# A Twelve Week Home Exercise Program to Improve the Physical Fitness in the Elderly

Sakara Tunsophon*, Wanwisa Deenin and Benjarat Janson

Human Nutrition and Exercise Physiology Unit, Department of Physiology, Faculty of Medical Science, Naresuan University, Phitsanulok, 65000, Thailand

* Corresponding author. E-mail address: sakarat@nu.ac.th

Received: 24 July 2018; Accepted: 8 August 2018

**Abstract**

An aging population is an increasing world phenomenon that will continue to affect Thailand, and the whole world. One of the factors for achieving a healthy body is to maintain regular physical activity. Normally, aging results experience a significant decline in physical fitness. Exercise will help to improve physical fitness, which is associated with the ability to perform daily tasks. However, suitable exercise regimes for the elderly are still a challenge. Therefore, the aim of this study was to evaluate the outcome of an easy-to-follow home exercise program for 12 weeks. The quasi experiment research design was used for this study. Thirty two healthy elderly were recruited through convenient sampling and their physical fitness assessed before the program started. They were given an exercise plan to follow at home, and were examined after 6 and 12 weeks. All exercises were selected for safety, ease of performance, and without the use of equipment, to improve all aspects of their physical fitness. The groups were asked to perform these exercises regularly -standing on one leg, wall press ups, hamstring stretches, heel and toe raises, calf stretches, and step forward, for the allotted time 5 times a week, for 12 weeks. Comparison of the baseline and post exercise intervention measurements, demonstrated a significant improvement in agility, coordination, grip strength and balance ($P<0.01$) but not in leg strength and flexibility. In conclusion, a 12 week home exercise training program is beneficial to improve the important variables of physical fitness in elderly people. An exercise frequency of five times per week is recommended in order to maintain a healthy physical function in the elderly.

**Keywords:** home exercise program, physical fitness, elderly

## Introduction

The average human lifespan is increasing throughout the world. An aging population is a world problem, and is related to economics, social and public health challenges. Like many other countries, the numbers of old people aged 60 and over have risen rapidly and Thailand is now an aging society (Christensen, Doblhammer, Rau, & Vaupel, 2009; Sasat & Bowers, 2013). Aging is associated with the physiological and biological changes in many systems with a decline in body structure, functions, and muscle mass, including, strength, speed, flexibility, agility and balance (Reuter, 2012). Some studies reported that those who are less active, and have sedentary lifestyles, have a tendency to a greater risk of chronic diseases, such as obesity, diabetes mellitus, cardiovascular, neurodegenerative and musculoskeletal diseases (Seeman, Merkin, Crimmins, & Karlamangla, 2010). It has also been reported that the elderly who have poorer health tend to have a relatively lower physical fitness level (Brach, Simonsick, Kritchevsky, Yaffe, & Newman, 2004). The term exercise is defined in Caspersen, Powell, and Christenson (1985) as a subset of physical activity that is planned, structured, repetitive and has a final achievement for the improvement and the maintenance of physical fitness. They also stated that physical fitness is attributed to either function- or skill, which can be measured with specific tests. In

this study, we focused on function related physical fitness that is directly associated with the ability of a person to do daily activities.

Health is a key concern and challenge for aging society. Physical fitness has been reported to relate to the quality of life in aging people (Chang et al., 2001). Therefore, the improvement of physical fitness can assist the elderly to do their daily activities and help them to live well. There have been a great number of reports concerning the beneficial effect of exercise to improve physical and mental functioning. In addition, some chronic diseases can be delayed by regular physical activity and exercise (Seeman et al., 2010). Healthy aging is an achievable mind-set goal for the government strategy in order to promote a good health toward the late stage of life. Exercise has been reported for the association of good health and is always a strategy for health promotion. The study of 12 weeks of water aerobics twice a week demonstrated benefits in body strength, body composition, and the blood pressure of adults and older adults (Pereira-Neiva, Brandao-Fail, Izquierdo, Marques, & Marinho, 2018). The study of the effect of exercise frequency on functional fitness was conducted using older women as subjects. It reported that an exercise frequency of at least three times a week, 45-60 minutes for 12 weeks significantly improved functional fitness including balance, coordination and muscle endurance (Nakamura, Tanaka, Yabushita, Sakai, & Shigematsu, 2007). On the other hand, the study over three months where subjects stopped exercising. They showed a decline in dynamic balance and also in their quality of life (Esain, Gil, Bidaurrazaga-Letona, & Rodriguez-Larrad, 2018). They suggested that a specifically designed exercise program should be prescribed for an elderly in order to prevent a decline in their physical functioning. The study of Ramalho et al. (2018) found that 6 months of community-based exercise intervention can be used by exercise professionals in prescribing community exercise programs, as well as by health professionals in promoting active aging. However, another group of researchers found that 12 weeks of Tai Chi Chuan exercise has no significant effect on balance and functional fitness parameters in older Japanese adults (Takeshima et al., 2017, p. 32). The controversial beneficial result of exercise and improvement of physical fitness in terms of exercise duration, intensity and protocol has been still unclear.

Therefore, the objective of this study was to evaluate the effectiveness of an easy-to-follow home exercise regime for 12 weeks to improve physical fitness in elderly. The outcome of this study would provide beneficial knowledge to promote health and disease prevention in aging society.

## Methods and Materials

### Participants

All protocols were approved by the Human Ethic Committee Institutional Review Board at the Naresuan University, Phitsanulok, Thailand (Project number 327/58). Prior to participating in this study, all participants signed a written informed consent form in accordance with the ethical principles of the Declaration of Helsinki. The thirty two healthy male and female participants living in the surrounding community near the campus were recruited through convenient sampling. The study included participants who were aged 60 years and older, and able to follow the instructions for testing and training. Participants who had a history of musculoskeletal problems, neurological or cardiovascular diseases or other disorders that limited their exercise ability were excluded from the study.

**Study design**

This is a quasi-experimental pre-test/post-test study without a control group that includes data from 32 healthy aging individuals conducted in surrounding community near Naresuan University. The objective of this study was to evaluate the effectiveness of home exercise program for 12 weeks to improve physical fitness in elderly. All participants participated in the study were regularly performed exercise as instructed, their physical fitness were evaluated before and after the exercise training program.

**Methods**

Physical fitness assessment: The physical fitness assessment in this study comprised of six selected tests that represent the muscular strength, agility, coordination, balance and flexibility as shown in Figure 1A-Figure 1F. The testing items were selected according to Chang et al. (2001), and by considering their safety and simplicity.

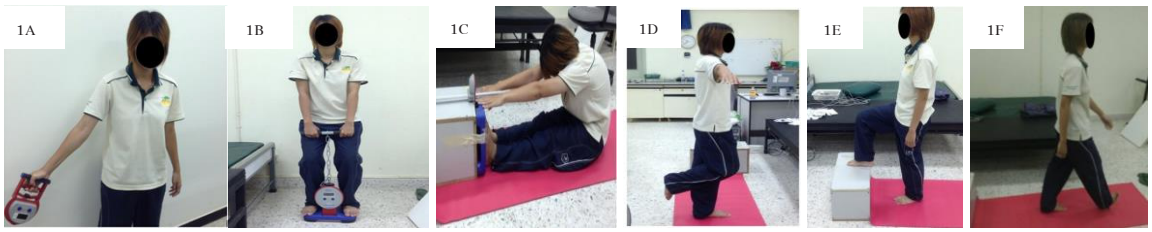


**Figure 1** Physical fitness testing position A) hand grip strength B) leg dynamometer test C) sit and reach test D) one leg standing time E) stepping rate F) walking speed

The six selected physical fitness test items were explained as follows:

1A) Hand grip strength was measured using a hand dynamometer (T.K.K.5101 Grip D, Takei, Japan). The subject held the dynamometer in the right or left hand with their elbow by their side and flexed to right angles, and a neutral wrist position. The subject was asked to grab with the maximal force for three times with 30 s resting within each trial. The strength was recorded in kilograms.

1B) Leg-back dynamometer test or isometric leg-back test using a leg-back dynamometer (T.K.K.5102 Back D, Takei, Japan). The subject stood upright on the dynamometer base with feet approximately 20 cm apart. Both hands held the centre of the bar and the chain was adjusted for the knees to slightly bend. The head and back of the subject were held upright. With this starting position, the subject was then instructed to pull the chain against the weight steadily with maximal force while keeping arms, legs and back straight. Three repetitions were performed with a 30 s rest between each trial. The strength was recorded in kilograms.

1C) Sit and reach test: The subject was asked to sit in a sit and reach box without bending the knees and then tried to stretch forward as much as possible. The longest extension was recorded in centimetres.

1D) Standing on one leg at a time: The subject stood on one leg while the other leg was off the floor. The subject maintained the position as long as possible, until the subject lost balance let one foot drop on the floor. The standing time was recorded in seconds. While doing this test, the trained researcher stood right behind the subject for safety purposes.

1E) Stepping rate: The subject stepped on and off a 30 cm (12 inch) step 24 times per minute for 1 minute. An electronic metronome set at 96 beats per minute and the rate was recorded in times/minute.

1F) Walking speed: The subject was instructed to walk as fast as possible from one side to another side, approximately 10 meters. The researcher recorded the walking time in seconds.

Home exercise program: The home exercise program was based on Chang et al. (2001). The following six positions were introduced to the participants. The exercise positions were shown in Figure 2A-Figure 2F. They had to do these exercise 5 times a week for 12 weeks. After the 6$^{th}$ and 12$^{th}$ week of exercise program, physical fitness were evaluated and compared to the value prior to the starting of the home program. The research assistant demonstrated all exercise positions and all participants were fully instructed to assure that they understood what they have to do.


**Figure 2** Home exercise position A) standing on one leg B) wall press C) hamstring stretches D) heel and toe raises E) calf stretches F) step forward

The six home exercise positions were explained as follows:

2A) standing on one leg: The subject was asked to stand on one preferred leg while another leg was off the floor for 20 s, with a 10 s rest then switched to another leg for 20 s (1 set). The subject was asked to do 10 sets of the exercise in order to improve balance.

2B) Wall press: The subject was asked to stand face a wall with a farther than arm's length, then lean the body forward to the wall while the palms are placed against the wall, hold this position for 10 s (1 set), then repeat 10 sets a day. This position was intended to strengthen arm, shoulder and chest muscles.

2C) Hamstring stretches: The subject was asked to sit and try to stretch forward as much as possible until the finger tips touch the toes without bending the knees, hold this position for 10 s (1 set). Rest and then repeat the hamstring stretch for 10 sets in order to improve flexibility.

2D) Heel and toe raises: Hold on to a chair for safety. Lift the toes off the floor while keeping the heels on the floor and keep the knees straight. Hold for the count of 5-10 (1 set). Rest and repeat the heel and toe raises for a set of 10 in order to improve balance.

2E) Calf stretches: Stand about 2-3 feet away from the wall, with hands placed against the wall. Place one leg behind another leg then bending the front leg while keeping the back leg straight. Lean against the wall and press the back heel on the ground, hold for 10 s then switch to another leg (1 set). Rest and repeat the calf stretch for 10 sets in order to increase flexibility.

2F) Step forward: The subject was instructed to stand on one leg and to slowly step forward from the starting position then hold in this position for 10 s and repeat the same thing with another leg. Step forward to another side (1 set). Repeat the step forward for 10 sets in order to increase agility and coordination.

### Statistical analysis

The results are presented as the mean ± SEM. The statistical analyses were performed using IBM SPSS version 23. Group difference was assessed by a one-way analysis of variance (ANOVA), followed by Tukey's test for multiple comparisons. A $p$-value < 0.05 was considered statistically significant.

### Results

All demographic characteristics are given in table 1. In this study, the thirty two participants were participated with 9 male and 23 female. The average age of participants was 66.38±5.13, with the average BMI of 23.63±3.38. Blood pressure was measured twice and calculated for the average, before the beginning of the physical fitness test. The average participants' blood pressure were 135±5/79±4 mmHg which is considered normal according to the guidelines in the treatment of hypertension from the Thai Hypertension Society (2015).

**Table 1** The demographic characteristics of the participants (n = 32)

| Variables | Mean |
|---|---|
| Gender | Female (23) |
| | Male (9) |
| Age (yr) | 66.38±5.13 |
| Weight (kg) | 59.63±1.76 |
| Height (cm) | 159.09±2.33 |
| BMI | 23.63±3.38 |
| SBP (mmHg) | 135±5 |
| DBP (mmHg) | 79±4 |
| Monthly income (THB) | 984.38±210.80 |

### Effect of home exercise on physical fitness assessment

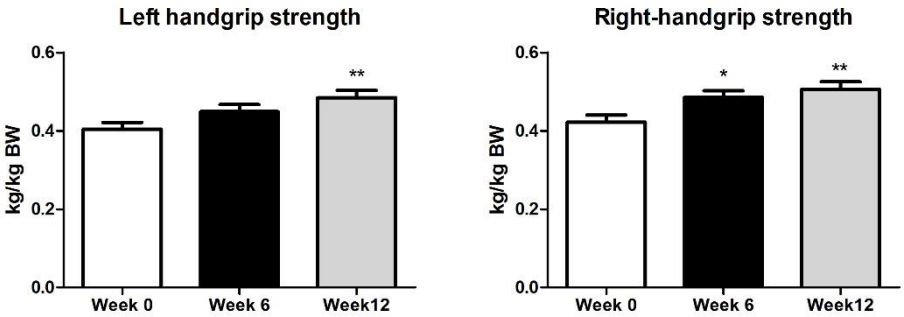


**Figure 3** Effect of the 12th week of exercise on left and right handgrip strength test. Data are expressed as mean+SEM. *,** indicates the statistically significant difference at $P$<0.05 and $P$<0.01, respectively when compared with week 0

The assessment of handgrip strength test by using handheld dynamometer demonstrated the increase in strength in both left and right hands after exercise for 12 weeks when compared with before exercising at week 0 ($P$<0.01) (Figure 3). However, the significant difference in week 6 was shown in only the right hand when compare to week 0 ($P$<0.05). The result might be from the difference between the dominant hands that is

always used. The grip strength test is considered as a useful tool to predict the health outcome, including mortality and disability (Bohannon, 2008). It is indicated from our result that all participants have a good prediction of health.

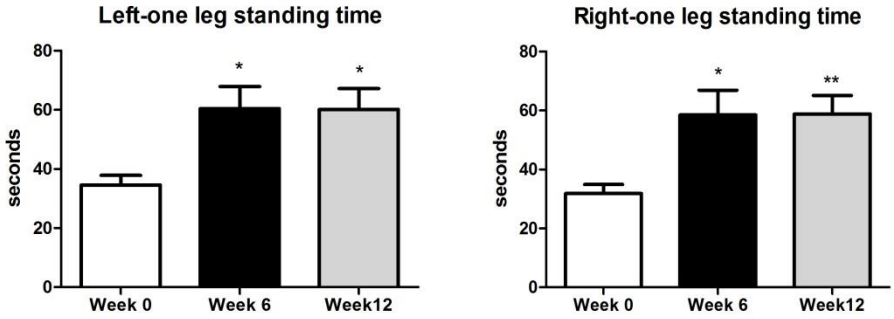


**Figure 4** Effect of the 12th week of exercise on left and right one leg standing test. Data are expressed as mean+SEM. *,** indicates the statistically significant difference at $P<0.05$ and $P<0.01$, respectively when compared with week 0

The result from Figure 4 showed that after exercising for 6 weeks, the measurement time of one leg standing test significantly increased in both legs ($P<0.05$). The similar results were also observed in the 12th week of exercise. The one leg standing test is an assessment for balance, therefore, it means that these parameters improved after regular exercise for a short period of time over 6 weeks.

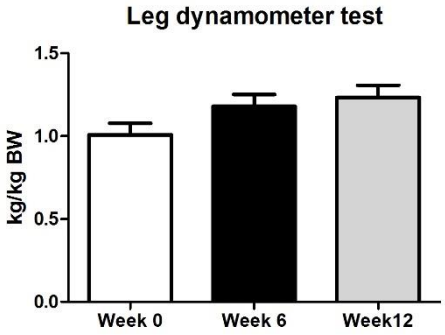


**Figure 5** Effect of the 12th week of exercise on leg dynamometer test. Data are expressed as mean+SEM.

The leg dynamometer test is a test to determine leg muscle strength. The leg dynamometer result is shown in Figure 5. The result showed no significant difference in leg dynamometer test after exercising for the 6th and 12th weeks. It can conclude from the result that the home exercise program had a limited effect on the strength of the leg muscles. The tendency to increase albeit slowly was noted.

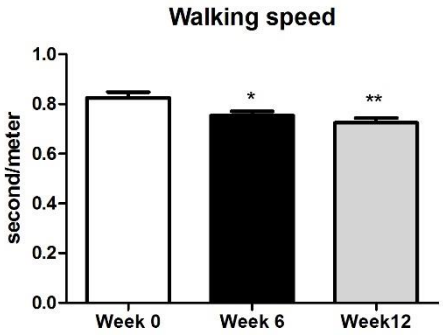


**Figure 6** Effect of the 12th week of exercise on the walking speed test. Data are expressed as mean+SEM. *,** indicates the statistically significant difference at $P<0.05$ and $P<0.01$, respectively when compared with week 0

The walking speed assessment test is for the evaluation of agility and coordination. The results showed that the home exercise program over 12 weeks significantly improved the walking speed in the elderly ($P<0.01$). By reducing the time of walking at the certain distance, it can be implied that the seniors have more ability to move quickly and easily (Figure 6).

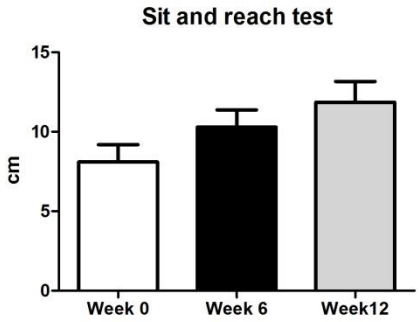


**Figure 7** Effect of the 12th week of exercise on sit and reach test. Data are expressed as mean+SEM.

The result from Figure 7 demonstrated that the flexibility evaluated by using the sit and reach test shows a tendency to improve, however, no significant difference after exercise for 6 and 12 weeks was observed. It can be interpreted that the exercise position of the present study cannot help to increase the flexibility of the related muscles surrounding the trunk, abdomen and legs.

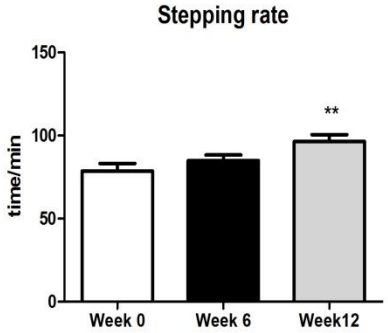


**Figure 8** Effect of the 12th week of exercise on the stepping test. Data are expressed as mean+SEM. ** indicates the statistically significant difference at $P<0.01$, when compared with week 0

The 12th week of home exercise program can significantly increase the numbers of step to the stepping box at $P<0.01$, however this test did not change in week 6 when compared to week 0 (Figure 8). The one minute stepping test is the modified method from the three minutes stepping test, in order to be more practical in aging participants. It can be concluded, from our result, that the home exercise program can improve the agility and balance of the elderly participants.

## Discussion

Numerous studies indicate the strong association of aging and the impairment of physical fitness such as muscle strength, endurance, speed, flexibility and balance (Milanovic et al., 2013). The low level of physical fitness in aging has a strong correlation with several age-related diseases, increased risk of morbidity and mortality (Ashe, Miller, Eng, & Noreau, 2009). Several studies over the past decades have shown that exercise can help improve these functions as well as the well-being in older adults physically and mentally (McAuley & Rudolph, 1995; Chang et al., 2001; Neid & Flanklin, 2002). The benefit of exercise and physical activity has an important role for health promotion in elderly people (Chodzko-Zajko et al., 2009, p.1511). It is important for the elderly to exercise regularly to maintain their ability of physical fitness to perform normal functions and reduce the risk of illness or injury.

Our present study was to evaluate the effectiveness of before and after home exercise regimens on the physical fitness in elderly participants. From this present study, all exercise positions which consisted of one leg standing (balance), heel and toe raises (balance), step forward (agility and coordination), hamstring stretches (flexibility), calf stretches (flexibility and leg muscle strength) and wall press up (arm, shoulder and back muscle strength) were performed 5 days a week for 12 weeks. Besides habit and attitude, cognitive decline, discomfort and fear of injury are one of the most common barriers for exercising in older adults (Schutzer & Graves, 2004). Hence, all home based exercise positions were chosen in this study based on its safety, effectiveness and acceptable in older people.

The main finding of this study demonstrated that the 12 week intervention showed the greatest improvement in agility, balance, coordination and hand muscle strength which were determined by using one leg standing, stepping rate, walking speed and handgrip tests, respectively. Our results are in accordance with the previous studies, demonstrating that older women who participate in an exercise program at least three times a week for 12 weeks gain greater functional fitness benefits than those who exercise less frequently (Nakamura et al., 2007). Our results were in part similar to the results from the study of Gomez-Cabello, Gonzalez-Aguero, Ara, Casajus, and Vicente-Rodriguez (2013). They studied an 11 week exercise program using whole body vibration to improve physical fitness, including agility, speed, balance and strength in both elderly men and women. Okubo et al found that the walking and balance training program was able to be the efficiency to improve balance in older adults. It is according of our program training that all elderly participants performed a step forward, heel and toe raises and one leg standing for improve the balance and coordination (Okubo et al., 2016, p.118). In addition, these results are accordance with the report from Binder et al. (2002), which reported that the exercise program of physical therapy of older adults for 12 weeks can improve the stretching, flexibility, balance and coordination (Binder et al., 2002, p.1921). Similarly, we report the ability of the short term intervention and its effectiveness for improvement of elderly fitness.

However, the exercise training that we used show no significant changes in flexibility and leg muscle strength through the entire intervention. A study by Yamamoto, Hotta, Ota, Mori, and Matsunaga (2016), found that the elderly who exercise regularly had a greater exercise capacity that improved physical fitness in term of strength of the muscles and movement. This study found that the home exercise program can increase forearm muscles, but not leg muscle strength. Studies investigating the muscle strength and power improvements induced by strength training in elderly have shown that moderate and high intensities ranging from 6 to 24 weeks can enhance muscle strength (Cadore, Pinto, Bottaro, & Izquierdo, 2014). It apparently showed that in our study, there was not sufficient exercise position to improve leg strength. Based on the research of Romeu and colleagues, they studied an aerobic exercise for 9 months and the result showed that resistance exercise can significantly increase the ability of balance and flexibility (Mendes, Sousa, Themudo-Barata, & Reis, 2016). In our study, we found a tendency to increase flexibility after exercise intervention, however no significant change was observed in a 12 week period of intervention. Although flexibility might decline with age, older adults are recommended to maintain or improve it through stretching and joint mobility exercises. Hamstring stretches has been used in our study, but one position might not be enough to improve flexibility. Dissimilar findings may be from the difference method of exercise, intensity and duration that differ between our intervention and other studies.

Nonetheless, our home-based exercise program could significantly improve important physical functions, including balance, agility, coordination and also grip strength. Balance is a key component in many activities of daily living such as standing or walking. The ability to control balance declines with age as a result of disintegration in physiological systems such as nervous, vestibular, visual and musculoskeletal systems (Dunsky, Zeev, & Netz, 2017). An impairment of balance in aging people is caused a risk for falling which is considered as a harmful situation in older adults. It is not only the decreased ability to control balance, but also the decreased agility regarded as a falling factor in aging (Miyamoto et al., 2008). Agility training regimen which comprised of an integrative neuromuscular training strategy in our study might serve as a promising and efficient strategy for fall prevention programs in the elderly. A devastating decline in motor coordination results observed in aging, leads to a problem in walking, and motor functions. Recent studies have reported that strength and coordination training for 6 weeks can improve the postural tremor and some motor deficits in older adults (Keogh, Morrison, & Barrett, 2010). Weak grip strength is linked to sarcopenia and frailty and is associated with subsequent disability and mortality (Dodd et al., 2016). The similar findings from Ling et al. (2010) suggest a greater association between handgrip strength and rate of mortality with increasing age, even the underlying mechanism is still unclear. It is interesting that our exercise regimens can increase the grip strength in the elderly which can imply good health in our participants.

It is noteworthy to demonstrate that our home exercise programs in this present study certainly improve important functional fitness practiced. The enhancement of physical fitness could improve an older individual's ability to perform daily activity in consequence to an increased quality of life as suggested by other (Esain et al., 2018). The remarkable findings would be used as one of the home strategies for health intervention to promote healthy aging in term of physical well-being in the elderly.

## Conclusion and Suggestions

The main finding is that an easy-to-follow home exercise training program in this present study can result in the great improvement of some important physical fitness components, including agility, coordination, balance and grip strength. Flexibility is also important in elderly, therefore the next regimen needs to be addressed on this particular parameter. Overall, the outcome of this study would provide beneficial scientific knowledge of practical and simple guidelines to promote healthy aging in the present population aging. However, further study is needed and should be conducted in a larger sample size in order to assure its positive effects on physical fitness in elderly adults.

## Acknowledgments

The authors would like to thank all volunteers participated in this work and also the well-trained research assistants who helped to collect the data. This work was supported by the National Research Council of Thailand to ST (grant number R2560B138). We are grateful for Mr. Kevin Roebl from the division of internal affairs and language development (DIALD), Naresuan University for his assistance in English expression in this work.

## References

Ashe, M. C., Miller, W. C., Eng, J. J., & Noreau, L. (2009). Older adults, chronic disease and leisure-time physical activity. *Gerontology*, *55*(1), 64-72. http://doi.org/10.1159/000141518

Binder, E. F., Schechtman, K. B., Ehsani, A. A., Steger-May, K., Brown, M., Sinacore, D. R., . . . Holloszy, J. O. (2002). Effects of exercise training on frailty in community-dwelling older adults: results of a randomized, controlled trial. *Journal of the American Geriatrics Society, 50*(12), 1921-1928.

Bohannon, R. W. (2008). Hand-grip dynamometry predicts future outcomes in aging adults. *Journal of Geriatric Physical Therapy, 31*(1), 3-10.

Brach, J. S., Simonsick, E. M., Kritchevsky, S., Yaffe, K., & Newman, A. B. (2004). The association between physical function and lifestyle activity and exercise in the health, aging and body composition study. *Journal of the American Geriatrics Society*, 52(4), 502-509. doi: 10.1111/j.1532-5415.2004.52154.x

Cadore, E. L., Pinto, R. S., Bottaro, M., & Izquierdo, M. (2014). Strength and endurance training prescription in healthy and frail elderly. *Aging and Disease*, *5*(3), 183-195. http://doi.org/10.14336/AD.2014.0500183

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126-131.

Chang, M., Kim, H., Shigematsu, R., Nho, H., Nishijima, T., & Tanaka, K. (2001). Functional fitness may be related to life satisfaction in older Japanese adults. *International Journal of Aging and Human Development, 53*(1), 35-49.

Chodzko-Zajko, W. J., Proctor, D. N., Fiatarone Singh, M. A., Minson, C. T., Nigg, C. R., Salem, G. J., & Skinner, J. S. (2009). American college of sports medicine position stand. exercise and physical activity for older adults. *Medicine and Science in Sports and Exercise*, *41*( 7) , 1510- 1530. doi: 10.1249/MSS.0b013e3181a0c95c

Christensen, K., Doblhammer, G., Rau, R., & Vaupel, J. W. (2009). Ageing populations: the challenges ahead. *Lancet*, *374*(9696), 1196-1208. http://doi.org/10.1016/S0140-6736(09)61460-4

Dunsky, A., Zeev, A., & Netz, Y. (2017). Balance performance is task specific in older adults. *BioMed Research International*, *2017*, 6987017. http://doi.org/10.1155/2017/6987017

Dodds, R. M., Syddall, H. E., Cooper, R., Kuh, D., Cooper, C., & Sayer, A. A. (2016). Global variation in grip strength: a systematic review and meta-analysis of normative data. *Age and Ageing*, *45*(2), 209-216. http://doi.org/10.1093/ageing/afv192

Esain, I., Gil, S. M., Bidaurrazaga-Letona, I., & Rodriguez-Larrad, A. (2018). Effects of 3 months of detraining on functional fitness and quality of life in older adults who regularly exercise. *Aging clinical and experimental research.* doi: 10.1007/s40520-018-0990-1

Gomez-Cabello, A., Gonzalez-Aguero, A., Ara, I., Casajus, J. A., & Vicente-Rodriguez, G. (2013). Effects of a short-term whole body vibration intervention on physical fitness in elderly people. *Maturitas*, *74*(3), 276-278. doi: 10.1016/j.maturitas.2012.12.008

Keogh, J. W., Morrison, S., & Barrett, R. (2010). Strength and coordination training are both effective in reducing the postural tremor amplitude of older adults. *Journal of aging and physical activity*, *18*(1), 43-60.

Ling, C. H. Y., Taekema, D., de Craen, A. J. M., Gussekloo, J., Westendorp, R. G. J., & Maier, A. B. (2010). Handgrip strength and mortality in the oldest old population: the Leiden 85-plus study. *Canadian Medical Association Journal*, *182*(5), 429-435. http://doi.org/10.1503/cmaj.091278

Mendes, R., Sousa, N., Themudo-Barata, J., & Reis, V. (2016). Impact of a community-based exercise programme on physical fitness in middle-aged and older patients with type 2 diabetes. *Gaceta Sanitaria*, *30*(3), 215-220. doi: 10.1016/j.gaceta.2016.01.007

Milanovic, Z., Pantelic, S., Trajkovic, N., Sporis, G., Kostic, R., & James, N. (2013). Age-related decrease in physical activity and functional fitness among elderly men and women. *Clinical Interventions in Aging*, *8*, 549-556. http://doi.org/10.2147/CIA.S44112

Miyamoto, K., Takebayashi, H., Takimoto, K., Miyamoto, S., Morioka, S., & Yagi, F. (2008). A new simple performance test focused on agility in elderly people: The Ten Step Test. *Gerontology*, *54*(6), 365-372. doi: 10.1159/000146787

Nakamura, Y., Tanaka, K., Yabushita, N., Sakai, T., & Shigematsu R. (2007). Effects of exercise frequency on functional fitness in older adult women. *Archives of Gerontology and Geriatrics*, *44*(2), 163-173.

Nied, R. J., & Franklin, B. (2002). Promoting and prescribing exercise for the elderly. *American Family Physician*, *65*(3),419-426.

Okubo, Y., Osuka, Y., Jung, S., Rafael, F., Tsujimoto, T., Aiba, T., . . . Tanaka, K. (2016). Walking can be more effective than balance training in fall prevention among community-dwelling older adults. *Geriatrics and Gerontology International*, *16*(1), 118-125. doi: 10.1111/ggi.12444

Pereira-Neiva, H., Brandao-Fail, L., Izquierdo, M., Marques, M. C., & Marinho, D. A. (2018). The effect of 12 weeks of water-aerobics on health status and physical fitness: An ecological approach. *PLoS ONE*, *13*(5), e0198319. http://doi.org/10.1371/journal.pone.0198319

Ramalho, F., Santos-Rocha, R., Branco, M., Moniz-Pereira, V., André, H.-I., Veloso, A. P., & Carnide, F. (2018). Effect of 6-month community-based exercise interventions on gait and functional fitness of an older population: a quasi-experimental study. *Clinical Interventions in Aging*, *13*, 595-606. http://doi.org/10.2147/CIA.S157224

Reuter, I. (2012). Aging, physical activity, and disease prevention 2012. *Journal of Aging Research*, *2012*, 373294. http://doi.org/10.1155/2012/373294

Sasat, S., Bowers, B. J. (2013). Spotlight Thailand, *The Gerontologist*, *53*(5), 711-717. https://doi.org/10.1093/geront/gnt038

Schutzer, K. A., & Graves, B. S. (2004). Barriers and motivations to exercise in older adults. *Preventive Medicine*, *39*(5), 1056-1061. doi: http://dx.doi.org/10.1016/j.ypmed.2004.04.003

Seeman, T. E., Merkin, S. S., Crimmins, E. M., & Karlamangla, A. S. (2010). Disability trends among older Americans: National Health and Nutrition Examination Surveys, 1988-1994 and 1999-2004. *American Journal of Public Health*, *100*(1), 100-107. http://doi.org/10.2105/AJPH.2008.157388

Takeshima, N., Islam, M. M., Kato, Y., Koizumi, D., Narita, M., Kitabayashi, Y., ... Rogers, M. E. (2017). Effects of 12 weeks of Tai Chi Chuan training on balance and functional fitness in older Japanese adults. *Sports*, *5*(2), 32. http://doi.org/10.3390/sports5020032

Yamamoto, S., Hotta, K., Ota, E., Mori, R., & Matsunaga, A. (2016). Effects of resistance training on muscle strength, exercise capacity, and mobility in middle-aged and elderly patients with coronary artery disease: A meta-analysis. *Journal of Cardiology*, *68*(2), 125-134. doi: 10.1016/j.jjcc.2015.09.005