Master's Thesis of Science

The Effects of a 12-week Ballet Fitness Program on Fall-Related Fitness Factors in Middle-Aged and Elderly Women

12주간 발레피트니스 프로그램이 중년 및 노인 여성의 낙상 관련 체력 요인에 미치는 영향

August 2019

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Submitting a master's thesis of Public Administration

August 2019

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Abstract

Objective: The primary objective of this study is to develop an effective ballet fitness program for positive effects on fall-related fitness factors in middle-aged and elderly women.

Methods: Women ages 50~79 were recruited from a volunteer center in Seoul, South Korea. The subjects recruited were divided into a control group in which the subjects did no exercise for 12 weeks and an exercise group in which subjects participated in a 12-week ballet fitness program. The ballet fitness program included basic ballet and mat Pilates movements and was designed to improve fall-related fitness factors in the participants. The ballet fitness class was held twice a week with 60 minutes of moderate-level exercise for each class. Anthropometric and physical fitness measurements were performed before and after the 12-week program for both groups at the volunteer center. Fall-related psychological measurement surveys were also performed before and after the intervention.

Results: The subjects who participated in the 12-week ballet fitness program showed significant improvements in several fall-related fitness variables including flexibility and lumbar strength (flexibility: p=0.003; lumbar strength: p=0.045). They also showed statistically significant improvements in psychological variables related to falls (FES-I: p=0.012, K-SAFE: p=0.032). However, there were no significant improvements in BMI (p=0.182), gait speed (p=0.157), core strength (p=0.407) or static balance (p=0.113) in comparison to the control group.

Conclusion: A 12-week ballet fitness program is an effective and safe exercise program for middle-aged women in order to help prevent falls in the middle and later stages of life.

Keywords: Ballet, Ballet Fitness, Ballet Pilates, Middle-Aged Women, Fall Prevention

Table of Contents

List of Tables and Figures

List of Figures

List of Tables

I. Introduction

1.1 Significance of the Study

Falls and injuries related to falls are common in elderly populations. The frequency and risk of fall-related injuries increase with age and close to 10% of all falls result in major injuries (Tinnetti, 1998). Several major risk factors for falls include records of previous falls, impairments in strength, balance and gait, as well as visual and hearing impairment. Elderly women in Korea are a population group with a high risk of injury due to falls. Falls are one of the most common medical issues regarding Korean elders (Kim et al, 2017). As South Korea has the fastest aging population among developed countries, it is important to assess fall risks and elaborate on fall prevention interventions (Kim et al, 2017).

There are many articles of research that have been done on fall prevention of the South Korean elderly population (Kim et al, 2017; Choi, 2009). Based on the results of these studies, it is clear to see that there has been an increase in research regarding fall prevention of elderly people. However, the prevalence of falls in middle-age people is often overlooked (Peeters, 2018). There are hardly any studies on fall prevention in this age group. While middle-

aged adults have a lower rate of fall prevalence than that of older adults, recent findings show that fall prevalence in middle-aged people is not low (Peeters, 2018).

Women in their post-menopause stage are known as a population group that has a high risk of injury due to falls (Schoenaker, 2014). This age group includes middle-aged and elderly women. Therefore, more research on fall-risk factors in middle-aged and elderly women could be the key to effective interventions targeted towards fall prevention in this age group that potentially contain benefits that could be sustained into older age.

There are many previous studies that have been performed on exercise interventions on fall prevention in elderly women. Exercise has been shown to be an effective intervention program for improving bone and muscle strength, balance and muscle mass (U.S Department of Health and Human Services, 2004). This means that fitness factors related to falls have shown significant improvements which could decrease the risk of falling. The types of exercise in these interventions include multiple forms of physical activity such as tai chi, yoga, and resistance exercise.

Several studies have also been done on the effects of dance in fall prevention interventions (Merom, 2013; Verghese, 2006). One intervention study stated that dance therapy results in positive functional trends, which

suggested that further studies on dance-based therapy could be helpful to decrease fall risks in the older population (Krampe, 2010). Previous studies have shown that ballet is an effective form of physical activity that can improve fall-related fitness factors in adults older than the age of 60 (Moon, 2013). Ballet includes movements that can improve muscle strength, flexibility and balance (Moon, 2013; Kim, 2000). Ballet is also shown to be more effective in improving those same fitness factors in comparison to other forms of dance (Jung, 2010). In addition, basic ballet movements have been shown to improve the flexibility of the body by moving the muscles that are not used frequently, helping correct body alignment and develop a sense of balance by using fine feet and lower leg movements (Kim, 2011).

It has been shown in previous studies that in order to increase physical stability (required to prevent falls in older adults), trunk stabilization exercise can be beneficial for enhancing balance ability (Hodges, 1997). This is due to the fact that the muscular strength of the trunk is directly related to balance and functional activities (Hodges, 1997). Strengthening of the trunk muscles can help maintain balance against gravity, adjust body posture, and prepare the individual for the movement in daily living activities (Verheyden, 2006). Mat Pilates is an exercise that focuses strengthening the trunk muscles through core exercise (Critchley, 2011). It also includes balance exercises which also help

stabilize the trunk (Smith, 1999).

It has been shown that ballet and mat Pilates have similar principles and movements. Pilates was used by many professional ballerinas and ballerinos to strengthen the hip muscles as well as lower leg muscles (Amorim, 2011). This study also states that professional dancers learned Pilates in order to improve balance as well as improve their ballet performance. One previous study stated that ballet and Pilates should be combined by dance instructors in order to provide a more effective program for dancers (Ahearn, 2011).

Although there are many forms of physical activities that could be used as possible effective fall-prevention interventions, this study investigated the effects of ballet in combination with mat Pilates. Ballet in combination with mat Pilates has many names such as Ballet Pilates, BalleCore and Ballet Fitness (Oh, 2013). This study aimed to see if a Ballet Fitness program (BalletFit) is an effective exercise for improving fall-related fitness factors in middle-aged and elderly women.

1.2 Purpose of the Study

The objective of this research is to observe the effects of a 12-week BalletFit exercise program on fall-related fitness factors in middle-aged and elderly women in Seoul, South Korea.

1.3 Research Hypothesis

A. A 12-week BalletFit exercise program will be effective in improving fall-related fitness factors in middle-aged and elderly women.

B. BalletFit is an exercise beneficial to strengthening muscles in the core as well as the lower leg regions of the body.

C. BalletFit can be used as an exercise to improve balance and flexibility.

D. BalletFit will improve fear of falling in middle-aged and elderly women

1.4 Limitations

The number of subjects in the control group was not large enough equal that of the control group. As well, the average age of the control group was slightly younger than the average age of the exercise group. Therefore, although the control group did not have statistically significant results for any of the measured variables, some of the variables seemed to have increased in the control group.

The center at which this study was performed did not have ballet bars which is one of the most important parts of ballet fitness. There have been

several studies performed on the effects of ballet bar movement on fall prevention and the health benefits of ballet exercise with the barre.

II. Literature Review

2.1 Falls in Middle-Aged Women

A recent cohort study researched the prevalence of falls in adults of the middle-age category (aged 40–64 years) from four different countries (Peeters, 2018). This study studied populations from Ireland, Australia, Great Britain and the Netherlands, stating that fall prevalence in women begins to increase starting from the age of 40. This study found that the prevalence of falls in middle-aged women was about 8.7% in 40-44 year olds and 29.9% in 60-64 year olds. Women also had a higher rate of falls than men (27% and 15.2% respectively) (Peeters, 2018). This study states that the rate of falls is already quite high starting from the age of 50.

Current fall prevention guidelines are targeted towards adults over 65 years of age. However, it has been observed that balance ability as well as many other physical functions decline between the ages of 40 and 60. These risk factors for falls are prevalent after the age of 50, especially in menopausal women. In the Australian Longitudinal Study on Women's Health middle-aged cohort, fall prevalence varied from 21% to 31% for women of the ages 53-58 and 62-67 respectively (Peeters, 2017). Therefore, fall prevalence was notably

higher than the results found in the 2008 U.S. National Health Interview Survey which showed a prevalence of 11.4% in adults between 45-64 years of age (Verma, 2016). It was also a higher percentage than the 2-year prevalence of 21% in adults of the same age group that was published in the Baltimore Longitudinal Study of Aging (Talbot, 2005). These results show consistence evidence that there has been a recent increase the prevalence of falls in middle-aged women.

One possible explanation for fall prevalence increase in middle-aged women may be due to a higher increase in prevalence of fall risk factors. Such risk factors are caused by illnesses such as diabetes, cardiovascular diseases or post-menopause. However, exact key risk factors in middle-aged women have not been identified. Therefore further research is required in order to identify these fall risk factors in women of middle-age. In one recent study, the results showed a marked increase in fall prevalence from 8.7% to 19.1% in Irish women ages 40-45 to women ages 45-50 respectively (Kearney, 2011). This increase seems to occur at the onset of menopause which causes a high risk of injury due to falls in women of this age group (Schoenaker, 2014). Hormonal changes that are related to menopause are the main reasons behind falls in post-menopausal women. Changes in hormones lead to reduction in bone mass and bone density as well as reduce functions such as balance and flexibility.

In the cohort study mentioned above, it stated that fall prevalence was about 21% in women 50-54 years old, 27% in women 55-59 years old and 30% in women 60-64 years old. It is being emphasized that it may more effective to detect and prevent fall risk factors at an earlier stage (Peeters, 2018).

2.2 Falls in Elderly Women

There are many articles of research that have been done on fall prevention of the South Korean elderly population. Based on previously conducted research, it is clear that there are many elders who have reported to be hospitalized due to injuries from falls. One study showed that in a questionnaire-based survey of 2,295 older adults in Korean rural areas, 32% of participants suffered from injuries related to falls within the past 12 months (Lee, 2011). Another study of 351 elders found that 42% of participants reported at least one case of falling within the past year. 38% of these participants required hospitalization or attendance by a physician (Sohng, 2004). Based on the results of these studies, it is clear to see that there has been an increase in research regarding fall prevention of elderly people.

Falls in the elderly population may lead to fractures. About 30% of individuals aged 65 or above fall on average at least once a year (Tinetti, 2003).

Falls are the cause of 90% of hip fractures in older people (Tinetti, 2003). Many articles of previous research have shown the relationships between falls, physical activity and fall-related fitness factors (Sung, 2004; Barr, 2005). Many exercise program targeted for the elderly population and fall prevention have been shown to be effective (Freiberger, 2012; Schoenfelder, 2000). Regular exercise has been shown to prevent falls among the elderly population (Kim, et al. 2017).

2.3 Fall Prevention Guidelines

Based on the Fall Prevention Guidelines for Korean Elders that was published in 2017, there are three steps to following these guidelines (Kim et al., 2017). First, primary care physicians should perform screening for falls to identify elders that require fall prevention interventions. Second, multifactorial fall risk assessments should be done to identify fall risk factors. These multifactorial fall risk assessments include measurements such as fall history, gait & balance, fear of falling, muscle weakness, and visual impairment. Third, assessments should be followed by interventions that target fall risk factors. As intervention programs, this guideline states that regular exercise can prevent falls in Korean elders and that elderly persons at high risk of falling should

undergo balance training, strengthening exercises, aerobic and resistance exercises. The 2017 guidelines for fall prevention in Korean elders shows the same structure to that of the 3 steps to fall prevention created by STEADI, the Stopping Elderly Accidents, Deaths, and Injuries program under the American Center for Disease Control and Prevention. This program also states that fall risk screening, assessment, and intervention is required in order to decrease fall risk in the elderly (Centers for Disease Control and Prevention, 2016).

The 2018 ACSM Exercise Guidelines for the Elderly is as follows (Dalleck, 2018). This standard states that aerobic, resistance, flexibility and neuromotor exercises are beneficial for elders and shows time and intensity recommendations for each type of exercise. It is stated here that a combined exercise plan or program that includes all four components will work most effectively as fall prevention interventions in the elderly.

Although there are many exercise intervention programs that aim at fall prevention, there are not many programs that include all four elements of the ACSM exercise guidelines. A currently trending exercise called Ballet Fitness is a form of exercise that could be used as effective intervention exercise program for fall prevention in elderly women. Ballet Fitness consists of movements and exercises that include all four types of exercise which shows that it may be an exercise program that works effectively in fall prevention in the elderly.

2.4 The History and Definition of Ballet Fitness

Ballet Fitness, otherwise known as BalletFit or Ballet Pilates, is a group-based exercise program combined from classical ballet and mat Pilates (Oh, 2013). BalletFit includes ballet barre work and floor-based exercises and functions to target muscle strength, flexibility and body conditioning. It has recently become a popular exercise, especially among women, due to exercise goals such as body posture and diet. Although this has become a popular form of exercise within the past decade, there are scarcely any studies on the health benefits of Ballet Fitness. One previous study on this exercised showed the effects of Ballet Pilates on lower back pain in young women (Oh, 2013). This research manuscript states that more studies must be done on the effects of Ballet Fitness when performed by different age groups (Oh, 2013).

The history of Ballet Fitness began as ballet and Pilates began to merge into one form of exercise. Pilates was used in the 1900s as an exercise to rehabilitate injured ballerinas (Fitt, Sturman, & McLain-Smith, 1994) and professional dancers as well as to help dancers improve their dancing technique. In 2001, The New York City Ballet Company introduced an exercise program titled “New York City Ballet Workout” through a book and video targeted to non-dancers (Schaefer, 2011). This workout included ballet movements as well

as exercises used by professional dancers. For the next 10 years after this program was released, many exercise programs involving ballet were created with names such as Barre Work, Ballet Stretch, Barre Core and more (Oh, 2013).

For this experiment, Ballet Fitness was defined as a combination of classical ballet that aims for liberal arts, posture, and emotional expression combined with the medical goals of Pilates that aims for rehabilitation, proper body posture and core stability. Although most BalletFit programs include ballet floor work and ballet and Pilates equipment, the BalletFit program in this intervention only included Pilates and ballet movements performed on a yoga mat and ballet floor movements.

2.5 The Principles of Ballet Fitness

The basics of Ballet Fitness consists of 4 main principles. The first principle is breathing. Proper breathing during exercise will allow oxygen to pass through blood veins which will help release tension in the muscles. This will allow the body to strengthen endurance and muscular strength. The breathing technique for Pilates involves breathing in through the nose and closing the diaphragm with upper abdominal strength during inhale and exhaling through the mouth when performing movement. This allows for better

movement and control during exercise (Blount & McKenzie, 2001).

The second principle is pelvis stabilization and movement (Oh, 2013). When standing upright, the pelvis should be in neutral position. Neutral position is when the ASIS (Anterior Superior Iliac Spine) and the Pubic Bone is in line with each other on the Coronal Plane of the body. Ballet Fitness is currently used as an effective method for proper pelvic alignment.

The third principle is spine stabilization and movement (Oh, 2013). The spine is what supports the muscular alignment of our bodies. There is a principle of body alignment associated with posture accuracy in ballet. Pilates also carries out body alignment through neutral posture (the ideal posture of the spine and pelvis) (Hubert & Weber, 2001). BalletFit exercise tries to make sure that our bodies do not lean to one side by holding the spine steady through abdominal muscles. Strengthening the muscles of the core will help straighten the back and make sure that both shoulders are in line with the pelvis.

The fourth principle is scapular stabilization and movement (Oh, 2013). In BalletFit, there are many forms of movement that help strengthen the shoulder blades. Both shoulder blades are pulled downward diagonally in order to properly align the scapula.

There are several studies that state that classical ballet and Pilates use the same body posture principles as well as the same principles of movement (Kim, 2017; Oh, 2013). Therefore, when the basic principles of both are

combined, it is narrowed down to the four principles mentioned above.

In Ballet Fitness, classical ballet and Pilates are merged together to provide a more effective form of movement. It has been shown in previous studies on Pilates and ballet that the basic postures and movements of the ballet could be used as stretching, preparation, and finishing at the beginning and end of Pilates movements. Pilates and ballet have complementary functions and they are thought to be able to increase the scalability and effectiveness of Pilates movements when performed together (Kim, 2017).

Ballet and Pilates have many similarities but they also each have their own benefits that could add to the effectiveness of this exercise. For example, Pilates is more effective when it comes to positioning of the body and muscular strengthening whereas ballet provides aerobic exercise components that are lacking in Pilates (Cohen, 2014). Ballet is a relatively safe form of exercise for elders as there are many senior ballet classes being provided worldwide. Together these two forms of physical activity strengthen each other to form a comprehensive exercise that can be beneficial for preventing falls in middle-aged and elderly women.

2.6 Dance and Fall Prevention

Tai Chi, one of the most effective fall prevention interventions, has been reported to be able to reduce fall rates by 37% (Gillespie, 2012). Tai chi is a combination of physical and cognitive elements that create a synergetic effect. Dance is said to be another form of physical activity that uses a similar approach to Tai Chi. Dance also integrates physical and cognitive elements that target factors related to fall prevalence (Britton, 2017; Merom, 2013). It is a sensorimotor rhythmic activity that uses many simple repetitive movements that help improve strength and balance. Several cross-sectional studies state that dance interventions have been proven effective for fall prevention as older adults who dance have better balance and gait functional abilities than their peers (Verghese, 2006).

Dance has been rising as a favorable potential intervention method for fall prevention especially as it has shown to be more favorable than other exercise programs in dropout rates. One study that compared line dance to Tai Chi in 8 Canadian senior centers showed that the average dropout rate in dance classes (10%) was significantly lower than that of Tai Chi classes (23%) (Gavin, 2003). This 10% rate of drop-outs also showed to be considerably lower than drop-out rates from other programs for elders such as cardio and strength

classes (Merom, 2013). As variety is a characteristic associated with dance, participants find dance to be more exciting and therefore it helps older adults to maintain a higher level of exercise participation.

However, certain types of dance such as social dancing did not seem to prevent falls in older adults (Verghese, 2006). Therefore modified dance programs containing training elements have been suggested as a better intervention program targeted at low and high-fall risk participants. Therefore, the combination of classic ballet and fitness components as in ballet fitness would be a good intervention to study in terms its benefits to reduce fall prevalence.

III. Methods

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3.1 Research Participants

Participant recruitment as well as the exercise intervention took place in a volunteer center in the D region of Seoul, South Korea. The ballet fitness class (5070 Silver Wings Ballet Fitness) was included as a class in the Silver Wings Volunteer Program at the volunteer center. Participant criteria included women between the age of 50~79 with no record of injuries within the past 3 months and those who were able to walk without aid. A total of 36 participants were recruited through advertisement at the volunteer center.

3.2 Exercise Intervention

2 groups: Exercise group, Control group

1. IRB
2. Fall screening (Timed Up and Go test)
3. Anthropometric measurements and Physical Fitness Measurements before exercise
4. Fear of Falling survey before exercise
5. Exercise group participates in BalletFit program for 12-weeks (2 times/week, 60min)
6. Anthropometric measurements, Physical Fitness Measurements after exercise and after-exercise fall screening
7. Fear of Falling survey after exercise

The Borg Rating of Perceived Exertion Scale (Borg, 1980), which is a tool used to measure exercise intensity, was used to determine the intensity of the ballet fitness exercise during the 12-week intervention program. The exercise program was adjusted by receiving feedback from the subjects at the end of each month.

The program was divided into 3 levels. The first level was maintained

during the first 4 weeks of the program at an exertion level of 10 to 12 (between light and relatively light intensity). The second level occurred during weeks 4~8 at an exertion level of 12 to 14 (relatively light to moderately hard intensity). The third level occurred during weeks 8~12 at an exertion level of 14 to 16 (moderately hard to hard intensity). The difference of intensity of these three levels allowed the ballet fitness exercise to increase in difficulty throughout the weeks in order to prevent a plateau effect of the exercise benefits as well as maintain the excitement of the program.

3.3 Ballet Fitness Class Program

The third component of this experimental method is a BalletFit exercise program which is structured based on the 2018 ACSM exercise guidelines for the elderly. A 12-week BalletFit exercise program was constructed at the dance hall located at the volunteer center of the Silver Wings Volunteer Program. The exercise class was held every Tuesday and Wednesday at 10:30am for a length of 60 minutes. The ballet fitness program comprised of flexibility training, balance training, muscle strengthening and aerobic exercises. A yoga mat and was used as exercise equipment to provide a more dynamic and beneficial

exercise program for participants. Due to time constraints, each class began with flexibility training warm up exercises and included balance, muscle strengthening and aerobic exercises.

The following are the ballet fitness movements performed during the exercise program.

1. To improve flexibility, we performed ballet and Pilates stretching with light to moderate strength. Each operation was held for 10 to 30 seconds and repeated 3 to 4 times. Stretching was performed by warm-up for 20 minutes after class start and 5 minutes for cleanup.
2. Muscle Strengthening included moderate strength core exercise and lower body strength exercise. Each operation was repeated 10 to 15 times, 1 to 3 sets.
3. Aerobic exercise consisted of a centered work without a ballet bar and included mid-intensity movements including jumps and turns. Balance training also included a mid-strength center work.

3.4 Measurements

A 1-hour information session with all participants in attendance was held at the volunteer center the week of the physical fitness and anthropometric measurements. This information session included teaching the participants about the principles of ballet fitness, the basic positions of ballet, experimental measurement procedures and the effects of BalletFit on fall prevention. Participants signed up voluntarily for the program after the 1-hour information session.

The next part consisted of a multifactorial fall risk assessment including physical fitness as well as anthropometric measurements. Anthropometric measurements included height (measured by an extensometer), weight, BMI, and skeletal muscle mass (all of which was measured by Inbody 370). The variables that are listed next are known as factors that are related to falls in middle-aged and elderly women. The variables that were measured were BMI, flexibility, static balance, leg strength, core stability and fear of falling.

Experimental measurements were performed before and after the 12-week exercise program was completed. The experimental procedure for this experiment was based on the three steps of the 2017 Korean fall prevention guidelines (Kim et al., 2017). The first step includes fall screening of the

participants. This was done by performing the Timed Up and Go Test to check for balance and mobility through the progress of balance, sit to stand position, and gait speed. The second part consisted of a multifactorial falls evaluation. Multifactorial fall risk assessments can include fall history, gait, balance, muscle strength and mobility tests as well as fear of falling assessments (Kim et al., 2017). The third part consisted of 12-week a fall-prevention BalletFit exercise program.

3.5 Physical Assessments

3.5-1 Timed Up and Go

The Timed Up and Go test is a commonly used test of gait and balance (Kim et al., 2017). A Timed Up and Go test was performed by placing two chairs 3m apart. The participants were asked to start in seated position and walk 3m, turn around, walk back and sit back down in the chair. Two trials were performed and an average of the two trials was measured in seconds.

3.5-2 Leg Strength

Leg Strength was performed by using a lumber extension machine (Apsun Inc., Hamburg, Germany). The measurement of leg strength by knee extension power performed on the extension machine was used in previous studies (Kim, 2011). Subjects were instructed to sit on the chair of the machine with their backs leaning against the back of the chair. The subjects placed their shins against the leg piece (leg resistance bar) and their hands on the handles next to the chair. Subjects were instructed to kick their legs upwards with full strength and hold the position for 3~4 seconds. This procedure was performed twice and the subjects were allowed a 10 second rest period between trials. The average score was recorded as the measurement score.

3.5-3 Flexibility

Flexibility was measured twice by the sit-and-reach test. The sit-and-reach test was performed on a measuring device that consisted of a 30cm ruler attached to a box. The subjects were told to sit on a yoga mat and place their feet flat against the box with their legs fully extended forward. Subjects were asked to slowly reach forward with both hands placed on top of each other (palms faced down). The average score of the two trials was measured in cm.

3.5-4 Core Strength

The core is the base of all appendicular movement as well as the stabilization of the spine, hips, pelvis and lower body (Faries, 2007; Kibler, 2006). The core is necessary for performing daily living activities, enhancing balance and improving posture (Richardson, 1995). Although sit-ups and curl-ups have been used to asses abdominal endurance, there have been many concerns with these methods as they have been linked with increased pressure on lumber discs (Baxter, 2003). This can lead to back pain which could cause an issue when assessing core strength in the elderly. Furthermore, the sit-up and curl-up tests require subjective interpretation of form to ensure validity and reliability of the assessments (Knudson, 1995).

The forearm plank test challenge the core muscles and provides a

proper stimulus of the rectus abdominis and external oblique abdominis (Ekstrom et al., 2007) which are important for prevention of injury (Nadler, 2002). As well, the plank test seems to be an adequate test for abdominal and trunk stabilization while minimizing the risk of lower-back pain and injury (Strand, 2014).

Core Strength was measured by a one-trial timed plank test on a yoga mat. The correct plank position was demonstrated by the researcher before the trial. Subjects were told to place their elbows on the yoga mat and extend both legs behind while balancing their weight on their toes. The plank test was timed in seconds.

3.5-5 Static Balance

A previous study states that the one-leg balance is a significant and easy-to-administer predictor of falls in the elderly (Vellas et al., 1997). The one-leg balance test with both eyes closed was administered in this study (Zou, 2019). Balance was measured by a one-leg balance test performed twice. Participants were asked to lift one leg and place it next to the ankle bone with their arms spread out to the sides. Once the leg was lifted, the participants closed their eyes and were timed in seconds to measure their balance time. The average of the two trials was taken as the timed score.

3.6 Self-Reported Questionnaires

3.6-1 Fall Efficacy Scale International

The Falls Efficacy Scale was developed by Tinetti and colleagues (Tinetti et al., 1990). FES-I was formed as part of the Prevention of Falls Network Europe (ProFaNE) project from 2003~2006 (University of Manchester). The Falls Efficacy Scale International (FES-I) is a test that measures “fear of falling” or concerns that elders may have about falling. The mean score across all questions is taken, with higher scores meaning a lower fear of falling (Lachman et al., 1998).

3.6-2 Korean Survey of Activities and Fear of Falling in the Elderly

Another measure of fear of falling, the Survey of Activities and Fear of Falling in the Elderly (SAFE) is an acceptable measure of psychometric characteristics (Lachman et al., 1998). The SAFE contains daily activities such as taking a shower, using the toilet, cleaning the house, etc. It also includes mobility assessment such as going out when it is slippery, walking outside, using the stairs, etc. Finally, it includes ability to perform social activities such as visiting friends or relatives and going to places with crowds. It asks when one does the activity, how does he or she feel while performing the activity (0 = not at all worried, 1 = a little worried, 2 = somewhat worried, and 3 = very

worried). For this assessment, a higher score indicates a greater level of fear (Lachman et al., 1998).

3.7 Statistical Analysis

Windows SPSS 25.0 was used to perform statistical analysis of the data. Paired t-test was performed in order to examine pre- and post-intervention differences within the control and exercise groups. Independent t-test to examine differences in results between groups and a Two Way ANOVA was performed in order to examine the pre- and post-intervention differences between the two groups. The statistical significance level was set to $\alpha = 0.05$.

IV. Results

4.1 Participant Characteristics

A total of 40 participants were recruited at the volunteer center and participated in the pre-intervention fitness test. Of these participants, 15 participants did not attend more than 10% of the ballet fitness classes and were therefore placed in the control group. Of these, 6 participants did not return for the post-intervention fitness test for personal reasons. Of the 25 participants placed in the exercise group, 10 participants dropped out completely or did not attend more than 80% of the classes and therefore were categorized in the drop-out group. This left a total of 15 participants in the exercise group and 9 participants in the control group.

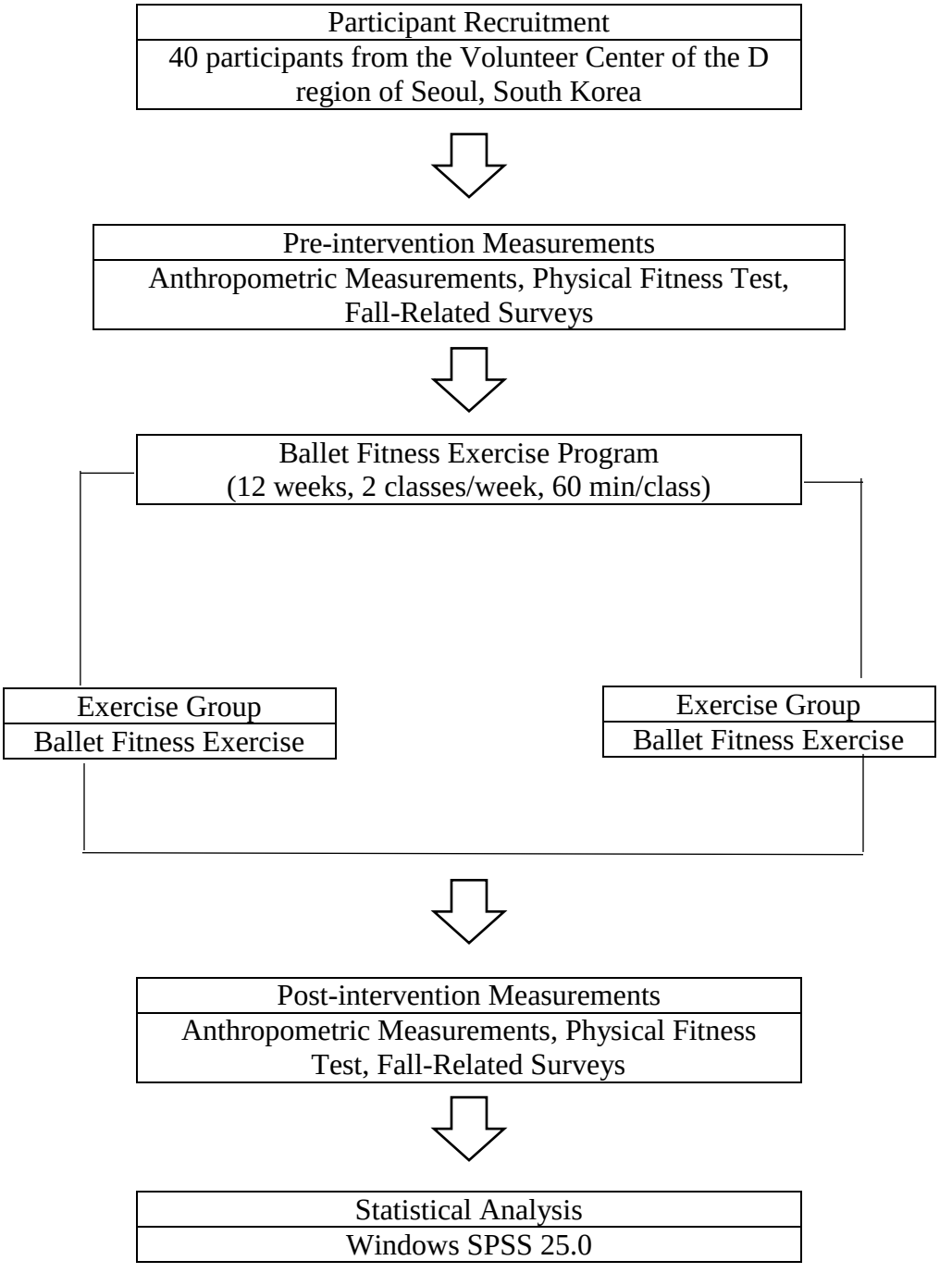

Figure 1. Experimental Methods

4.2 Anthropometric Measurements

The average age of the control group participants was 61.44 ± 8.76. There were no significant differences between pre- and post- intervention measurements for the rest of the anthropometric variables.

Table 1. Anthropometric Measurements of Control Group Participants

Measurement (Average ±Standard Deviation)	Pre-Measurement	Post-Measurement
Age	61.44 ± 8.76	
Height(cm)	154.94 ± 6.59	154.94 ± 6.59
Weight(kg)	57.90 ± 5.91	56.52 ± 5.53
Skeletal Muscle Mass	20.71 ± 2.03	20.10 ± 1.69
Body Fat Mass	19.50 ± 4.92	19.27 ± 4.94
BMI	24.16 ± 1.78	23.56 ± 2.02
Body Fat Percentage	33.32 ± 6.36	33.69 ± 6.23

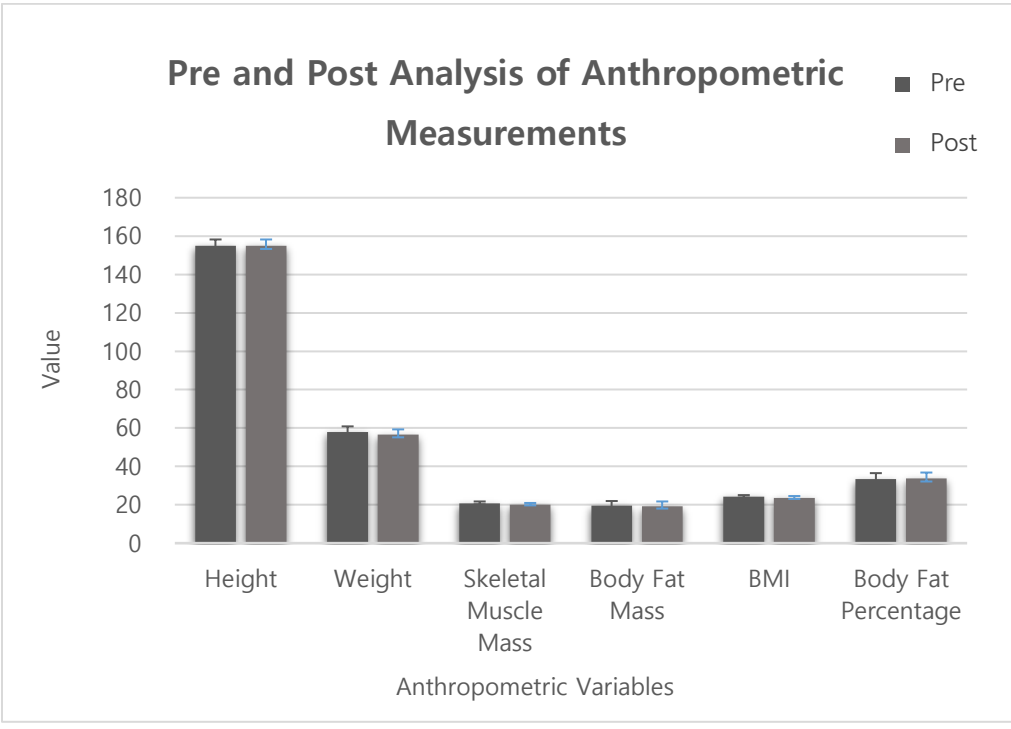

Figure 2. Pre- and Post- Analysis of Anthropometric Measurements of Control Group Participants

The average age of the exercise group participants was 65.87 ± 5.78. The average age of the control group participants was slightly younger than that of the exercise group participants. There were no significant differences between pre- and post- intervention measurements for the rest of the anthropometric variables.

Table 2. Anthropometric Measurements of Exercise Group Participants

Measurement (Average ±Standard Deviation)	Pre-Measurement	Post-Measurement
Age	65.87 ± 5.78	
Height(cm)	149.81 ± 23.31	149.81 ± 23.31
Weight(kg	58.43 ± 6.51	58.46 ± 7.16
Skeletal Muscle Mass	20.94 ± 3.11	20.57 ± 3.08
Body Fat Mass	19.71 ± 4.17	20.26 ± 4.39
BMI	24.28 ± 2.70	24.11 ± 2.86
Body Fat Percentage	33.71 ± 5.65	34.55 ± 5.45

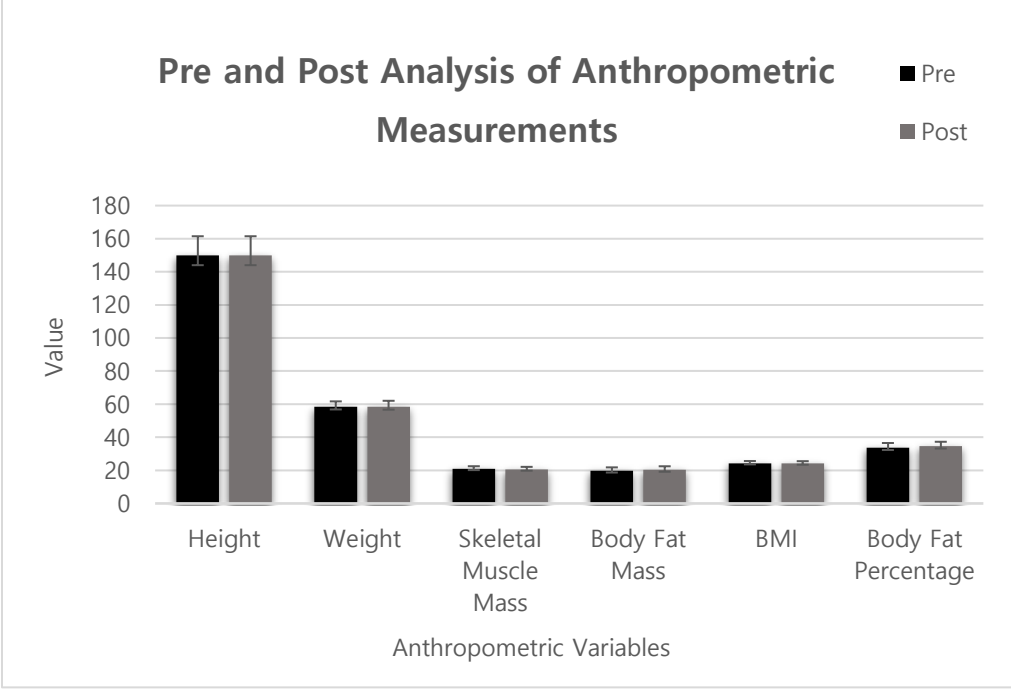

Figure 3. Pre- and Post- Analysis of Anthropometric Measurements of Exercise Group Participants

4.2-1 Body Mass Index

The results for BMI for the exercise group was 24.11 ± 2.86 and 23.56 ± 2.02 for the control group. The results for BMI did not show any significant changes between the Time*Group comparison (p=0.182).

Table 3. BMI Results

BMI	Pre-Measurement Average(±Standard Deviation)	Post-Measurement Average(±Standard Deviation)	Time*Group
Control	24.16 ± 1.78	23.56 ± 2.02	p=0.182
Exercise	24.28 ± 2.70	24.11 ± 2.86	

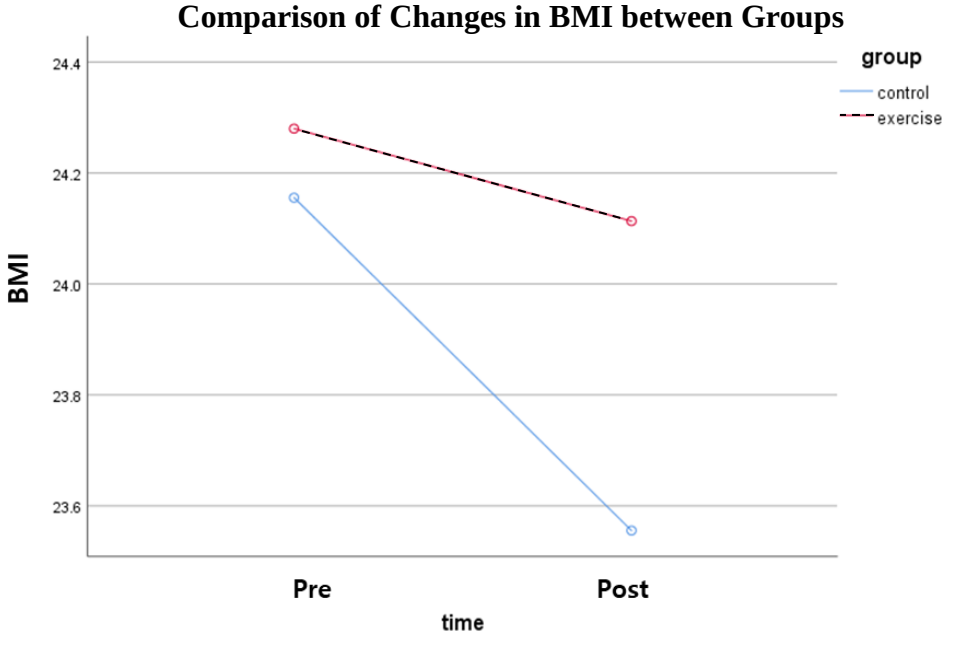

Figure 4: Comparison of Changes in BMI between Groups

4.3 Self-Reported Questionnaires

4.3-1 Falls Efficacy Scale – International

The average score for the Falls Efficacy Scale International for the exercise group was 9.65 ± 0.52 out of a total score of 10. The average score for the control group was 9.82 ± 0.33 for the control group. Although the average score was higher in the control group to begin with, there was a greater score improvement in the exercise group. The results for the Falls Efficacy Scale International between groups was shown to be statistically significant (p=0.012).

Table 4. Fall Efficacy Scale- International Results

Balance (sec)	Pre-Measurement Average(±Standard Deviation)	Post-Measurement Average(±Standard Deviation)	Time	Time*Group
Control	9.70 ± 0.44	9.82 ± 0.33	p=0.300	p=0.012
Exercise	9.31 ± 0.78	9.65 ± 0.52	p=0.009	

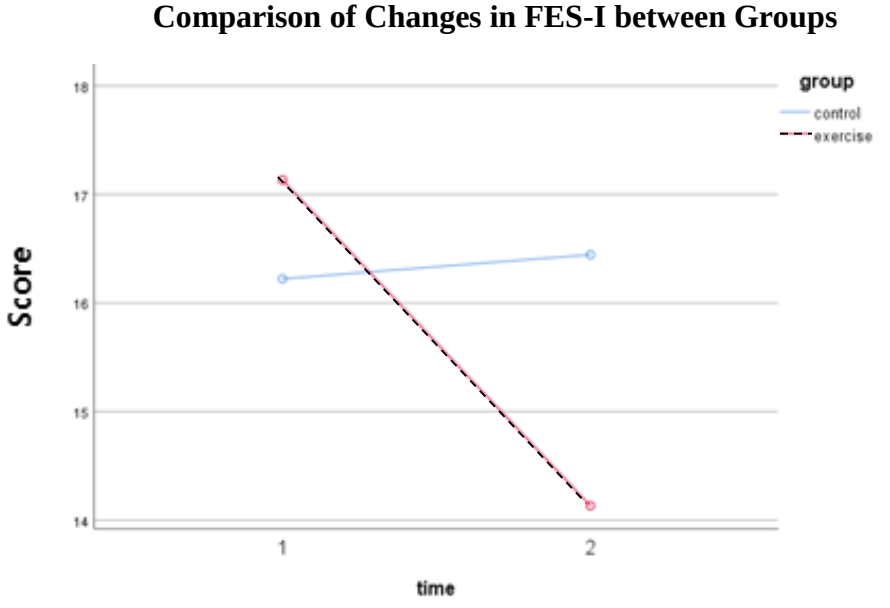

Figure 5. Comparison of Changes in Falls Efficacy Scale-International between Groups

4.3-2 K-SAFE

The average score for the Survey of Activities and Fear of Falling in the Elderly (K-SAFE) in the exercise group was 14.13 ± 3.52. The average score for the control group was 16.22 ± 5.14. The results for the K-SAFE showed a statistically significant decrease in scores in the exercise group in comparison to the control group (p=0.032). A decrease in scores means that there was a significant improvement in fear of falling in the exercise group compared to the control group.

Table 5. K-SAFE Results

Balance (sec)	Pre-Measurement Average(±Standard Deviation)	Post-Measurement Average(±Standard Deviation)	Time	Time*Group
Control	16.44 ± 4.98	16.22 ± 5.14	p=0.351	p=0.032
Exercise	17.13 ± 5.00	14.13 ± 3.52	p=0.016	

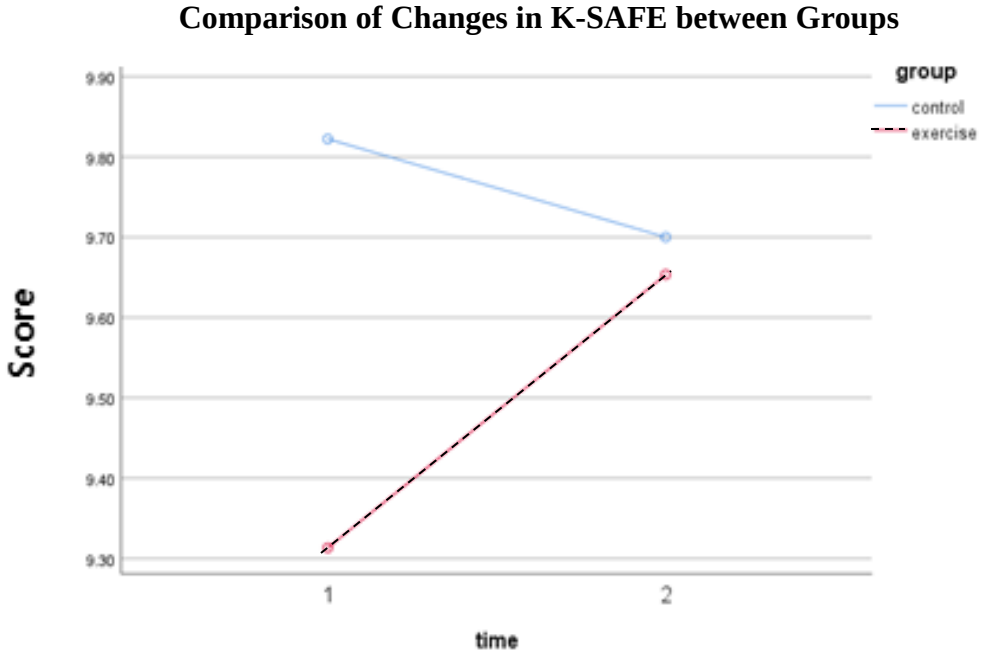

Figure 6. Comparison of Changes in K-SAFE between Groups

4.4 Fitness Test Variables

4.4-1 Timed Up and Go

The scores for the Timed Up and Go in the exercise group was 5.97 ± 0.90 seconds. The scores for the control group was 6.39 ± 1.27. The scores for the Timed Up and Go test showed a statistically significant result in terms of before and after the intervention program in the exercise group. However, the results were not statistically significant between the control and exercise group (p=0.157).

Table 6. Timed Up and Go Results

Gait Speed (sec)	Pre-Measurement Average(±Standard Deviation)	Post-Measurement Average(±Standard Deviation)	Time	Time*Group
Control	7.03 ± 2.11	6.39 ± 1.27	p=0.362	p=0.157
Exercise	7.50 ± 0.90	5.97 ± 0.90	*p=0.0001	

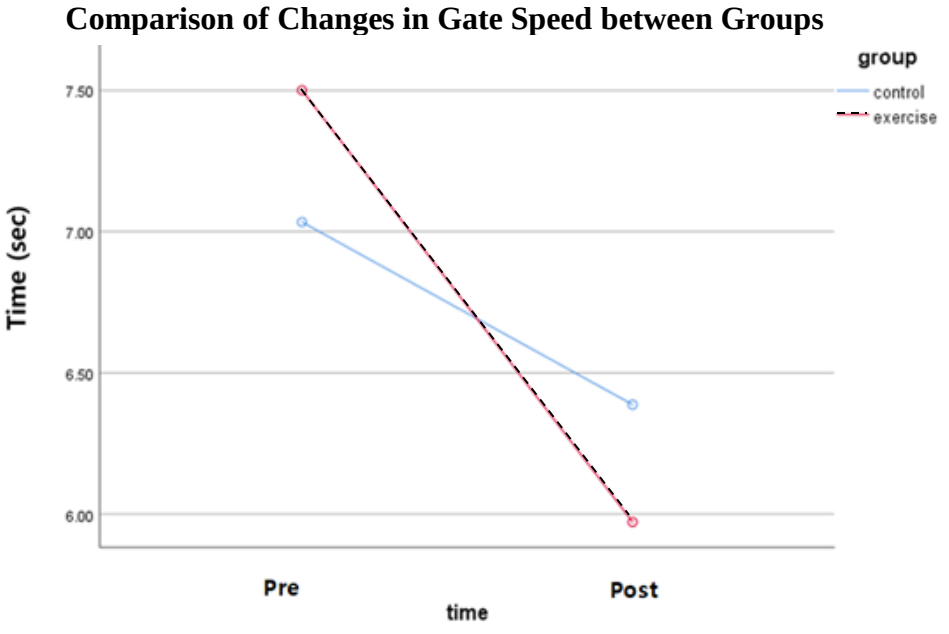

Figure 7. Comparison of Changes in Gait Speed between Groups

4.4-2 Lumbar Strength

The lumbar strength of the exercise group was 39.33 ± 12.28 kg and the results for the control group was 36.36 ± 9.76 kg. The results between the control and exercise group showed statistically significant results (p=0.045).

Table 7. Lumbar Strength Results

Lumbar Strength (kg)	Pre-Measurement Average(±Standard Deviation)	Post-Measurement Average(±Standard Deviation)	Time	Time*Group
Control	35.78 ± 8.56	36.36 ± 9.76	p=0.883	p=0.045
Exercise	29.55 ± 9.96	39.33 ± 12.28	p=0.011	

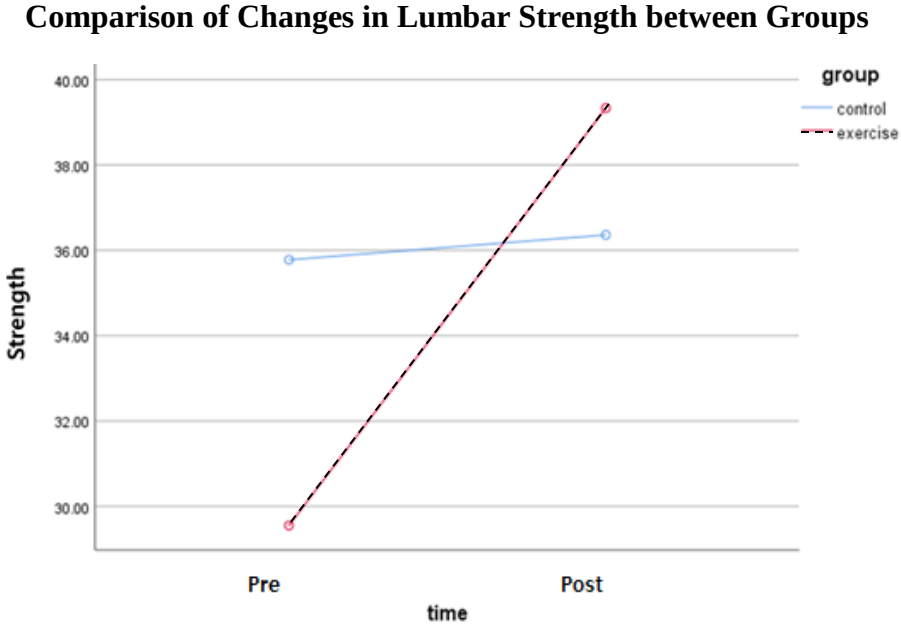

Figure 8. Comparison of Changes in Lumbar Strength between Groups

4.4-3 Flexibility

The results for flexibility for the exercise group was 14.60 ± 6.86 cm and the results for the control group was 10.27 ± 8.19. The results for flexibility showed statistically significant results before and after the intervention for the exercise group (p=0.003).

Table 8. Flexibility Results

Flexibility (cm)	Pre-Measurement Average(±Standard Deviation)	Post-Measurement Average(±Standard Deviation)	Time	Time*Group
Control	12.17 ± 6.19	10.27 ± 8.19	p=0.468	p=0.003
Exercise	7.22 ± 9.46	14.60 ± 6.86	*p=0.0001	

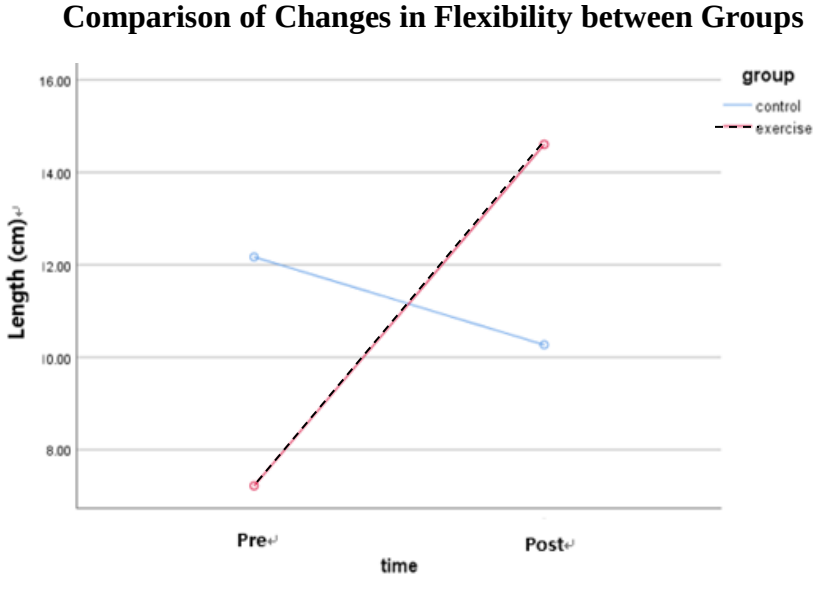

Figure 9. Comparison of Changes in Flexibility between Groups

4.4-4 Core Strength

The results for core strength for the exercise group was 39.33 ± 12.28 sec and 36.36 ± 9.76 sec for the control group. The results were not statistically significant for either the control or exercise groups. It was also not statistically significant for the in-between groups analysis (p=0.407).

Table 9. Core Strength Results

Core Strength (sec)	Pre-Measurement Average(±Standard Deviation)	Post-Measurement Average(±Standard Deviation)	Time	Time*Group
Control	35.78 ± 8.56	36.36 ± 9.76	p=0.054	p=0.407
Exercise	29.55 ± 9.96	39.33 ± 12.28	p=0.089	

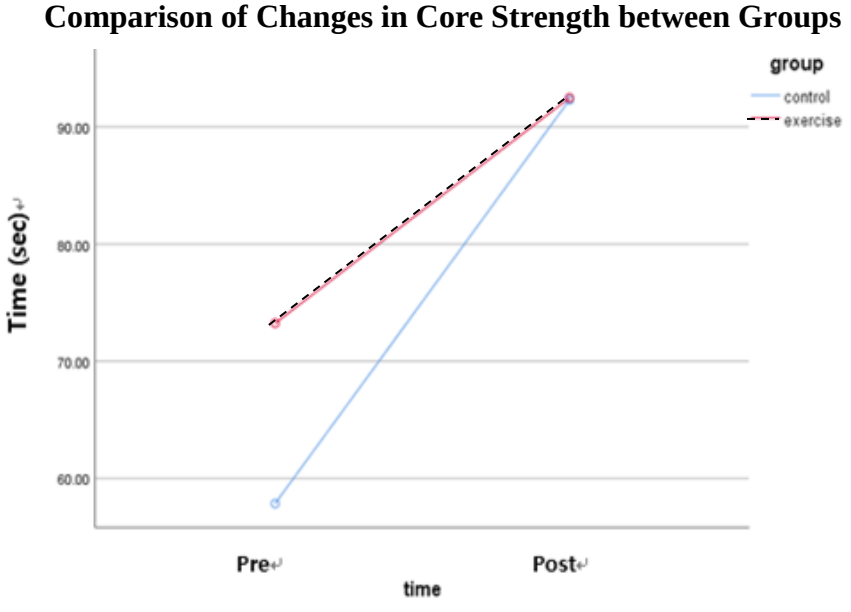

Figure 10. Comparison of Changes in Core Strength between Groups

4.4-5 Static Balance

The results for static balance for the exercise group was 6.92 ± 6.35 sec and 8.03 ± 7.85 sec for the control group. The results were not statistically significant for either the control or exercise group. It was also not statistically significant for the in-between groups analysis (p=0.113).

Table 10. Static Balance Results

Balance (sec)	Pre-Measurement Average(±Standard Deviation)	Post-Measurement Average(±Standard Deviation)	Time	Time*Group
Control	11.23 ± 9.83	8.03 ± 7.85	p=0.386	p=0.113
Exercise	4.82 ± 3.20	6.92 ± 6.35	p=0.149	

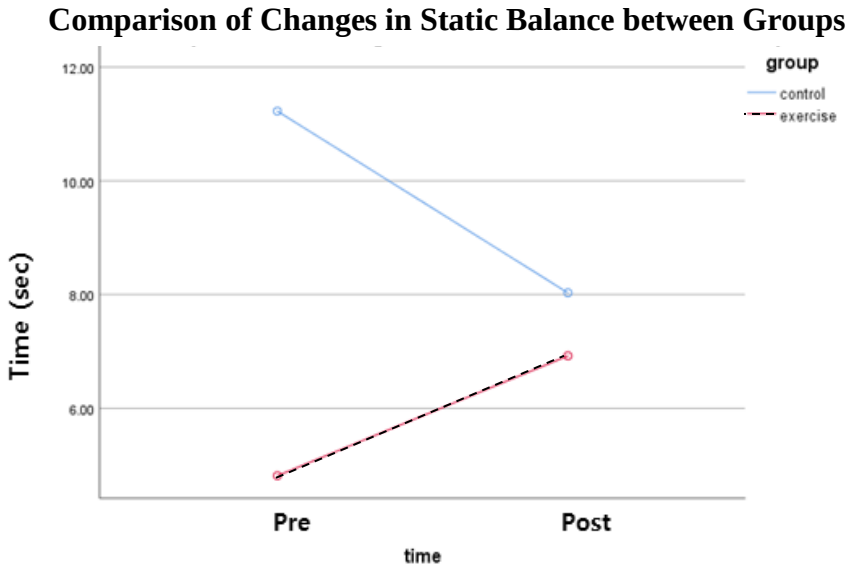

Figure 11. Comparison of Changes in Static Balance between Groups

V. Discussion

Ballet is a form of physical activity that uses a high level of energy and requires a high level of muscular strength, flexibility, speed, coordination, agility and balance (Park, 2002). Ballet has been proven to show improved strength in muscles in the body and increase flexibility (Kim, 2017). Not only ballet but also Pilates exercise has been shown to bring positive effects in areas such as power, muscle endurance, flexibility, perception of activity, balance, balance, agility, as well as cardiovascular endurance (Kim, 2017). Therefore the target of these physical fitness components combined with other fitness components such as body rehabilitation, proper body posture and core stability provided by the Pilates components of this particular exercise, may prove that ballet fitness is a more effective fall prevention intervention than ballet (dance) or Pilates would be alone.

In this study, a statistically significant increase in leg strength was shown between the control and exercise group. A meta-analysis of the effects of exercise on fall prevention found a relationship between decrease in fall rates and improvement of leg strength and balance in exercise intervention groups (Zhao, 2016). Ballet consists of many movements that can help improve muscle strength in the lower body. For example, a plié is a two-knee bending motion

with a straight posture that bends one or both knees, allowing the body to work vertically, developing the leg muscles (Kim, 2017). It is most likely that leg-based ballet movements such as battement and plié helped increase lumbar strength in the subjects.

Flexibility was another fitness factor that improved statistically significantly between the two groups. Flexibility is known to deteriorate with an increase in age. As well, a previous study suggests a link between decreased flexibility and falls in the elderly. Such previous studies state that exercises focused on improving flexibility are highly efficient for preventing falls in older adults, increasing functional mobility (Skelton, 2003).

Pilates exercise has been shown to increase flexibility of skeletal muscles in middle-aged adults due to improved muscle range of motion, postural alignment and flexibility of joints (Emery, 2010; Kibar et al. 2016). In a previous study, 10 weeks of lower extremity stretching exercises was shown to be effective in improving single limb stance time and Berg Balance score. It was also stated in the same study that lower extremity stretching exercises are effective in improving balance and thereby decreasing falls in elderly (Reddy, 2016). Therefore the Pilates components of the BalletFit program could have been effective in improving flexibility in the participants of this study.

As well, reduction in flexibility of the lower body may have a negative

impact on gait speed (Kwak, 2016). This shows that flexibility is related to gait speed. This was shown by the results in this study in which the results for the Timed Up and Go test in the exercise group improved significantly when comparing the pre- and post-intervention times(sec) (****p=0.0001). The results for flexibility in the exercise group also improved significantly when comparing the pre- and post-intervention scores (****p=0.0001). Therefore we can see that the gait speed improved as the flexibility increased in the exercise group.

Another previous study has suggested a link between reduced ROM in the lower limb and falls in the elderly. It seems that the decreased activation of the muscle spindle as a result of decreased stretch in the muscle may lead to decreased amplitude of the stretch reflex that would impact the successful use of the stretch reflex to regain balance (Chiacchiero, 2010). Possible explanations for these results are the activation of muscle spindles or decreased renal reflexes due to decreased flexibility of the muscles due to aging. A muscle stretch reflex means that when a muscle is stretched, it contracts reflexively, resisting the stretch. The risk of injury is increased because it leads to a decrease in the amplitude of the reflex reflection to the fall. Stretching has a positive effect on the use of muscles by increasing reflex reflexes, which can easily restore balance before a fall. Therefore, it is reported that improving the

flexibility of leg strength can reduce the fall of the elderly. It is possible to conclude that the increased flexibility has a positive impact on fall prevention.

Fear of falling is known to be one of the most common fears in older women (Murphy, 2002). It has been shown in many previous studies that exercise and physical activity show positive effects on fear of falling (Brouwer, 2003). In this particular study involving BalletFit exercise, fear of falling also showed to be statistically significant between the control and exercise group. It was shown in a previous intervention study that an 8-week Pilates program was effective in reducing fear of falling (Seo, 2013). In another previous study, dance therapy was shown to significantly improve fear of falling (Veronese, 2017). Therefore, not only is Pilates an effective exercise program for fall-related psychological factors, but also dance intervention such as ballet seems to be effective as a treatment program for fear of falling. This in turn shows that a 12-week BalletFit exercise program which includes both Pilates and dance components is a good intervention for reducing fear of falling.

The results for static balance did not turn out to be significant in this study. In one previous study, a 12-week mat Pilates program did not seem sufficient to determine meaningful improvement on static balance (Bergamin et al, 2015). Therefore, it may have been that the duration of this experiment was not long enough to have seen significant results in static balance. As well,

although many previous studies show usage of the one-leg balance test with both eyes closed (Zou, 2019), if the test had been performed with eyes open, the results could have shown significant improvement in static balance. The impact that the visual system has on the body equilibrium has been described in numerous studies (Asslander, 2015; Sozzi, 2011). Although it has been stated in previous studies that visual perception of surroundings is not obligatory for maintaining balance, postural performance has been shown to decline with the exclusion of visual cues that come from spatial orientation which could possibly affect balance (Toosizadeh, 2018).

As well, the volunteer center at which this experiment was performed lack ballet barres, limiting movement to only a yoga mat. Therefore, there was a limitation in the variation of balance movements that could be performed in this experiment. Another limitation to this study was that the average age of the control group participants was slightly younger than that of the experimental group participants (61.44 ± 8.76 and 65.87 ± 5.78 respectively). This could have effected some of the scores in the physical fitness assessment where the pre- and post-results within groups was significant but was not significant for between groups.

The results for BMI also did not show to be statistically significant in this study. Many previous studies show that ballet includes aerobic exercise

components (Cohen, 2014; Oh, 2003). Although it was shown in one study that BMI did decrease in the exercise group of a ballet study performed on elderly women, the results did not show to be statistically significant (Lee, 2011). There are also several previous studies that state that ballet is not effective in decreasing BMI in study participants (Oh, 2003; Lee, 2011). For this study, due to the limitation of space at the dance hall of the volunteer center, there was a limitation in variation of aerobic exercise movements that could be performed. As well, many of the participants were afraid of performing movements that included jumps and any movements that required any sort of pressure in the knees. Therefore, there was a limitation in the movements that could be included in this BalletFit program.

VI. Conclusion

This experiment showed that a 12-week Ballet Fitness Program is an effective intervention for fall prevention in middle-aged women, especially in terms of flexibility and lumbar strength.

1. A 12-week Ballet Fitness exercise program showed statistically significant increases in lumbar strength and flexibility.
2. Improvements in fear of falling and performance of daily activities showed to be statistically significant.

Although measurements such as core strength and balance did not have statistically significant results, most of the experimental variables showed a positive trend after participating in 12-weeks of ballet fitness. As well, ballet fitness showed to be a safe form of physical activity for middle-aged and elderly women. Therefore, it could be used as a safe intervention for improving fall-related fitness factors as well as fall prevention.

Appendix 1

한국어판 낙상 효능 척도

날짜:

질문: "귀하는 다음과 같은 일을 넘어지지 않고 할 자신이 얼마나 있습니까?" **1**= '전혀 할 수 없다 에서부터 **10**= '아주 잘 할 수 있다'										
1. 목욕이나 샤워를 한다.	1	2	3	4	5	6	7	8	9	10
2. 옷장(벽장) 안에서 물건을 꺼낸다.	1	2	3	4	5	6	7	8	9	10
3. 가벼운 집안일을 한다(먼지 닦기/옷장 청소 등)	1	2	3	4	5	6	7	8	9	10
4. 집 주변을 산책한다.	1	2	3	4	5	6	7	8	9	10
5. 잠자리에 들고, 일어난다.	1	2	3	4	5	6	7	8	9	10
6. 밤에 화장실 가기 위해 일어난다.	1	2	3	4	5	6	7	8	9	10
7. 의자에 앉고 선다.	1	2	3	4	5	6	7	8	9	10
8. 옷을 입고 벗는다.	1	2	3	4	5	6	7	8	9	10
9. 세수, 머리 빗기 등 몸단장을 한다.	1	2	3	4	5	6	7	8	9	10
10. 변기에 앉고 선다.	1	2	3	4	5	6	7	8	9	10

Appendix 2

한국형 노인 낙상공포 및 활동척도(K-SAFE)

다음은 11가지 일상생활 활동을 수행할 때에 낙상에 대한 공포를 측정하는 것입니다. 1~4점 사이에 표시해 주시기 바랍니다. 1점으로 갈수록 낙상에 대한 공포가 전혀 없다는 뜻이며, 4점으로 갈수록 낙상에 대한 공포가 많다는 뜻입니다.

문 항		점 수			
		전혀 피하지 않는다 (1)	거의 피하지 않는다 (2)	종종 피한다 (3)	항상 피한다 (4)
1	몸소 상점에 가기				
2	몸소 간단한 음식 준비하기				
3	욕조에서 목욕하기				
4	잠자리에서 혼자 일어나기				
5	운동 삼아 걸어 다니기				
6	미끄러운 날 외출하기				
7	혼자서 친구나 친지 방문하기				
8	머리 위에 높이 있는 물건 내리기				
9	사람 많은 장소 다니기				
10	2-3km의 거리 걷기				
11	허리 구부려 물건 잡기				
합 계					

VII. References

Ahearn, E. L. (2006). The Pilates Method and Ballet Technique: Applications in the Dance Studio. *Journal of Dance Education*, *6*(3), 92-99. doi:10.1080/15290824.2006.10387321

Amorim, T. P., Sousa, F. M., & Santos, J. A. (2011). Influence of Pilates training on muscular strength and flexibility in dancers. *Motriz: Revista De Educação Física*, *17*(4), 660-666. doi:10.1590/s1980-65742011000400010

Assländer, L., Hettich, G., & Mergner, T. (2015). Visual contribution to human standing balance during support surface tilts. *Human Movement Science, 41,* 147-164. doi:10.1016/j.humov.2015.02.010

Baxter, R. E., Moore, J. H., Pendergrass, T. L., Crowder, T. A., & Lynch, S. (2003). Improvement in Sit-up Performance Associated With 2 Different Training Regimens. *Journal of Orthopaedic & Sports Physical Therapy, 33*(1), 40-47. doi:10.2519/jospt.2003.33.1.40

Bergamin, M., Gobbo, S., Bullo, V., Zanotto, T., Vendramin, B., et. al. (2015). Effects of a Pilates exercise program on muscle strength, postural control and body composition: Results from a pilot study in a group of post-menopausal women. *Age, 37*(6). doi:10.1007/s11357-015-9852-3

Britten, L., Addington, C., & Astill, S. (2017). Dancing in time: Feasibility and

acceptability of a contemporary dance programme to modify risk factors for falling in community dwelling older adults. *BMC Geriatrics*, *17*(1). doi:10.1186/s12877-017-0476-6

Brouwer, B. J., Walker, C., Rydahl, S. J., & Culham, E. G. (2003). Reducing Fear of Falling in Seniors Through Education and Activity Programs: A Randomized Trial. *Journal of the American Geriatrics Society, 51*(6), 829-834. doi:10.1046/j.1365-2389.2003.51265.x

Carande-Kulis, V., Stevens, J. A., Florence, C. S., Beattie, B. L., & Arias, I. (2015). A cost–benefit analysis of three older adult fall prevention interventions. *Journal of Safety Research*, *52*, 65-70. doi:10.1016/j.jsr.2014.12.007

Chiacchiero, M., Dresely, B., Silva, U., Delosreyes, R., & Vorik, B. (2010). The Relationship Between Range of Movement, Flexibility, and Balance in the Elderly. *Topics in Geriatric Rehabilitation, 26*(2), 148-155. doi:10.1097/tgr.0b013e3181e854bc

Critchley, D. J., Pierson, Z., & Battersby, G. (2011). Effect of pilates mat exercises and conventional exercise programmes on transversus abdominis and obliquus internus abdominis activity: Pilot randomised trial. *Manual Therapy*, *16*(2), 183-189. doi:10.1016/j.math.2010.10.007

Dalleck, L. C., & Tischendorf, J. S. (2018). Guidelines for Exercise Testing and Prescription (ACSM). *Encyclopedia of Lifestyle Medicine & Health*.

doi:10.4135/9781412994149.n165

Donoghue, O. A., Mcgarrigle, C. A., Foley, M., Fagan, A., Meaney, J., & Kenny, R. A. (2018). Cohort Profile Update: The Irish Longitudinal Study on Ageing (TILDA). *International Journal of Epidemiology*, *47*(5), 1398-1398l. doi:10.1093/ije/dyy163

Ekstrom, R.A., Donatelli, R.A., Carp, K.C. (2007). Electromyographic analysis of core trunk, hip, and thigh muscles during 9 rehabilitation exercises. *J. Orthop. Sports Phys. Ther.* *37*:754–762. doi: https://doi.org/10.2519/jospt.2007.2471

Emery, K., Serres, S. J., Mcmillan, A., & Côté, J. N. (2010). The effects of a Pilates training program on arm–trunk posture and movement. *Clinical Biomechanics, 25*(2), 124-130. doi:10.1016/j.clinbiomech.2009.10.003

Faries MD, Greenwood M. (2007). Core training: stabalizing the confusion. *Strength Cond J. 29*(2):10–25

Freiberger, E., Häberle, L., Spirduso, W. W., & Zijlstra, G. A. (2012). Long-Term Effects of Three Multicomponent Exercise Interventions on Physical Performance and Fall-Related Psychological Outcomes in Community-Dwelling Older Adults: A Randomized Controlled Trial. *Journal of the American Geriatrics Society*, *60*(3), 437-446. doi:10.1111/j.1532-5415.2011.03859.x

Gillespie, L., & Handoll, H. (2009). Prevention of falls and fall-related injuries

in older people. *Injury Prevention*, *15*(5), 354-355. doi:10.1136/ip.2009.023101

Halvarsson, A., Dohrn, I., & Ståhle, A. (2014). Taking balance training for older adults one step further: The rationale for and a description of a proven balance training programme. *Clinical Rehabilitation*, *29*(5), 417-425. doi:10.1177/0269215514546770

Hita-Contreras, F., Martínez-Amat, A., Cruz-Díaz, D., & Pérez-López, F. R. (2016). Fall prevention in postmenopausal women: The role of Pilates exercise training. *Climacteric*, *19*(3), 229-233. doi:10.3109/13697137.2016.1139564

Hodges, P. W., & Richardson, C. A. (1997). Contraction of the Abdominal Muscles Associated With Movement of the Lower Limb. *Physical Therapy*, *77*(2), 132-142. doi:10.1093/ptj/77.2.132

Howe, T., Waters, M., Dawson, P., & Rochester, L. (2004). Exercise for improving balance in older people. *Cochrane Database of Systematic Reviews*. doi:10.1002/14651858.cd004963

Jang, H., & Ahn, S. (2014). A Predictive Model of Fall Prevention Behaviors in Postmenopausal Women. *Journal of Korean Academy of Nursing*, *44*(5), 525. doi:10.4040/jkan.2014.44.5.525

Kanis, J. A., & Kanis, J. A. (1994). Assessment of fracture risk and its application to screening for postmenopausal osteoporosis: Synopsis of a

WHO report. *Osteoporosis International*, *4*(6), 368-381. doi:10.1007/bf01622200

Kibar, S., Yardimci, F.Ö., Evcik, D., Ay, S., Alhan, A., Manço M., et al. (2016). Can a pilates exercise program be effective on balance, flexibility and muscle endurance? A randomized controlled trial. *J Sports Med Phys Fitness. 56*(10):1139-1146

Kibler, W. B., Press, J., & Sciascia, A. (2006). The Role of Core Stability in Athletic Function. *Sports Medicine, 36*(3), 189-198. doi:10.2165/00007256-200636030-00001

Kim, M., & Oh, D. (2018). Effects of 12-Week Exercise Program Applying Basic Ballet Movements on Flexibility, Balance Ability and Fall Efficacy of Women over 60 Years of Age. *Dance Research Journal of Dance, 76*(1), 1-17. doi:10.21317/ksd.76.1.1

Kim, Y. (2016). A Meta-analysis of the Effects of Dance Programs on Body Composition for Women. *KSDS.* doi: 10.21539/ksds.2016.33.4.93

Knudson, D., & Johnston, D. (1995). Validity and Reliability of a Bench Trunk-Curl Test of Abdominal Endurance. *The Journal of Strength and Conditioning Research, 9*(3), 165. doi:10.1519/1533-4287(1995)0092.3.co;2

Kofotolis, N., Kellis, E., Vlachopoulos, S. P., Gouitas, I., & Theodorakis, Y. (2016). Effects of Pilates and trunk strengthening exercises on health-

related quality of life in women with chronic low back pain. *Journal of Back and Musculoskeletal Rehabilitation*, *29*(4), 649-659. doi:10.3233/bmr-160665

Kostić, R., Uzunović, S., Purenović-Ivanović, T., Miletić, Đ., Katsora, G., Pantelić, S., Milanović, Z. (2015). The effects of dance training program on the postural stability of middle aged women. *Central European Journal of Public Health*, *23*(Supplement). doi:10.21101/cejph.a4206

Krampe, J., Rantz, M. J., Dowell, L., Schamp, R., Skubic, M., & Abbott, C. (2010). Dance-Based Therapy in a Program of All-inclusive Care for the Elderly. *Nursing Administration Quarterly*, *34*(2), 156-161. doi:10.1097/naq.0b013e3181d91851

Lachman, M. E., Howland, J., Tennstedt, S., Jette, A., Assmann, S., & Peterson, E. W. (1998). Fear of Falling and Activity Restriction: The Survey of Activities and Fear of Falling in the Elderly (SAFE). *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 53*B(1). doi:10.1093/geronb/53b.1.p43

Lee SG, Kam S. (2011). Incidence and estimation of socioeconomic costs of falls in the rural elderly population. *J Korean Geriatr Soc*. doi:15:8–19

Lee, JS. (2011). The effect of using ballet silver dance program of basic fitness and blood lipid in older women. *Hanyang University*.

Li, F., Harmer, P., & Fitzgerald, K. (2016). Implementing an Evidence-Based

Fall Prevention Intervention in Community Senior Centers. *American Journal of Public Health*, *106*(11), 2026-2031. doi:10.2105/ajph.2016.303386

Mccartney, K. N., & Forsyth, J. (2017). The efficacy of core stability assessment as a determiner of performance in dynamic balance and agility tests. *Journal of Human Sport and Exercise*, *12*(3). doi:10.14198/jhse.2017.123.08

Merom, D., Mathiew, E., Cerin, E., Morton, R., Anstey, K., Sherrington, C., et al., (2017). Social Dancing To Reduce Falls In Older Adults—A Cluster Randomised Controlled Trial. *Innovation in Aging,* 1(Suppl_1), 267-268. doi:10.1093/geroni/igx004.980

Merom, D., Cumming, R., Mathieu, E., Anstey, K. J., Rissel, C., Simpson, J., et al., (2013). Can social dancing prevent falls in older adults? a protocol of the Dance, Aging, Cognition, Economics (DAnCE) fall prevention randomised controlled trial. *BMC Public Health*, *13*(1). doi:10.1186/1471-2458-13-477

Moon E. (2013). The Effects of 12 weeks of Ballet Session on Elderly Women in Improving Bone Density and Enhancing Bodily Functions To Prevent from Falling. *Hanyang University.*

Murphy, S. L., Williams, C. S., & Gill, T. M. (2002). Characteristics Associated with Fear of Falling and Activity Restriction in Community-Living Older

Persons. *Journal of the American Geriatrics Society, 50*(3), 516-520. doi:10.1046/j.1532-5415.2002.50119.x

Nadler, S. F., Malanga, G. A., Bartoli, L. A., Feinberg, J. H., Prybicien, M., & Deprince, M. (2002). Hip muscle imbalance and low back pain in athletes: Influence of core strengthening. *Medicine & Science in Sports & Exercise, 34*(1), 9-16. doi:10.1097/00005768-200201000-00003

Peeters, G., White, A., & Tooth, L. (2017). Fall Risk Factors In Mid-Age Women: Results From The Australian Longitudinal Study On Women's Health. *Innovation in Aging, 1*(Suppl_1), 522-522. doi:10.1093/geroni/igx004.1848

Qin, L., Au, S., Choy, W., Leung, P., Neff, M., Chan, K. (2002). Regular Tai Chi Chuan exercise may retard bone loss in postmenopausal women: A case-control study. *Archives of Physical Medicine and Rehabilitation, 83*(10), 1355-1359. doi:10.1053/apmr.2002.35098

Reddy, R. S., & Alahmari, K. A. (2016). Effect of Lower Extremity Stretching Exercises on Balance in Geriatric Population. *International Journal of Health Sciences, 10*(3), 371-377. doi:10.12816/0048733

Richardson, C.A., Jull, G.A. (1995). Muscle control-pain control. What exercises would you prescribe*? Man Ther.* 2–10. doi: 10.1054/math.1995.0243

Roller, M., Kachingwe, A., Beling, J., Ickes, D., Cabot, A., & Shrier, G. (2018).

Pilates Reformer exercises for fall risk reduction in older adults: A randomized controlled trial. *Journal of Bodywork and Movement Therapies*, *22*(4), 983-998. doi:10.1016/j.jbmt.2017.09.004

Schoenaker, D. A., Jackson, C. A., Rowlands, J. V., & Mishra, G. D. (2014). Socioeconomic position, lifestyle factors and age at natural menopause: A systematic review and meta-analyses of studies across six continents. *International Journal of Epidemiology*, *43*(5), 1542-1562. doi:10.1093/ije/dyu094

Schoenfelder, D. P. (2000). A Fall Prevention Program For Elderly Individuals: Exercise in Long-Term Care Settings. *Journal of Gerontological Nursing, 26*(3), 43-51. doi:10.3928/0098-9134-20000301-09

Schoenaker DAJM Jackson CA, Rowlands JV Mishra GD (2014). Socioeconomic position, lifestyle factors and age at natural menopause: a systematic review and meta-analyses of studies across six continents. *Int J Epidemiol.* doi:10.1093/ije/dyu094

Seo, J., & Kim, S. (2013). Prevention of Potential Falls of Elderly Healthy Women: Gait Asymmetry. *Educational Gerontology, 40*(2), 123-137. doi:10.1080/03601277.2013.802181

Skelton, D.A., Beyer, N. (2003). Exercise and injury prevention in older people. *Wiley Online Library.* doi:10.1034/j.1600-0838.2003.00300.x

Smith, M. B. (1999). The Swiss Ball Theory, basis exercises and clinical

application. *Physiotherapy*, *85*(5), 274. doi:10.1016/s0031-9406(05)61443-5

Sohng KY, Moon JS, Song HH, Lee KS, Kim YS (2004). Risk factors for falls among the community-dwelling elderly in Korea. *Taehan Kanho Hakhoe Chi*. doi;34:1483–1490

Sozzi, S., Monti, A., Nunzio, A. M., Do, M., & Schieppati, M. (2011). Sensori-motor integration during stance: Time adaptation of control mechanisms on adding or removing vision. *Human Movement Science, 30*(2), 172-189. doi:10.1016/j.humov.2010.06.002

Strand, S. L., Hjelm, J., Shoepe, T. C., & Fajardo, M. A. (2014). Norms for an Isometric Muscle Endurance Test. *Journal of Human Kinetics, 40*(1), 93-102. doi:10.2478/hukin-2014-0011

Tinetti, M (2003). Clinical practice. Preventing falls in elderly persons. *N Engl J Med.* doi: 10.1056/NEJMcp020719

Talbot, L. A., Musiol, R. J., Witham, E. K., & Metter, E. J. (2005). Falls in young, middle-aged and older community dwelling adults: Perceived cause, environmental factors and injury. *BMC Public Health*, *5*(1). doi:10.1186/1471-2458-5-86

Toosizadeh, N., Mohler, J., & Marlinski, V. (2018). Low intensity vibration of ankle muscles improves balance in elderly persons at high risk of falling. *Plos One*, *13*(3). doi:10.1371/journal.pone.0194720

Verghese, J. (2006). Cognitive and Mobility Profile of Older Social Dancers. *Journal of the American Geriatrics Society, 54*(8), 1241-1244. doi:10.1111/j.1532-5415.2006.00808.x

Vellas, B. J., Wayne, S. J., Romero, L., Baumgartner, R. N., Rubenstein, L. Z., & Garry, P. J. (1997). One-Leg Balance Is an Important Predictor of Injurious Falls in Older Persons. *Journal of the American Geriatrics Society, 45*(6), 735-738. doi:10.1111/j.1532-5415.1997.tb01479.x

Verheyden, G., Vereeck, L., Truijen, S., Troch, M., Herregodts, I., et al (2006). Trunk performance after stroke and the relationship with balance, gait and functional ability. *Clinical Rehabilitation*, *20*(5), 451-458. doi:10.1191/0269215505cr955oa

Verma, S. K., Willetts, J. L., Corns, H. L., Marucci-Wellman, H. R., Lombardi, D. A., & Courtney, T. K. (2016). Falls and Fall-Related Injuries among Community-Dwelling Adults in the United States. *Plos One, 11*(3). doi:10.1371/journal.pone.0150939

Veronese, N., Maggi, S., Schofield, P., & Stubbs, B. (2017). Dance movement therapy and falls prevention. *Maturitas*, 102, 1-5. doi:10.1016/j.maturitas.2017.05.004

Verschueren, S. M., Roelants, M., Delecluse, C., Swinnen, S., Vanderschueren, D., & Boonen, S. (2003). Effect of 6-Month Whole Body Vibration Training on Hip Density, Muscle Strength, and Postural Control in

Postmenopausal Women: A Randomized Controlled Pilot Study. *Journal of Bone and Mineral Research*, *19*(3), 352-359. doi:10.1359/jbmr.0301245

Wallace, B. A., & Cumming, R. G. (2000). Systematic Review of Randomized Trials of the Effect of Exercise on Bone Mass in Pre- and Postmenopausal Women. *Calcified Tissue International*, *67*(1), 10-18. doi:10.1007/s00223001089

Wolf, S. L., Sattin, R. W., Kutner, M., Ogrady, M., Greenspan, A. I., & Gregor, R. J. (2003). Intense Tai Chi Exercise Training and Fall Occurrences in Older, Transitionally Frail Adults: A Randomized, Controlled Trial. *Journal of the American Geriatrics Society*, *51*(12), 1693-1701. doi:10.1046/j.1532-5415.2003.51552.x

Zhao, R., Feng, F., & Wang, X. (2016). Exercise interventions and prevention of fall-related fractures in older people: A meta-analysis of randomized controlled trials. *International Journal of Epidemiology*. doi:10.1093/ije/dyw142

Zou, L., Loprinzi, P. D., Yu, J. J., Yang, L., Li, C., Yeung, A. S., . . . Xiao, T. (2019). Superior Effects of Modified Chen-Style Tai Chi versus 24-Style Tai Chi on Cognitive Function, Fitness, and Balance Performance in Adults over 55. *Brain Sciences, 9*(5), 102. doi:10.3390/brainsci9050102

국문초록

12주간 발레피트니스 프로그램이 중년 및 노인 여성의 낙상 관련 체력 요인에 미치는 영향

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현재 ACSM 낙상 예방 지침은 65 세 이상의 성인을 대상으로 하고 있지만 낙상위험 초기 단계에서 낙상 위험 요소를 탐지하고 예방하는 것이 더 효과적 일 수 있을 것으로 사료된다.

발레피트니스에 대한 공식적인 정의는 없지만 이 연구에서 하는 발레 피트니스에 대한 정의는 교양과 올바른 자세를 목적으로 두는

클래식 발레와 재활, 체형교정, 그리고 코어강화를 목표로 하는 필라테스의 의학적 목표가 결합된 것을 의미한다. 발레와 필라테스는 많은 유사점을 가지고 있지만 각각의 효과는 발레피트니스의 전체적인 효과에 좋은 시너지를 줄 수 있을 것으로 사료된다. 이 연구의 목적은 낙상 위험이 높은 한국 노인 여성의 낙상 예방에 대한 12 주간 BalletFit 운동 프로그램의 효과를 관찰하는 것이다.

피험자 모집 및 intervention 실시는 서울특별시 D 지역의 자원봉사센터 은빛날개 자원 봉사 프로그램에서 진행되었다. 운동 프로그램 참여 기준은 만 50 세 ~ 79 세 사이의 여성이며 지난 3 개월 이내에 부상 기록이 없으며 보행 도구 없이 이동이 가능한 노인 여성만 포함했다. 자원 봉사자 센터에서 광고를 통해 총 36 명의 피험자를 모집하였다.

낙상에 대한 두려움과 일상생활 수행에 대한 자신감을 평가하기 위해 한국형 노인 낙상공포 및 활동척도와 Falls Efficacy Scale 설문지를 사용하였다. Windows SPSS 25.0 로 측정시기와 그룹간의 상호작용 효과를 보기 위해 Repeated Measures two-way anova 로 데이터 분석을하였고 통계적 유의 수준은 $\alpha = 0.05$ 로 설정하였다.

낙상관련 심리적 요인들과 일상생활 수행능력에 있어서 발레피트니스 프로그램의 효과는 통계적으로 유의하게 나타났다. 사후측정에서 하지근력과 유연성의 향상을 보였으며 시기와 그룹간에 따른 상호작용 효과는 통계적으로 유의한 차이가 나타났다. 따라서 발레피트니스 운동프로그램이 낙상예방 처치프로그램으로서 효과가 있는 것으로 나타났다. 이 연구에서 측정한 모든 체력 요인들이 모두 통계적으로 유의하게 나타난 것은 아니었으나, 대부분 측정항목에서 개선되는 경향성이 보였다.

이상의 결과를 살펴보면, 본 연구에서 실시한 발레피트니스 운동프로그램이 노인여성의 체력을 유지 및 증진시키는데 긍정적인 영향을 미쳤다고 볼 수 있다. 따라서 규칙적인 발레피트니스 운동프로그램을 실시한다면 노인들의 체력이 향상되어 일상생활수행능력을 개선시키며 낙상 예방에 도움이 될 것으로 사료된다.

향후 음악에 맞춰서 하는 발레의 리드미컬한 동작들이 노인여성의 체력과 낙상에 미치는 효과에 대한 연구가 필요할 것으로 보인다. 또한 발레 피트니스가 다른 연령 그룹에서 수행되었을 때 나타나는 효과에 대한 더 많은 연구가 이루어져야 될것으로 사료된다.