subjects selected in Rikli 1999 [22], Zhoa 2021[124], Chung 2016[125], and Chen 2009.[123]

In addition, for the 8-foot up and go, which investigate agility and dynamic balance the results in present study were lower than the previous study [22, 123, 126] implying that the physical fitness level were considerably lower (lower than the 50th percentile) compared to the elderly subjects tested from the US.[22] The 8-foot up and go test at the 75th percentile (8.1 seconds) in this study was lower than Rikli 1999 (4.8 seconds)[22], Zhoa 2021 (6.3 seconds)[124], and Chung 2016 (5.66 seconds)[125].

The back scratch assess upper body flexibility in present study at the 75th percentile (-5.0 centimetres) was lower than that reported Rikli 1999 (1.5 centimetres)[22], Zhoa 2021 (-3 centimetres)[124], and Chung 2016 (3.5 centimetres)[125]. In addition, the back scratch score in present study (men = -20.6±15, female = -14.3 ±12.7) were lower than the results of The Sports Authority of Thailand (men = -5.3±12.1, female = -2.8 ±9.3)[127], which studied elderly Thai subjects at the same age for both genders. The back scratch scores were lower than the MDC scores (4.6 centimeter). The back scratch test is the test for flexibility of the shoulder joint which declines with advancing age.[22] People who use their shoulders flexibility such as gymnastics, athletes or occupations that use the shoulder joint regularly have good shoulder flexibility.

The physical fitness levels of the participants in present study were different from other reports.[22, 122, 123, 126] This may reflect different levels of physical activity and exercise. For example, more than 65% and 77% of volunteers in other studies[22, 123, 127]reported to have exercise at least 3 days/week. But in the present study, the participants lived in community and more than 60% of the participants did not report doing any other physical activity apart from daily-living tasks. Up to 40% of the participants were farmers, but they did not work every day and followed a sedentary life style.

Moreover, our data showed that male group were overweight (mean ± SD; 24.1±3.3) while female group were pre-obese (mean ± SD; 25.7±4.5). The BMI found in phase II of the present study was similar to that of Rikli 1999.[22] Compared to WHO category BMI classification, it was found that the average BMI of males was overweight, while the average of females was in the range of pre-obese. When looking at the percentile the both gender are in the normal to pre-obese of BMI. It is interesting that the BMI should be reported as the average or the percentile.

The waist circumference [58] of females groups in our data was more than 80 cm and associated with morbidity (diabetes mellitus, cardiovascular disease), and mortality.[67, 70] On the other hand, the score of males groups was lower than 90 cm with less risk factor for heart disease.[59]

Effect of gender groups

When looking at difference between genders, it was found that physical fitness levels in terms of lower body strength, cardiopulmonary endurance, and balance in males were all higher than females. This result is consistent with recent studies [22, 124] that usually indicate that males are physically stronger than females. In addition, males had more BMI scores than females. The results are the same as the previous studies.[22, 126] This may be due to the fact that males have less fat composition than females, which may result in a lower body mass index score. In present study, it was found that physical fitness levels in terms of upper body flexibility and lower body flexibility in females were higher than that of males, this result is consistent with recent studies.[22, 126] This may be females have more flexibility in their activity than men such as wearing the underwear. However, the 8-foot up and go scores were better than that reported in another Thai elderly study [128]. Therefore, it is important to examine the individualized fitness level before designing the exercise program to provide effective outcomes. The participants included in Phase III of this study also ranked at lower than 75th percentile of cardiopulmonary and lower limb strength which indicated an average in this group of elderly [129] thus the progressive exercise could enhance their fitness better than highly active elderly.

Phase III: Effect of 8 weeks individualized home-based exercise program in community-dwelling elderly

This randomized controlled trial studied the effect of a simple individualized home-based progressive exercise program on physical fitness levels in community-dwelling elderly for 8 weeks based on each participant's physical fitness test performance. This exercise program is designed to suit each individual person according to the level of physical fitness of the elderly. The exercise's postures are easy and similar to in the elderly's daily activities. The exercise program also applied the elderly's body weight as resistance. The progressive exercise program is adjusted according to effective principles that the elderly could exercise at home-based without injury.

The progressive exercise program prescribed in the present study included resistant exercise, cardiopulmonary endurance exercise, flexibility exercise, and balance exercise. The results showed that at 4 week and 8 week the exercise group has significantly improved physical fitness levels in the 5 physical fitness tests (arm curl test, chair stand test, 2-minute step in place test, chair sit and reach test, and 8-feet up and go test) excluding back scratch test when compared to the control group. The findings were similar to other studies that the significant improvements after 4 weeks training were found in strength, cardiopulmonary endurance, and dynamic balance.[87, 130, 131] The improvement in the present study could be the effect of the progressive exercise program used that was individually designed based on prior physical performance and the program was easy for participants to perform exercise at least 3 times per week.

These results of strength are consistent with those found, that in Matsuda et al. (2010)[87] studied the effect of involving in a 6-week home-based exercise program on physical fitness in the frail elderly. They found that the strengthening of upper and lower extremities was improved, which were increased of 35% and 59% respectively. In the same way, Brovold et al. (2013)[132] studied the effect of high intensity aerobic interval exercise in a 3-month home-based program for the elderly. They found that the strengthening of upper and lower extremities was improved, which score per 30 seconds on the chair stands and arm curl mean were increased by 1.3 and 1.6 respectively. The increase in strength as indirectly measured by arm curl test and chair stand test may link to neuromuscular adaptation. The resistance training induced neuromuscular adaptation and muscle hypertrophy in the elderly.[133, 134] Some studies have reported changes in neuromuscular adaptation following 6-12 week exercise training such as increased motor unit firing rate[135, 136]. Recently the Position Statement from the National Strength and Conditioning Association also provided evidence to support the application of individualized, periodized, and progressive resistance training in older adults [137]. The results in present study confirmed that individualized progressive strength training could accelerate the efficacy of training in elderly.

Cardiopulmonary adaptation in elderly could also be improved by training. Locks et al showed improved performance in the 6MWT and five-time chair stand test in the elderly after a 6 weeks resistance exercise program performed twice a week [138]. In addition, Matsuda et al. (2010)[87], studied the effect of involving in a 6-week home-based exercise program on physical fitness in the frail elderly. They found that the cardiovascular endurance or 4-m gait velocity was improved, which increased of 33%. While Brovold et al. (2013)[132], reported the improvements on the Senior Fitness Test (chair stand, arm curl and 6MWT) after the high interval aerobic exercise in home-based program for the elderly consisted of endurance, strength, and balance exercises at 3 months. Progressive marching exercise used in the present study was a simple cardiopulmonary exercise therefore it was easy for the elderly to perform 3 times per week and could enhance cardiopulmonary endurance after only 4 weeks. However, incorporation of functional training exercises such as marching exercise in the present study may add beneficial effects on activities daily living performance.

Dynamic balance as measured by 8-foot up and go test in the present study was also improved in the exercise group. Our data were consistent with other studies that balance training for 6–12 weeks in the elderly improved the 8-foot up and go score[87, 130, 139-141]. Matsuda et al. (2010)[87], studied the effect of involving in a 6-week home-based exercise program on physical fitness in the frail elderly. They found that the balance or 8-foot time up and go score was improved, which decreased of 26%. In addition, Thiamwong et al. (2014)[140], studied the effect of involving in a 12-week home-based balance training on balance performance in the elderly. They found that the balance or 8-foot time up and go score was improved. In the present study, one leg stand, marching exercise and sit to stand exercise were prescribed using the concept of balance exercises as suggested by ACSM recommendations.[142] One leg stand is a progressively difficult posture that decreases base of support while marching exercise and sit to stand exercise are dynamic movements that stress postural muscles. Improvement of balance found in the present study may consist of both static and dynamic balance training components.

In the present study lower limb flexibility was increased as measured by sit and reach test in the elderly after 4 and 8 weeks while there was no significant improvement in upper limb flexibility. Results of lower limb flexibility improvement in the present study were consistent with other studies[139, 143, 144]. Hong et al. (2017)[145], studied the effect of involving in a 12-week home-based tele-exercise on physical performance in the elderly. They found that the flexibility or chair sit and reach length was improved. The age and health condition may affect the flexibility outcome after training as shown in the institutionalized elderly that no significant improvement in upper and lower limb flexibility after 12-week aerobic, resistance, balance and flexibility exercises, performed 3 times per week were found.[130] The flexibility of the shoulder joint is influenced by many factors such as the capsule around the shoulder joint, the point of attachment, as well as the tightness of the muscles around the shoulder joint. However, back scratch scores were not significantly different between the exercise group and control group after 12 weeks of flexibility training.[145] There is a need for further research regarding flexibility improvement in the elderly to define specific programs designed for each individual's condition[146].

In the present study, improvements physical fitness score at week 4 after exercise were higher than minimal detectable change (MDC) including the arm curl test (3.4, MDC = 2.3 repetitions), the chair stand test (2.4, MDC = 1.3 repetitions), the 2-minute step in place test (11.8, MDC = 4.1 repetitions), back scratch test (6.1, MDC = 1.8 centimetre), and chair sit and reach test (7.5, MDC = 1.7 centimetre) only 8-foot up and go test in present study was equal to MDC in MDC reported by Bhattacharya study[147].

Dropout rate in the present study was less in exercise groups (16.2%) than the control group (25%). The rule of thumb provides that up to 20% of dropout during trial considered acceptable. The low dropout rate than 20% in the exercise group indicated that the exercise program was acceptable for 8 weeks[148].

However, adherence was important for home-based exercise programs. Follow up every 2 weeks either by home visit or by phone as performed in the present study were beneficial as this study. The simple individualized progressive exercise prescription as applied in the present study would enhance functional ability in elderly and could be applied as part of health promotion and prevention home-based program.

Limitation and further study

In phase II, the present study included participants 60 - 69 years old, therefore, our results cannot be generalized to other age groups. Moreover, the sample size of the elderly in present study (n=191) may not be sufficient to represent Thai elderly as it is only represent elderly in Ongkharak district. Other studies in the U.S.[22], Taiwan[123], Spain[122], and Portugal[126] reported sample sizes of approximately 379 to 3,314. In addition, participants were only community-dwelling. Thus, it may not be possible to generalize our data to people living in cities. Further studies on city populations with difference lifestyles may show different physical fitness levels. In addition, studies in the elderly should be conducted in other age groups (>69 year old).

In phase III study, due to community setting, participants were enrolled in a study to either exercise or control groups by cluster sampling therefore each cluster may not have the same number of participants. In addition, the sample size was small, selected from a limited region of the area, which is a limitation of the study. Moreover, limitation was that 2MST was utilized in this study because a long walkway was not available in all the participants' home and community setting therefore 6-minute walk test that regularly used in other studies could not be applied in the present study. Future research should explore the effect of individualized home-based progressive exercise programs on the quality of life, maximum oxygen consumption and long-term follow-up after training in the elderly. Application of such prescription in less active elderly or frail elderly may expand the preventive exercise efficacy.

Implication

The 2MST could be utilized to evaluate cardiopulmonary endurance in the elderly similarly to 6MWT. The individualized home-based progressive exercise program used in the present study is safe and easy to perform. In addition, a suitable progressive exercise prescription for community-dwelling elderly was recommended to evaluate their individualized physical fitness levels before application of an exercise program.

Continuous follow-up such as telephone call used in this study will help to achieve adherence.

Conclusions

This study established the physical fitness levels for elderly in community-dwelling in Ongkarak, Thailand (age 60-69). The physical fitness levels differentiated male from female. The physical fitness levels score may be helpful for the age-assessment of fitness performance and the design of individualized progressive exercise programs that promote functional ability in older adults, in particular for those who achieved lower than average.

Our results showed that individualized home-based progressive exercise training for 4-8 weeks improved physical fitness including the arm curl test, chair stand test, 2-minute step in place test, and chair sit and reach test in community-dwelling older adults. However, this program did not improve the back scratch test.

We found that individualized home-based progressive exercise training for 4-8 weeks improved physical fitness, including the arm curl test, chair stand test, 2-minute step in place test, and chair sit and reach test, but not the back scratch test, in community-dwelling older adults. Accordingly, our progressive training program, which was based on individual's baseline physical fitness, effectively improved strength, cardiopulmonary endurance, balance, and lower body flexibility in community-dwelling elderly in only 4 weeks.

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