# The Effect of Pilates Exercise on the Static and Dynamic Balance Ability and Balance Confidence in the Elderly

Li Jiang

A Thesis Submitted in Partial Fulfillment of Requirements for
degree of Master of Science in Exercise and Sport Science
May 2025

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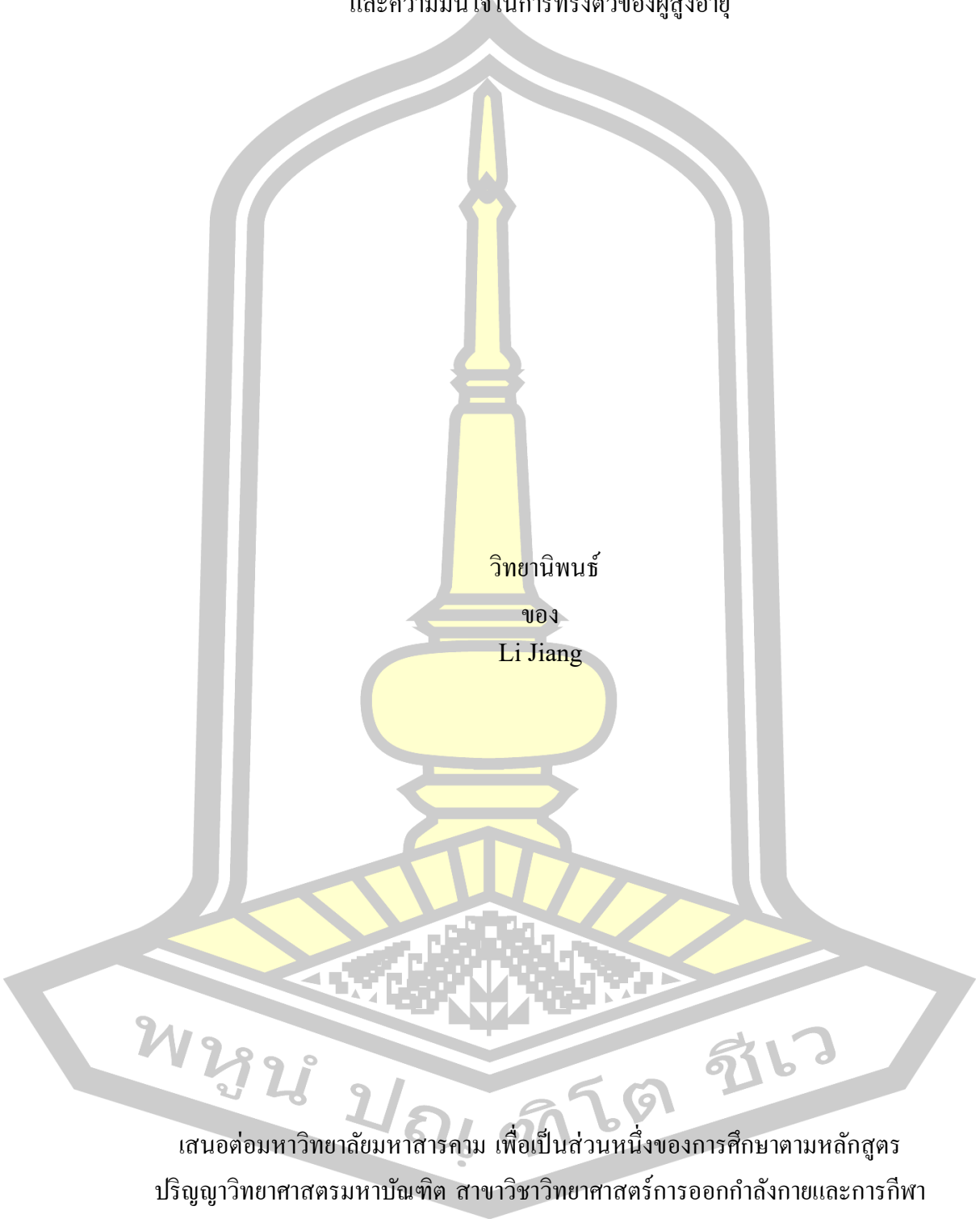

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**TITLE** The Effect of Pilates Exercise on the Static and Dynamic Balance Ability and Balance Confidence in the Elderly

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## ABSTRACT

This study investigated the effect of Pilates on static and dynamic balance ability and balance confidence in elderly. 48 participants from Chongqing Hongshan Community Elderly Care Center were involved. Participants were randomly assigned to 2 groups of 24 each.The experiment lasted 12 weeks. The experimental group was given Pilates exercise as intervention twice a week, 60 minutes each time while the control group maintained the same life routine as usually. The static balance ability was measured by the lasted time in 2 tests: Standing on one leg with eyes open and Standing on one leg with eyes closed. The dynamic balance ability was measured by the costed time in 2 tests: Standing up and walk timing test and Walking though the balance beam test. The Balance confidence was measured by ABC (Activity Balance Confidence) Questionnaire. Finally there were 43 elderly who participated completely while 5 of them dropped out due to their personal reasons. Data was collected before and after the experiment and statistical analysis was conducted using independent samples t-test and paired t-test. The result showed that 12 weeks of Pilates practice have positive effect on improving the static and dynamic balance ability as well as balance confidence in the elderly.

Keyword : Pilates, Dynamic Balance Ability, Static Balance Ability, Balance Confidence

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# CHAPTER I
# INTRODUCTION

## 1. Background

The World Health Organization puts forward the influencing factors of health and life expectancy, of which lifestyle accounts for 60% and environment accounts for 17%. Studies have found that older people who do not participate in social activities have a higher risk of heart disease, high blood pressure and Alzheimer's disease. The development of healthy aging needs to create a good lifestyle and healthy activity atmosphere, so that the elderly can actively participate in various sports and social activities and improve their sense of self-confidence and happiness. The Outline of the "Healthy China 2030" Plan released in 2016 requires strengthening health services for the elderly as a key group, promoting healthy aging, supporting elderly care institutions to strengthen the construction of relevant fitness facilities and medical service systems, promoting the development of "physical and medical integration", preventing falls and various diseases, and safeguarding the health of the elderly. In 2019, The General Office of the State Council issued the Healthy China Action Plan (2019-2030). And issued the "Healthy China Action Organization Implementation and Assessment Program" (State Office Fa[2019] No.32) to encourage and support universities for the elderly, elderly activity centers, grassroots elderly associations, qualified social organizations to carry out health activities for the elderly, improve the health status of the elderly, and improve the quality of life of the elderly. The results of the Fifth National Physical Fitness Monitoring Bulletin in 2021 showed that the national standing on one foot with eyes closed, grip strength, back strength and push-ups decreased by 0.2% to 10.6% compared with 2014. The one-legged standing test with closed eyes mainly reflects people's balance ability, and the decline in its test data indicates that the national balance ability has weakened compared with 2014. The decline in the balance ability of the elderly will certainly affect the activity ability of the elderly, and the reduction of activity will reduce muscle mass and function, becoming a vicious circle.

As of May 2021, according to the results of 7th National Census Main Data Bulletin of China (National Bureau of Statistics,2021), there are about 264 million elderly people aged 60 and above in China, accounting for 18.7% of the total. There are about 190 million people aged 65 and above, accounting for 13.5%. Balance ability is a person's ability to perceive and control the position of their body, which is the basis of human activities. The elderly gradually decline with the increase of age. After the age of 60, the balance of the human body decreases significantly, and the average rate of decline is 16% every 10 years. Therefore, the age of 60 is also known as the watershed of the human body's balance ability. People over 65 years of age are at an increased risk of falling, with about one-third of older adults having at least one fall each year. Among them, 53% are due to daily activities walking or standing instability caused by the body out of balance. The national physical fitness monitoring content uses closed eyes standing on one foot to test the balance ability of the elderly, and the results show that the average time of 60-69 years old people standing on one foot with their eyes closed is about 10 seconds. However, the average standing test time of 60-69 elderly people in Chongqing Hongshan Community Elderly Care Service Center with closed eyes and one foot is about 5 seconds, indicating that the balance ability of 60-69 years old people in this area is low and needs to be improved. Balance ability is closely related to fall, and the weakness of balance ability is an important factor that causes fall phenomenon. The improvement of balance ability not only reduces the probability of falling, but also improves the health level of the elderly, enhances the self-confidence of the elderly and the ability to maintain the independence of independent life, and reduces the pressure of society and family children to a certain extent.

Relevant research data prove that Pilates exercise plays an important role in improving the stability and core strength of the human body. The core strength and stability of the human body reflect the balanced ability of the human body to some extent. Pilates practice emphasizes the principles of breathing, concentration, control, core, precision, and flow, focusing on the integration of body, mind, and consciousness. Each pose matches the correct breathing mode, strengthens the nervous system's muscle control, requires accurate and smooth completion of body

movements, can stimulate deep muscles, exercise core muscles, improve core stability, and help improve body control and balance. In particular, Pilates exercise on the mat, the movement rhythm is slow, the exercise intensity is low, and the exercise load is small, which is more applicable for the elderly with organ degeneration and muscle, bone and joint degeneration, and the balance ability is generally reduced. Therefore, this study explored the effects of Pilates exercise on the balance ability of 60–69-year-old people through Pilates exercise intervention experiment.

**2. Research Purpose**

1. To compare the static and dynamic balance ability and the balance confidence of the elderly within experimental group and within control group before and after 12 weeks' experiment.

2. To compare the static and dynamic balance ability and the balance confidence of the elderly between experimental group and control group before and after 12 weeks' experiment.

**3. Research Hypothesis**

1. The static and dynamic balance ability and the balance confidence of the experimental group could be improved after 12 weeks' Pilates exercise intervention while the control group doesn't have significant change.

2. The static and dynamic balance ability and the balance confidence of the experimental group could be improved significantly compared with the control group after 12 weeks' experiment.

**4. Significance of Study**

Exploring the effect of pilates exercise on the balance ability of the elderly is an effective supplement to the traditional balance ability training theory and practical experience and can provide certain theoretical guidance for pilates to improve the balance ability of the elderly and how to carry out pilates exercise in the health activities of the elderly.

The effect of pilates exercise on the balance ability of the elderly was verified by practice. The improvement of the balance ability of the elderly helps to strengthen the control of the body posture, promote the activity ability and physical health level of the elderly, reduce the phenomenon of falling, and reduce the economic and life pressure of society and children. In addition, this study adopts pilates cushion exercise, which is mainly anti-self-weight strength exercise, which is safe, simple and easy to learn. Let the elderly participate in pilates exercise, understand pilates exercise, enrich fitness methods and contents, learn to integrate pilates exercise into life, make them achieve physical, mental and psychological health through correct, simple, safe and efficient exercises, and maintain a healthy lifestyle, improve the quality of life to provide feasible practice programs.

Pilates is an emerging project introduced from Germany. In foreign countries, there are many studies on its application to sports rehabilitation training and fall prevention for the elderly. In China, there are many studies on the impact of Pilates on the athletic level of athletes or the balance ability of middle-aged women, and Pilates is also applicable for men. Founder Josef Pilates initially used Pilates for military rehabilitation. In this study, pilates practice and balance ability of 60-69 year old people were closely linked, regardless of gender.

The balance ability of the elderly not only refers to the sense of body balance, but also is affected by their own balance confidence. Activity balance confidence Scale (ABC) has been used in the assessment of balance ability and screening of fall risk in the elderly in foreign countries, while there is a lack of research on the use of ABC in fall risk and balance efficacy in China. This study not only uses static balance ability and dynamic balance ability test to detect changes in physical balance ability of 60-69 year old people, but also pays attention to the study on the influence of mental balance confidence of 60-69 year old people, and uses activity balance confidence scale to explore the changes in balance confidence of 60-69 year old people before and after the experiment. To explore the effect of pilates exercise on the level of balance self-efficacy in 60-69 year old people.

Therefore, for elderly people of different genders, Pilates exercise not only improves the sense of propriety balance, but also pays attention to its impact on balance confidence, which is the innovation of this study.

**5. Definitions**

**5.1 Balance Ability**

Scholars such as Wang Ruiyuan (2012) hold that balance ability refers to a certain posture of the body and the ability to automatically adjust the body posture and maintain it when in motion or subjected to external forces. Nan Dengkun (2008) proposed in "Rehabilitation Medicine" that "balance is a self-regulating ability of body posture, the ability to maintain body posture and stability when subjected to external forces or during physical activities." The Anthropometry and Evaluation Writing Group (1990) wrote in "Anthropometry and Evaluation" : "Balance ability is the ability to maintain body posture, especially the ability to control the center of gravity of the body on smaller support surfaces."

According to the above definition, balance ability is an essential ability for human activities, maintaining body posture and controlling body stability.

Static balance was defined as the ability to hold an upright position while keeping the feet in full contact with the floor (e.g. maintaining an upright stance while the feet are together).

Dynamic balance was defined as the ability to maintain equilibrium while moving through space either with or without moving the feet (eg, standing up from a chair, walking 3m, turning, and returning to the chair to sit down, as in the Standing up and walk timing test; or reaching forward while keeping the feet in full contact with the floor, as in the Functional Reach Test).

**5.1.1 Standing on one leg with eys open or closed**

This is a test for static balance ability. For this test, the subjects should place their hands naturally on both sides of their bodies and open (or close) their eyes. When preparing, stand on one leg and bend the knee of the other leg, with the toe tip

touching the ground. When starts, bend the knee and lift the foot off the ground and start timing. The lifted foot should not rest on the standing leg. When doing test with eyes open, the eyes could look straight ahead. When doing the test with eyes closed, the eyes should keep closed. Stop the timing immediately if the lifted foot lands, the standing leg shifts, or the body shakes more than 15 degrees.

**5.1.2 Ground Balance Beam Walking**

This is a test for dynamic balance ability. The participant stands at one end of the balance beam. Upon hearing the command "Start," they immediately begin to walk quickly, and timing starts at that moment. The participant walks to the other end, turns around, and walks back. Timing stops immediately if the toe of either foot crosses the "exit line." The time taken to walk back and forth once on the balance beam is measured.

**5.1.3 Standing-up and walk**

This is a test for dynamic balance ability. Participants should wear their usual comfortable shoes and sit upright in a chair with a seat height of 45 centimeters and armrest height of 20 centimeters, with their back against the chair. A thick line is drawn in front of the chair as the first exit line, and participants must ensure their toes do not cross this line while seated. The second exit line is drawn 3 meters away from the first. When participants hear the command "Start," they stand up and walk 3 meters forward, turning around after crossing the second line, and sit back down in the chair with their back against the backrest. The timer records the time taken for the participant to leave the backrest, walk 3 meters forward, return, and sit back down with their back against the backrest, measured in seconds.

**5.2. Balance Confidence**

Balance confidence is defined as an individual's confidence in their ability to maintain their balance while performing various activities. The Activity Balance Confidence (ABC) scale was designed to measure balance confidence and takes approximately 20 minutes to complete. Individuals rate their confidence that they “will not lose their balance or become unsteady” when performing each daily task

(item) on the scale from 0 % (low confidence) to 100 % (high confidence). A total score(percentage) is calculated by averaging the percentages from all 16 items. (Bryant A.Seamon et al 2019)

**5.3. Pilates**

Pilates is an exercise method invented by Joseph Pilates (1883-1967), a renowned sports rehabilitation expert from the Federal Republic of Germany. It aims to enhance physical capabilities, increase muscle flexibility and movement coordination, improve body posture, and promote overall physical and mental health. This holistic exercise system emphasizes the importance of the core. By consciously controlling the body, maintaining a reasonable and correct sequence of muscle recruitment and bone arrangement, and focusing on the details of the movements, it combines targeted breathing patterns to enhance the overall health of the practitioner. (Wu,Z.2016). Meanwhile, Pilates is a fitness method that emphasizes posture symmetry, core strength, breathing control, spinal and pelvic balance stability, muscle flexibility and joint flexibility (Han, J. 2016). It can help people achieve a state of physical and mental health. Samantha Wood (2020) scholars have proposed that Pilates is a comprehensive approach, and its ultimate goal is to help practitioners achieve the harmonious development of physical, mental and psychological health.

Based on previous studies, the Pilates proposed in this paper is regarded as a functional exercise. It takes physical training as the basic means and sports anatomy as the theoretical basis. It exercises the deep muscles of the human body, enhances core strength and balance ability, improves human posture, strengthens the control ability of the nervous system over the limbs, promotes the coordinated movement of the whole body, and is a sports project that achieves physical and mental health.

**5.4 Elderly**

According to the United Nations standard, people could be defined as “Elderly” when the age reaches 60 years or 65 years. And the Article 2 of the Law of the People's Republic of China on the Protection of the Rights and Interests of the Elderly states that all people who aged over 60 years old in China belongs to Elderly.

## 6. Research Conceptional Framework

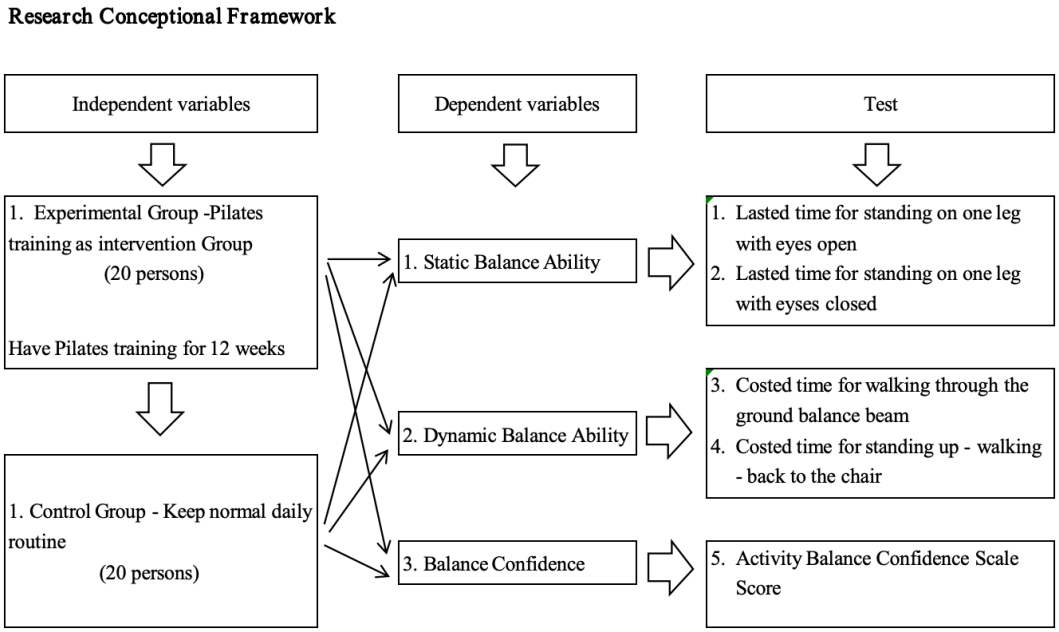



Figure 1 Research Conceptional Framework

# CHAPTER II
# LITERATURE REVIEW

The purpose of this study is to explore the effect of pilates exercise on the static and dynamic balance ability and balance confidence on the elderly before and after the experiment. This experiment referred to the following literature materials.

1. The Elderly
   1.1 Incidence of falls of the elderly
   1.2 Physical changes in the elderly
   1.3 Guidelines for exercise in the elderly
2. Pilates
   2.1 Development and function of Pilates
   2.2 Pilates Principles
3. Balance
   3.1 Influencing factors of balance ability
   3.2 Test methods of balance ability
   3.3 Balance ability of the elderly
4. Related research
   4.1 Research on Pilates exercise and balance ability
   4.2 Research on Pilates and balance ability of the elderly
   4.3 Research on Balance Confidence
5. Research conceptual framework

## 1. The Elderly

### 1.1 Incidence of falls of the elderly

Older people are also at risk of falling while walking naturally. It has been reported in the literature that 50%-70% of falls in the elderly occur during walking (Berg et al., 1997). Some studies have also shown that elderly people in the fall group show gait features with increased variability in stride frequency (Hausdorff et al., 2001) and step length during walking. Some scholars also evaluate gait stability by

acceleration during walking, and find that elderly people with low fall risk will maintain stability by reducing step speed and step frequency, while elderly people with high fall risk will also reduce head and pelvic acceleration in vertical and sagittal axis directions to maintain stability (Menz et al., 2003).Many studies have shown that the changes of temporal and spatial characteristics of gait in the elderly are closely related to the occurrence of falls. In daily life, most older people will adopt a more conservative and erratic way of walking. Studies have shown that the walking speed of elderly people in the fall group is significantly lower than that in the non-fall group (Menz et al., 2003).

At present, the high incidence and severe disability rate of falls among the elderly is one of the important causes of death among the elderly, and falls among the elderly have become a major public health problem worldwide. In 2006, the United States disease Control and Prevention also released data show that the annual probability of elderly people over 65 years old falling is about 33%, and more than half of them would fall again. The incidence of falls in older women is about twice that of men. Between 2003 and 2006, the number of elderly people in the United States who died as a direct result of falls rose from 13,700 to 15,802. Falls have become the sixth leading cause of death among older adults in the United States (Johansenv et al., 2011). China is also faced with the severe challenge of the high incidence and disability rate of falls among the elderly. The probability of falls among the elderly in China is 14.7%-34%, and 60%-75% of the falls will cause secondary injuries of different degrees (Kwan et al., 2011). Falls in the elderly are often the result of a combination of factors, including physical, environmental and psychological factors. In the elderly, degenerative changes in organ sensitivity, nervous system response, and muscle function due to aging affect sensation, responsiveness, and muscle strength, thereby increasing the risk of falls. In addition, anxiety and depression can also reduce patients' balance and concentration, eventually leading to falls (Serrano-Checa et al., 2020).Falling can cause complications such as soft tissue injury, bleeding, fracture, etc., reduce the quality of life of the elderly, and increase the burden of families and even society. As the number of elderly people continues to grow, this situation will continue to worsen (Ye et al., 2021). A fall is an

event in which an individual suddenly, unconsciously or unintentionally changes his position and falls to the ground or lower level(Wei et al,2021). Patients who suffer from a fear of falling limit their activities and have lower self-confidence, leading to decreased muscle function and an increased risk of falling. Moreover, the fear of falling can lead to anxiety, creating a vicious cycle that eventually leads to depression and activity self-restriction, significantly increasing the risk of falling.Natural walking puts a higher demand on the body's posture control system, so the elderly have a higher probability of falling when performing this mobile task activity.

Older adults experience varying degrees of functional decline in musculoskeletal and sensory components related to balance (Lord & Ward,1994). King et al. found that 39.8% of the elderly who fell showed varying degrees of decline in static balance ability, while the response time was prolonged in the dynamic balance test, indicating that the conduction nerve and central integration ability of the human body significantly declined with the increase of age. Therefore, decreased balance ability is the main cause of falls in the elderly, so the relevant balance ability test of the elderly can be used as an indicator to predict falls (Lajoie & Gallagher,2004).

Balance is the ability of the body to maintain the position of the body, that is, the ability to keep the body's center of gravity within a specific spatial range, known as stability limits. The stability boundary is the boundary range at which the body can maintain a certain position without changing its supporting surface (Rosenbaum, 2009). Thus, the reduced balance associated with falls can manifest as a lack of ability to maintain body stability during task-specific activities, such as natural standing, voluntary movement, and resistance to external disturbances. King et al. pointed out that the watershed of balance strength is at the age of 60, and after 60 years, the decline of 16.0% or more every 10 years, and the probability of falling also increases. Some scholars believe that dynamic balance tests can better reflect the risk of falls than static balance tests. It can be seen from the above that falling is an important public health problem faced by the elderly, and its high incidence and disability rate make it one of the main causes of death in the elderly. It is caused by physiological, environmental, psychological and other factors. The risk of falling

during walking is high, and the decrease of balance ability is the main cause. The relevant balance ability test can be used as a prediction index of fall.

1.2 Physical changes in the elderly

Huai Xiaodi(2014) believes that the particularity of the physiological characteristics of the elderly is multifaceted, and understanding these characteristics can better take care of the elderly and ensure that they remain healthy and comfortable in their later years. Among them, the changes in the "motor system" and "sensory system" are two important aspects of the physiological characteristics of the elderly.

**(1) Changes of motor system**

Sun Shuhan et al. (2009). found in their study that osteoporosis is a common problem of bone changes in the elderly, and the main reason is that the bone production is slightly less than the bone absorption, resulting in the reduction of bone mass, that is, the imbalance of bone reconstruction. In addition, factors related to bone remodeling imbalance may present symptoms such as arthritis and spinal degeneration. Related factors include changes in hormone levels, exercise and nutritional deficiencies, and side effects of medications. These changes will cause joint pain and mobility difficulties in the elderly, which will affect the daily life and physical health of the elderly.

De PaleviIle D T et al. (2009). believed that muscle changes in the elderly were mainly manifested as reduced muscle mass, weakened mass and functional degradation, which could lead to problems such as muscle weakness, muscle weakness, muscle stiffness, slow response and postural instability. Muscle strength declines by about 30% by the age of 65 due to a decrease in the speed of muscle protein synthesis, atrophy and reduction of muscle fibers. This makes the elderly muscle fatigue, injury and slow recovery, but also reduces muscle strength, speed and sensitivity, so that the daily walking speed is slow, gait instability, balance ability, difficult to climb stairs or lift heavy objects, thus affecting their daily life and health.

Sun Shuhan et al.(2019) also found in their research that the elderly wear joint cartilage, increase joint surface friction, joint burden, easy to cause pain, stiffness, arthritis and other problems. At the same time, the tissues around the joint are

degraded, including the joint capsule, ligaments and muscles, etc., affecting the stability, flexibility and range of motion of the joint.

To sum up, bones, muscles and joints all have an impact on the daily life and physical health of the elderly. Therefore, corresponding aerobic exercise and weight training can help the elderly enhance muscle mass and function, bone strength, joint flexibility, and reduce joint pain and discomfort. At the same time, due to collective changes, the elderly should also pay attention to balanced diet nutrition, protein is an important component of muscle, and adequate intake of calcium and vitamin D is very important for bone health. Finally, maintain a proper diet and adequate sleep, and provide a safe living environment for the elderly to reduce their exposure to fractures and other bone problems.

**(2) Sensory system decline**

Zhong Zhenya. (2016) believes that the sensory system of the elderly will experience inevitable decline, including vision, hearing and proprioception, which will have a great impact on the daily life and exercise and fitness behavior of the elderly.

Wu Jiahong et al. (2019) believe that the main purpose of proprioceptive system is to maintain postural balance and control the coordinated movement of limb muscles. Proprioceptive changes occur in the elderly, which are mainly manifested as decreased sense of balance, decreased sensitivity, slow response, and easy to fall and fracture. Rehabilitation training and fitness programs need to be developed for these characteristics to reduce the risk of injury.

Sheng Zhengxin et al(2022). believe that visual changes in the elderly are a common phenomenon in the aging process, mainly reflected in vision loss, color vision change, visual field reduction and visual adaptation. These changes can slow cognitive processes, leading to inconvenience and safety issues. Attention should be paid to the particularity of vision in the elderly. For example, keep the environment bright to improve perception and movement safety.

The research of Wang Chenglong et al(2024). found that the cells, neurons and other structures in the auditory system decrease or degenerate over time, resulting in the gradual decline of the hearing of the elderly, which affects their social life, communication and understanding ability, mainly manifested as difficulty in hearing clear dialogue, difficulty in identifying the source of sound, difficulty in hearing clear high-frequency sound, etc.

To sum up, the decline of the elderly's sensory system also seriously affects the physical health of the elderly, including vision, hearing and proprioception. In order to maintain the health and safety of the elderly, rehabilitation training and fitness programs need to be developed according to the visual, auditory and proprioceptive characteristics of the elderly, to help them maintain body balance, improve sensitivity and reaction speed, so as to reduce the risk of injuries such as falls.

1.3 Guidelines for exercise in the elderly

**(1) Physical condition assessment**

Yin Xiujuan (2011) pointed out that the elderly should first determine whether their physical conditions are suitable for exercise ,especially those suffering from heart disease, hypertension and chronic joint diseases should consult doctors before doing exercise.Otherwise excessive exercise will have the opposite effect. Before starting exercise, the elderly should have a comprehensive assessment of their physical conditions, including chronic diseases (such as heart disease, high blood pressure, diabetes, etc.), joint problems, muscle strength and balance. For example, in older people with arthritis, excessive joint movement may worsen pain and injury. Be aware of any recent physical discomfort or illness flare-ups, and make sure that exercise will not adversely affect existing illnesses.

**(2) Exercise principles**

Step by step: The elderly are relatively weak, so they need to choose the right exercise according to their own situation, and gradually increase the amount of exercise and exercise intensity. Avoid sudden high-intensity exercise, so as not to burden the body.The elderly should make exercise plans according to their physical

condition and health status, and avoid excessive exercise leading to physical fatigue or damage.

Perseverance: Exercise needs long-term persistence to achieve good results. The elderly should develop good exercise habits and maintain the continuity and regularity of exercise. Wang Ran, Cheng, Yunfei (2021) et al. Older people who regularly participate in exercise have higher health level. At present, older people who regularly participate in exercise have higher self-rated health level, higher physical health level and higher mental health level.

**(3) Exercise selection**

Chen Liquan et al. (2020) believe that the elderly generally do not attach importance to science in exercise, and are more active in Tai chi, brisk walking and other exercises with low intensity, but they do not pay attention to their own strength, flexibility and agility, and lack all-round training . Aerobic exercise: such as walking, jogging, cycling, etc., these exercises are moderate in intensity and help to improve heart and lung function and strengthen physical strength. Strength training: A moderate amount of strength training helps to enhance the muscle strength and bone density of the elderly, but you should choose the strength and weight that suits you and avoid overtraining. Flexibility training: such as yoga, tai chi, etc., these exercises help improve flexibility and balance in the elderly and reduce the risk of falls.

**(4) Exercise time**

Chen Limei (2018) found that nearly 70% of the elderly people took physical exercise three times or more a week, and the exercise time was concentrated in 60-90 minutes each time, and most of them took exercise in the morning. There is a big difference in the participation of urban and rural elderly in physical exercise. Most urban elderly have taken physical exercise as an important part of daily life, while rural elderly have insufficient awareness of physical exercise. Morning exercise: Fresh air and moderate sunlight exposure in the morning help to improve the mental state of the elderly. However, exercise on an empty or full stomach should be avoided. Afternoon exercise: Afternoon is the time when the body's Yang gradually converges, and exercise at this time helps to relieve fatigue and improve immunity. Evening

exercise: Evening exercise helps to regulate the balance of Yin and Yang and promote sleep. However, exercise should be avoided too late before going to bed, so as not to affect sleep.

**(5) Precautions**

Before exercise, you should do a full warm-up preparation, such as stretching exercises, to avoid sports injuries. Avoid strenuous exercise: The elderly should avoid long-distance running, high jump, long jump and other strenuous exercise to avoid danger; Healthy exercise intensity at any time, any discomfort in the body, timely mention. Maintain moderate water: During exercise, you should supplement the appropriate amount of water to prevent excessive sweating resulting in increased blood viscosity and accidents. Carry medicine with you: Elderly people with underlying diseases should carry emergency medicine with them when exercising for emergency needs.

To sum up, exercise guidance for the elderly needs to carry out physical condition assessment, pay attention to the principles of gradual progress, acting according to one's ability, perseverance, etc., choose the appropriate exercise mode and time, and pay attention to avoid strenuous exercise and warm-up preparation. At the same time, you can refer to the advice of authoritative medical journals and professional fitness coaches or doctors to develop personalized exercise plans and exercise.

The above studies mainly focus on falls, body changes and exercise guidance in the elderly. As a public health problem, falls have a high incidence and disability rate in both the United States and China. The incidence of falls in elderly women is about twice that of men, and falls can cause a variety of complications and increase the burden on families and society. Its causes involve physiological, environmental and psychological factors, such as physiological degenerative changes brought by age, anxiety and depression, fear of falling, etc., will increase the risk of falling. Among them, 50%-70% of the fall events occurred in the natural walking process. The elderly in the fall group had gait characteristics such as slow walking speed, increased stride

frequency and step length variability, and decreased balance ability was also the main cause of fall. The relevant balance ability test could be used as an indicator to predict fall. As for the physical changes and movement system of the elderly, there are problems such as osteoporosis, muscle mass reduction, functional degradation, joint cartilage wear and surrounding tissue degradation, which affect daily life and health, and need to be improved through aerobic exercise, weight training and reasonable diet. In the sensory system, visual, auditory and proprioceptive decline has a great impact on daily life and sports and fitness, and it is necessary to develop targeted rehabilitation training and fitness plans. Exercise guidance and precautions for the elderly are as follows: Assess your physical condition before exercise, especially for the elderly suffering from heart disease, high blood pressure and other diseases. Follow the principle of step by step, act according to one's ability and persevere. Exercise options such as walking, jogging and other aerobic exercise, moderate strength training, yoga, tai chi and other flexibility training. Exercise time in the morning, evening and afternoon can be, but there are points to pay attention to. In addition, warm up before exercise, avoid strenuous exercise, pay attention to the body at any time, moderate hydration, and the elderly with basic diseases have a good emergency remedy.

**2. Pilates**

**2.1 Development and function of Pilates**

Pilates is a sport founded in 1914 and named after its founder Joseph H.Pilates, and was first used to rehabilitate injured military personnel(Song,C.,&Wang,J.,2007). Pilates training can be divided into two types: mat training and machine training (Zhang,L.,&Yang, Y. 2009). In 1926, he established the Pilates studio in New York, the United States, and the famous New York Ballet company as neighbors. After 1928, it was mainly used for the rehabilitation training of ballet dancers and to improve the expression of dance movements. Mr. Joseph Pilates designed and built the first Pilates training machine, the Recombination Trainer, in the Isle of Man (Han,J.,2016).Over the course of his career, he has designed more than 600 different types of rehabilitation training using his own equipment. In 2000, Pilates project entered China, it has been 22 years, the development of Pilates project gradually hot.

Pilates has developed rapidly in clubs and training institutions, etc. In universities, there are also specialized basic courses that set Pilates into sports rehabilitation majors, and special courses for leisure sports majors, social sports majors and management majors, but they are not yet popular. The application of Pilates has been expanded, not only for rehabilitation training and dance, but also for auxiliary exercises in other sports and mass fitness. When training on the mat, the body contacts the ground in a large area, the body is more stable, applicable for beginners and the public. Machine training refers to the use of equipment to complete the movement. Equipment training is divided into large equipment training and props for training. Large equipment training mainly includes The equipment commonly used in Pilates includes:Reformer,Cadillac (Trapeze Table),Pilates Chair, Pilates Barrels, Magic Circle (Pilates Ring),Pilates Mat,Small Props that includes resistance bands, stability balls, yoga blocks, and foam rollers to enhance workouts.

**2.2 Pilates Principles**

Song Cuicui et al. (2007) studied the principles of Pilates and concluded that pilates exercise can integrate the respiratory system, maintain body posture, and increase body balance and coordination, thus achieving better health effects.Wu Zhenwei (2016) emphasizes the combination of the six principles of focus, precision, control, core, breathing and flow in Pilates practice. Gao Shili (2018) proposed that Pilates exercise is a fitness method mainly through coordinated breathing, focused attention and precise movements, and requires the Pilates exercise process to follow the principles of breathing, balance, coordination, control and concentration. Brooke Sailor (2019) pointed out that Pilates exercise is a more introspective and refined exercise system in which the whole body and mind are united, pursuing calm. It combines consciousness, balance, control, efficiency, function and coordination to achieve multiple goals such as improving the core strength of the human body, muscle flexibility, improving body posture, and creating a perfect body shape. Weng Jiayin et al. (2019) proposed that pilates exercise can relieve pressure and relax body and mind and improve the motor system and cardiovascular system in many aspects. Pilates is a fitness method that focuses on postural symmetry, core strength, breathing control, spinal and pelvic balance stability, muscle flexibility and joint flexibility (Han, J.,2016), which can help people achieve a state of physical and mental health.

Samantha Wood (2020) suggests that Pilates is an integrated approach with the ultimate goal of helping practitioners achieve a harmonious development of physical, mental and mental health. Combined with previous studies, Pilates in this paper is a kind of exercise program that exercises deep muscles of the human body, improves core control ability and balance ability, improves posture of the human body, strengthens the nervous system's control ability of limbs, promotes coordinated movement of the whole body, and achieves physical and mental health.

From the above, researchers agree that the principles and related functions of Pilates practice emphasize the control of nerves over muscles, muscle coordination, and the balance and stability of body posture. The ability to balance also emphasizes the control of one's own body posture and the maintenance of body stability, and the two are related to a certain extent. According to the physical and mental characteristics of the elderly, this study adopts pilates mat exercise to promote the development of balance ability of the elderly.

**3. Balance**

**3.1 Influencing factors of balance ability**

The Anthropometry and Evaluation team (1990) wrote in Anthropometry and Evaluation that "balance is the ability to maintain posture of the body, especially the ability to control the center of gravity of the body on small support surfaces".Balance ability refers to a posture of the body and the ability to automatically adjust the body posture and maintain such posture when exercising or being acted on by external forces (Wang Ruiyuan,2012). Nan Dengkun(2008) proposed in Rehabilitation Medicine that "balance is a kind of self-adjustment ability of body posture, which can maintain the posture and stability of the body when subjected to external forces or physical activities". According to the above definition, balance is the ability necessary for human movement, the ability to maintain posture and control body stability.

The factors affecting the balance ability of human body are very complex, so far, scholars at home and abroad have not explained in detail. At present, the balance ability is mainly divided into static balance ability and dynamic balance ability. The ability of static balance is a kind of function to maintain the stability of the body

posture. Homeostasis refers to the ability to maintain balance by adjusting one's posture during physical activity or when subjected to external forces.

Wang Xiuyang et al (2015) and other scholars proposed that balance ability is related to age, gender, BMI, physical exercise, test environment, sleep, drugs, dental health, etc. These factors influence and compensate each other. In the book "Sports Anatomy" edited by Hu Shengning (2000), it is believed that the sense of balance in human body comes from vestibular, visual and proprioception. Ren Zhibin et al (2021) emphasized that maintaining body balance must rely on the coordination of vestibular system, proprioceptive system and visual system as well as the integration of central nervous system functions. From the above, we can see that vision, vestibular and proprioceptive three systems are indispensable. Visual observation of the environment, collecting information to provide reference for the direction of body movement; The body sensory system helps the human body perceive the current position and posture, adjust the balance state and make compensation adjustment of the balance position; The vestibular organ is the most important neural terminal for the human body to sense its position and state. Zhang Yi&Wang et al (2022) and other scholars proposed that sports training can affect human balance ability. Peng Chunzheng et al (2023) and other researchers indicated that muscle strength is also a very important factor affecting balance ability.

Based on the above studies, it can be seen that balance ability is the human body's ability to coordinate responses to stimuli from vestibular organs, proprioception and visual organs, and is affected by many factors such as BMI, physical exercise and muscle strength, but some factors are controllable. Systematic and correct physical exercise can be used to improve body balance, adjust body weight, improve vestibular function, improve proprioceptive ability, enhance muscle strength and improve vision. Balance training is also a kind of training to strengthen the vestibular and proprioception of the human body. Balance ability is the basic quality of human movement.

**3.2 Test method of balance ability**

The test method of balance ability can be divided into static balance ability test method and dynamic balance ability test method. Static balance ability test methods include enhanced Romberg test (SR), closed eyes standing on one foot, etc. Dynamic balance ability test methods include walking in place with closed eyes, vertical X-column writing test, "balance beam" walking time (You,Y.,&Wen,A.,2014). Standing up and walking test (TUGT), star offset balance test (SEBT) (Sun,Q.2006), Bass dynamic balance test (Su,Y.,Zhang,S.,&Jin,X.2018), Y balance test (Zhang,P,&Long, D.et al 2018). Song Leilei (2016) pointed out that the balance ability of instruments can be tested by Win-pod balance tester, Tetrax balance training system and American Biodex sys balance system. Fan Chaoqun (2011) mentioned that among the non-test instrument measurement methods, the scales include Berg Balance scale and Morse Fall Risk Factor Assessment Scale.

Xiao Chunmei et al (2001) and other scholars made a comprehensive evaluation of the balance ability test methods for the elderly, and concluded that the proportion of standing on one foot with eyes closed was 37%, and the proportion of walking on balance beam was 30%, while the proportion before and after the improved Wolfson test was 18% and 15%, respectively, and pointed out that they can scientifically and comprehensively reflect the balance ability of the elderly. Without the need to rely on computerized dynamic balance machines. Chen Xiaoguang and Xiao Chunmei(2003) classified balance ability assessment methods according to different body postures of subjects, which mainly included: the ability to maintain a stable static posture without interference; The ability to maintain a static posture in the face of disturbance; The ability to maintain balance during active movement; The ability to maintain balance in the face of external disturbances during movement; And a comprehensive approach.Huo Hongfeng, Lin Jialong et al (2007) pointed out that "Standing up - walking" timing test is a commonly used balance scale in foreign clinical practice. Liu Chong et al (2009) pointed out that the “Stand up and Walk (GUGT)” time test can predict the fall risk, with a sensitivity and specificity of 0.87.Yuan Jinfeng et al (2013) mentioned that the measurement methods of balance ability usually include observation method, scale method and balance tester evaluation method, etc., and proposed standing on one foot with eyes closed as a test method for evaluating

national physical balance ability, which can test the balance ability of 60-69 year old people.Peng Nan, Zhou Ming et a (2014)] and other scholars compared several balance ability test scales and concluded that the "Standing and walking" timing test represented a negative correlation between the functional activity ability and walking speed of the elderly, which had a better correlation than BBS and FGA with walking speed, and was convenient for clinical application to test the dynamic balance ability and gait of the elderly. Li Yan and Huang Lihua (2019) pointed out that the Stand up and walk timing test (GUGT) is a common activity ability assessment method, which can measure the ability of elderly people to maintain balance while walking and help predict the fall risk of elderly people in the community. Shi Jianhua and Xie Kang(2020) concluded that only the balance beam test had significant differences and the test validity was the best through a comparative study of balance beam, standing on one leg with open eyes and strengthening Romberg balance test.

Many domestic scholars have also proposed that the balance ability of the elderly is related to their own balance confidence, with the increase of age or fall experience will affect the balance confidence of the elderly. Liu Haibing et al (2016) applied the activity balance confidence scale to the reliability study of the evaluation of chronic stroke patients, and emphasized that in addition to the comprehensive evaluation of balance function for hemiplegic patients, the assessment of patients' balance confidence in daily life should also be included. Chen Xiaochen, Xiao Yangyang, Pei Xianbo (2019) proposed that the lack of balance confidence in the elderly is a manifestation of the decline of balance function in the elderly. The elderly's balance confidence is enhanced, which can improve the compliance of the body to participate in daily activities. Guan Qiang et al (2011) showed that the Chinese version of activity balance Confidence Scale has good reliability and validity, and can effectively help elderly people in mainland China assess balance confidence and fear of falling.Wu Jing, Lu Yan et al (2021) and other scholars used the dynamic balance confidence scale to predict the value of falls of elderly residents in communities, and proposed the Activity Balance Confidence Scale (ABC), which mainly re1flects the balance self-efficacy of research subjects. Its homogeneity coefficient is 0.95 and stability

coefficient is 0.91, which has good reliability and validity, and can reflect the balance confidence of elderly people. However, the ability to assess fall risk is limited.

According to the above research, standing on one foot with closed eyes can be used to test the balance ability of the elderly aged 60-69 years in accordance with the national physical test standards. The balance beam walking test accounts for 30% of the balance ability test methods for the elderly, with high test validity, and can reflect the balance control ability of the elderly when disturbed during active movement. The standing and walking chronograph tests balance, functional mobility, and fall risk in older adults. It is an analysis of sitting, standing, and walking posture in older adults, and indirectly reflects their lower limb strength. Berg balance scale is often used in clinical assessment of the fall risk of elderly people in foreign countries, but the test time is longer, each elderly person needs about 20 minutes, and elderly people's tolerance fatigue affects the test effect. Compared with Berg balance scale, standing up and walking timing test is more applicable for the physiological characteristics of elderly people, and can also predict the fall risk. Therefore, this study pays attention to the combination of dynamic and static methods when selecting test methods. Starting from the vestibular, visual, physical, nervous and musculoskeletal system functions that affect balance ability, static balancing test methods are selected as standing on one foot with eyes open and standing on one foot with eyes closed, and dynamic balance ability is tested by beam walking test and standing up and walking timing test. Of course, the test of the balance ability of the elderly should pay attention to the test of the static and dynamic balance ability of the physiological, but also take into account the change of psychological balance confidence. The Activity Balance Confidence Scale (ABC), which focuses on the measurement of psychological dimension, has been verified by a number of scholars in China that it is an effective assessment tool for assessing balance self-efficacy and fall risk perception in the elderly. Therefore, the ABC scale was used to measure the balance confidence of the subjects aged 60-69 in this experiment. Combined with the static and dynamic balance ability tests, the changes of physical balance ability and psychological balance confidence of the elderly aged 60-69 were comprehensively tested and evaluated.

### 3.3 Balance ability of the elderly

The relevant domestic studies are in the same general direction, that is, to intervene the balance quality of the elderly with various exercise methods and exercise items. Experiments have shown that exercises such as brisk walking(Liu, N., Cui,W.,Tian,Y.,et al(2021),Tai chi(Li,X.,&Liu,H.,2021), square dancing and pilates(Gao,H.,Qu,F.Zhang,X.,et al,2019) can effectively improve the balance ability of the elderly. Wen, W., & Chen, T. et al (2021) also found in their study on elderly people with "mild cognitive impairment" that dance exercises can also interfere with their cognitive and balance abilities. Zhao Chenxi et al (2022) also found that the proportion of light physical activity and sedentary time in the daily life of the elderly were important factors affecting their balance ability, and those with more physical activity had relatively better balance ability.

In addition, the physiological characteristics of poor balance ability in the elderly make them a high-risk group of falls. Improving balance ability to prevent falls in the elderly has become an important direction of research. In studies on the prevention of falls in the elderly, the factors affecting falls are often divided into internal and external aspects, while the external factors are force majeure, and the internal factors include "balance ability, visual factors and chronic diseases". Li,J.,He,M.,&Ye,C. (2021), Xu Yumin et al (2016) even believe that balance ability can be used as a standardized index to measure the probability of falling and predict the risk of falling. Wang Xiaoxiao et al (2019) also believe that training for balance can effectively improve the balance ability of the elderly, so as to stabilize their movement pattern and reduce the risk of falling. Meanwhile, Zhang Qinglai (2021) used posture control ability to assess the fall risk of the elderly in his study, and pointed out that balance ability is a key element of posture control.

It can be seen from the above that reasonable exercise can improve the balance ability of the elderly and prevent them from falling. It is pointed out that balance ability is the key to posture control and the internal factor affecting falls. This also points out that balance ability is one of the factors that affect the healthy life of the elderly. This paper should further study the balance ability of the elderly and explore the effect of pilates exercise on the balance ability of the elderly.

Foreign countries closely focus on the physical function performance of the elderly to study the balance ability of the elderly, advocate the combination of various modes of movement, pay attention to the individual differences of the elderly and sports safety, emphasize the integration of physical medicine, research objects include patients suffering from cardiovascular and cerebrovascular diseases, aging, muscle attenuation syndrome, Alzheimer's disease, Parkinson's disease and other elderly diseases.For example,Li Fuzhong&Harmer,et al(2012) and other researchers concluded that Taijiquan has a significant effect on improving the balance ability and preventing falls of elderly patients with Parkinson's disease. Ambrose AF&Paul, G.& Hausdorff,et al (2013) proposed that the main risk factors for falls in the elderly are impaired balance and gait, and other risk factors include aging, environment, visual impairment, and decline in cognitive function, especially attention and executive dysfunction. Diego Urrunaga-Pastor et al (2018) and other scholars also proposed that balance ability is related to living altitude, and elderly people in high-altitude communities have poor balance ability. Exercise has been widely used by foreign researchers to improve the balance ability of the elderly. Beyranvand Ramin &Sahebozamani, et al(2018) studied 30 elderly men after 8-week water exercise intervention, and the results showed that compared with other lower limb joints, the improvement of proprioception of ankle joint played a more important role in improving the control ability of the elderly. It was suggested that in the exercise plan for improving the balance ability of the elderly, More consideration should be given to the special role of the ankle. Divya, J.& Kiruthika, et al (2018) also showed that ankle exercise was more effective in improving the static and dynamic balance of elderly people in the community. In addition to exercise intervention, we also pay attention to the impact of quality of life, cognitive resources and mental health on balance ability.Mohammadian Zahra et al (2019) improved the balance of the elderly through a 6-week shuttle balance balance exercise, increased walking speed and reduced the risk of falling. Krej i Milada et al (2019) analyzed the body balance index related to the quality of life index of the elderly, and pointed out that the body balance of the elderly over 65 years old is closely related to the SF-36 program, and the balance ability of the elderly is closely related to the quality of life. Li Han et al (2022) and other researchers conducted 12 weeks of cha-cha training for 40 healthy elderly

people, and the results showed that cha-cha is an effective exercise intervention, which can improve the balance ability of the elderly. Brahms Markus & Heinzel,et al (2022) and other scholars pointed out that cognitive resources contribute to balance control, while psychological exhaustion and reduced cognitive resources will reduce the balance ability of healthy elderly people.

Foreign studies have confirmed the effectiveness of exercise intervention in improving the balance ability of the elderly. In addition to the healthy elderly, foreign countries also pay attention to the balance ability of elderly patients with diseases, emphasizing the design of specific motor intervention for the elderly with impaired balance function. Foreign countries have closely linked the study of balance ability with the study of fall risk of the elderly, focusing on the combination of multiple sports, psychological and cognitive development to promote the development of balance ability of the elderly. Therefore, when studying the balance ability of 60-69 years old people, we should not only pay attention to the study of static and dynamic balance ability changes, but also take into account the balance confidence and psychological changes of the elderly.

**4. Related researches**

**4.1 Research on Pilates exercise and balance ability**

Pilates exercise itself has the principle of "balance" and "control", and in its specific training, it reflects the importance of balance and control ability of the body. In Liu Meiyun (2020) 's experiment on the influence of muscle strength and balance ability of young women, it was found that after 8 weeks of pilates training on the mat, both static and dynamic balance ability were significantly improved. Xu Jian (2013) also reached the same conclusion in his experiment on the influence of 25-40 year old female body static balance ability. In addition, Ruan Li&Xiao, L.et al (2014) concluded in their study on the special group of "deaf students" that the balance ability of Pilates core strength in deaf students was improved in the state of open eyes, but did not change in the state of closed eyes. Li Falin (2015) also limited the subjects to "female college students", and verified the significant difference in the balance ability of the subjects before and after the 14-week experiment with the test of "walking in a straight line". It is because of the characteristics of higher body fat and

weaker strength than men that women have become the "hot door object" in the research of balance ability.

As for the influence of Pilates on balance ability, many scholars have also made comparison and reference with other sports, and the results also show that pilates exercise can interfere with balance ability. Wen,W.(2011) connects Pilates with dance and verifies that the core, centripetal and centrifugal exercises of Pilates can play a good role in the balance quality of the body from the perspective of the science of human movement. Li Ruifang(2012) added Pilates as a training method to the aerobics teaching in colleges and universities, believing that many of its poses can effectively improve the balance ability and have a positive effect on the athletic performance of aerobics. Pilates's own focus on balance is also very similar to that of square dancing, which tends to be more dance-oriented. Li Yuquan et al (2016) combined the two to carry out comparative experiments, and the results showed that both of them could effectively improve the balance ability of elderly women.

According to the research results of the above scholars, Pilates is effective in improving people's balance ability, but there are still insufficient studies on the balance ability of the elderly, mainly targeting young people and women. The traditional idea is that the elderly are not applicablefor weight exercise, but in fact, appropriate weight-bearing exercise can effectively reduce the loss of bone density, prevent bone embrittlement and muscle decline, and is beneficial to maintain the healthy function of the body organs. Pilates exercise on the mat, the elderly activity center of gravity is low, mainly anti-weight exercise, exercise intensity and load size can be easily adjusted, the body contact pad surface is wide, the movement speed is slow, the muscle and joint damage is small, compared with other items more safe, more applicablefor the elderly group to use it for physical exercise.

Pilates exercise has strong functional characteristics, which is why most foreign studies on pilates exercise are applied studies, taking pilates exercise as a training means and functional intervention method for sports rehabilitation. Experiments have shown that pilates exercises can have a significant effect on the improvement of abnormal spinal curvature symptoms (GonzálezGálvez, et al 2022),(Ahmadi,F.,Safari, V.A.,Saadatian,A.,et al.,2021). And in such studies, the difference between the control

before and after the experiment is very obvious. In terms of rehabilitation, pilates exercise has also been used to intervene in the symptoms of lower back pain (Castro,J.B.P.d.,Lima,V.P.,Mello,D.B.d.,et al,2022), patellofemoral pain syndrome (Azab, A.R.,Abdelbasset,W.K.,Basha,M.A.,et al.(2022) and the development of knee deformity (Song,O.,Seo,K.,O'Sullivan,D.,&Park,J.(2021). At the functional training level, most of the studies focus on the degree of activation of specific muscle groups, and many of them take the physiological and mechanical theory as the theoretical perspective. Lee Kyeongjin et al(2021) found that the activation of the internal oblique muscle in Pilates core stability training was greater than that of the rectus abdominis muscle through myoelectric response, which confirmed that the function of emphasizing stability in Pilates exercise was actually concerned with the strength improvement of the deep muscles. In addition, Pilates related research results also show that it has a positive effect on the improvement of muscle endurance(Stanly,S. L.,Maniazhagu,et al,2021), pelvic floor muscle activation (Kannan,P.,Hsu,W.H.,Suen, W.T.,et al,(2022), and non-specific low back pain improvement(Alves,M.C.,Souza Neto, R.J.d.,Barbosa,R.I.,et al.,(2020). However, Samara Sousa Vasconcelos Gouveia et al (2022) 's study on the effect of respiratory muscle strength in Type II diabetic patients showed little effect. It can be seen that Pilates exercise has deep muscle activation function to a certain extent. However, the degree of expression in different types of people is different. Bagherzadeh Rahmani Behnam et al (2022) showed that 8 weeks of pilates or aqua-pilates training can improve lung function by about 34%, which can improve the respiratory capacity of people with a history of COVID-19. I.buulguroglu et al (2017) concluded that pilates can improve balance ability, functional flexibility, core stability, fatigue severity and quality of life in multiple sclerosis patients. McLaughlin and Emily Claire et al (2022) have shown that Pilates can improve osteoporosis, physical function, and quality of life, but there is limited evidence on the effects of pilates on BMD, falls, fractures, or adverse reactions. Sarashina,E.,Mizukami, K., Yoshizawa, Y., et al (2022) and other scholars advocate that pilates should be applied to exercise the frail elderly in the late stage to reduce the risk of falling. Choi Wonjae (2021) and other scholars emphasize that pilates exercise is a structured physical activity that has been proven to improve the physical function of the elderly, and is a beneficial exercise to improve the gait, muscle strength and

mobility of elderly women in the community. Scholars such as Teixeira de Carvalho Fabiana et al (2017) also indicated that pilates exercises can enhance the lower limb muscle strength of the elderly, which is very important for gait, posture stability and performance of daily living activities.

It can be seen from the above that muscle mass, strength and fitness decline during aging, and Pilates is an effective exercise method that can increase core muscle strength and endurance, improve flexibility, dynamic postural control and balance. In various sports intervention, pilates has been widely used in rehabilitation treatment, as an important training way to improve the physical quality of special groups.

**4.2 Research on Pilates and balance ability of the elderly**

The research results of Juliano Casonatto&Yamacita,C.M. (2020) and other scholars show that Pilates training program can be considered as an effective way to improve balance in the elderly. In addition, the length of the intervention, the number of pilates per week, and the quality of the study were not associated with the degree of impact on postural balance. Metz Vanessa Raque et al (2020) believe that pilates exercise can have varying degrees of influence on the physical function, quality of life and emotion of the elderly. Their experiments show that: After Pilates, the subjects' physical function and quality of life changed significantly, but their mental qualities such as emotion, autonomy and flexibility of thinking did not change significantly. As a typical group with poor balance ability, the elderly are at risk of injury and even death from falling easily. Studies have shown that falling is an important factor leading to the death of the elderly, and this phenomenon can be effectively improved by enhancing physical exercise (Fernández Rodríguez,R.,et al.,2021). Donatoni da Silva Larissa&McIntosh,C.et al (2021) in their study on the prevention of falls in the elderly through Pilates training, broke down the effects of Pilates into several levels: "fall risk, fall fear, postural balance, functional activity, spatio-temporal gait parameters, mobility and physical activity". It can be seen that most foreign scholars' studies on the balance ability of the elderly mainly focus on the prevention of falls, indicating that it is necessary to study the effect of Pilates on the balance ability of the elderly.

In summary, according to the relevant literature survey at home and abroad, Pilates can play an important role in developing various human qualities, enhancing body function and rehabilitation of injuries, pain and other diseases. The core and control of Pilates are closely related to the balance quality of the human body, that is, the deep muscle activation in Pilates exercise and the strengthening of the stability of the core muscle group can affect the balance ability. In domestic research, Pilates has been widely used in various situations, but whether it is used for rehabilitation or functional training, it has a certain impact on balance ability, and relevant foreign research also holds the same view. Domestic and foreign scholars are concerned about the prevention of falls in the elderly. Domestic scholars analyzed the "internal-external" factors of falls in the elderly, from the environment to the individual, from chronic diseases to drug use, and even taking into account cognitive ability and vision. It can be seen that these studies viewed this problem from a more comprehensive perspective - which provided rich and specific evaluation indicators for Pilates as the carrier of balance ability intervention research.

Foreign scholars pay attention to different angles. Many studies show that foreign scholars limit the phenomenon of elderly fall to the concept itself, and take the elderly as the designated object, clearly demarcating the level of influencing factors; At the same time, the idea of pilates training to prevent falls in the elderly has been clearly proposed in the study, which can be judged to be closely related to the effect of pilates on balance ability. Balance ability is not only an explicit body balance function, but also an implicit individual balance self-efficacy. His research mainly focuses on the comprehensive improvement of the body function of the elderly by Pilates. All these achievements provide scientific theoretical support for the research of this paper.

**4.3 Research on Balance Confidence**

Merrill R. Landers et al（2016） believes balance confidence was the best predictor of falling, followed by fear of falling avoidance behavior, and the “Standing up and walk timing test” after the prospective Analysis. Increasing balance confidence in older individuals is important towards improving their quality of life and reducing activity avoidance.Balance confidence is not often revealed during standard clinical

testing for balance and gait behaviors, however, which are often performed in a controlled environment(Rania Almajid et al 2020).

With increases in average life expectancy, the importance of improving and maintaining balance has significant societal relevance for the aging population .Lara A. Thompson et al (2021) concludes that falls are a major concern for all adults over 65 years old.

Balance confidence is considered a psychological element of falls and balance-demanding activities.The relationship of balance confidence with physical factors has been investigated.There was a significant correlation between the Activity Balance Confidence (ABC) Scale score and all physical and psychosocial measures (Zuhal Abasıyanık et al,2020). Except Zuhal Abasıyanık, there were a large quality of researchers also believe that ABC is the best scale to evaluate balance ability. The Activity Balance confidence (ABC) scale is a questionnaire developed to assess older individual's balance confidence in performing daily activities. ABC scale consists of a wide continuum of less and more challenging daily activities.

The ABC Scale was developed in 1995 using a convenience sample of 15 clinicians (physical and occupational therapists) and 12 physical therapy patients aged over 65 years. Is a structured questionnaire that measures an individual's confidence in performing activities without losing balance(Annabel Wildschut 2020).

The ABC Scale has 16 questions that require the patient to rate his/her confidence that he/she will not lose balance or become unsteady while performing the following activities:

Walking around the house

Walking up or down stairs

Bending over to pick up a slipper from the front of a closet floor

Reaching for a small can off a shelf at eye level

Standing on tiptoes and reaching for something above his/her head

Standing on a chair to reach for something

Sweeping the floor

Walking outside the house to a car parked in the driveway

Getting into or out of a car

Walking across a parking lot to the mall

Walking up or down a ramp

Walking in a crowded mall where people rapidly walk past

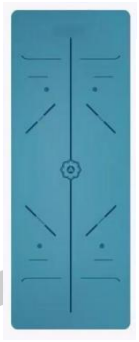
Being bumped into people as they walk through the mall

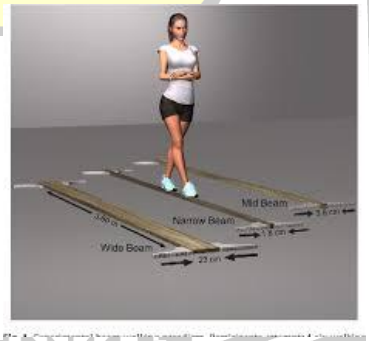
Stepping on to or off an escalator while holding onto a railing

Stepping onto or off an escalator while holding onto parcels (so that they are not able to hold the railing)

Walking outside on icy sidewalks

**Instruments**







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# CHAPTER III
# RESEARCH METHOD

This is an experimental study to study the effect of Pilates exercise on the static and dynamic balance and balance confidence on elderly.

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### 3.1 Research Objective and Subjects

The research's objective is the effect of Pilates exercise on the static & dynamic balance ability and balance confidence of the elderly. In this experiment, elderly individuals underwent assessments of static balance, dynamic balance, and activity balance confidence prior to the Pilates exercises. After completing the Pilates training, the same balance indicators were measured again. A comparison of the pre- and post-experiment data was conducted to examine whether Pilates exercise had a significant impact on the balance ability of the elderly participants. Using the elderly in Chongqing Hongshan Community Elderly Care Service Center as an experimental subject.

### 3.2 Research Methods

#### 3.2.1 Literature method

Through databases such as CNKI,PP,Science Direct etc., 19 core journals of Peking University, CSSCI and CSCD were searched with "Pilates" as the keyword, 92 core journals and 4 doctoral thesis were searched with "balance ability" as the keyword from 2017 to 2022. From 2010 to 2022, 145 core journals were searched with "elderly" and "balance ability" as keywords, and 11 literatures were retrieved with "Pilates" and "balance ability" as keywords, among which 2 core journals were searched. The current research status of pilates exercise and balance ability of elderly people was reviewed. Analyze the internal relationship between Pilates and balance ability. The foreign literature is mainly through ScienceDirect of science and SpringerLink English database platform. Search with keywords such as "Pilates", "balance ability", "Pilates and balance", "The balance ability of old people", Analyze

the relevant literature materials found to understand the development status of Pilates abroad and the research trend of the balance ability of the elderly, as well as the relevant research situation of the combination of the two to screen and sort them out, and consult relevant books in the school library: The Pilates Book, Pilates Anatomy, Pilates Rehabilitation Training, Elderly Exercise and Health Care, and Human Movement Balance provide theoretical basis for this study.

**3.2.2 Interview method**

Through face-to-face interviews, telephone interviews, WeChat interviews and other network interviews, 7 experts‘opinions were collected on whether the Pilates practice experiment plan proposed are reasonable, and whether the balance ability test indicators and methods are scientific (Appendix B). And according to the valuable opinions provided, the design of the experiment and the selection of experimental indicators were adjusted correspondingly. The interviewees and their basic information are shown in Table 1.

Table 1 Overview information of interviewee

| NO. | Name | Title | Workplace | Educational background | Research Direction |
|---|---|---|---|---|---|
| 1 | Expert A | Professor | Shanghai University of Sport | Doctor | Fall prevention and intervention in the elderly |
| 2 | Expert B | Professor | Chengdu Sport University | Master | Exercise rehabilitation, exercise intervention and health promotion |
| 3 | Expert C | Professor | Chengdu Sport University | Doctor | Exercise physiology, physical testing and evaluation |
| 4 | Expert D | Associate Professor | Chengdu Sport University | Doctor | Musculoskeletal exercise, rehabilitation, exercise and health |
| 5 | Expert E | Professor | Chengdu Sport University | Master | Exercise to promote the health of middle-aged and elderly people, Pilates |
| 6 | Expert F | Professor | Guangzhou Sport University | Doctor | Pilates, sports for females |
| 7 | Expert G | NONE | Dr.Bright Sport Rehab | Doctor | Pilates exercise, exercise rehabilitation |

### 3.2.3 Questionnaire survey method

3.2.3.1 Pilates practice content screening questionnaire

The selection table for Pilates poses was designed using the Likert 5-point rating scale, and it was iteratively modified and refined based on the results from expert interviews. The finalized "Applicability of Pilates Poses for Balance Training in the Elderly Selection Table" was then distributed to seven experts from the interviewed group for evaluation (Appendix C). The purpose was to identify applicable Pilates exercises for the experimental training content. The distribution and collection overview of the experts' questionnaires is presented in Table 2.

Table 2 Overview information of questionnaire distribution and collection

| Object | Qty Issued (copies) | Qty Collected (copies) | Valid Questionnaires (copies) | Questionnaire Collected Rate (%) | Valid Ratio (%) |
|---|---|---|---|---|---|
| Experts | 7 | 7 | 7 | 100 | 100 |

Questionnaire validity Testing: Based on the Likert 5-point rating scale, validity testing was conducted on the overall, structural, and content design of the "Applicability of Pilates Poses for Balance Training in the Elderly Selection Table." The purpose of this testing is to ensure that the questionnaire content is more scientifically sound and reasonable, the results are more objective and effective, and that the selection outcomes meet the requirements of the paper. The expert validity evaluation results for the questionnaire are shown in Table 3.

Table 3 The validity test result table of the questionnaire

| | Very Reasonable | Reasonable | Ordinary | Unreasonable | Very unreasonable |
|---|---|---|---|---|---|
| General design | 0 | 5 | 2 | 0 | 0 |
| Structure design | 1 | 4 | 2 | 0 | 0 |
| Content design | 1 | 5 | 1 | 0 | 0 |

Questionnaire Reliability Testing: The reliability of this questionnaire was tested using the test-retest method, aiming to ensure the reliability and stability of the questionnaire results. Three weeks after the initial distribution of the questionnaire, the same questionnaire was administered again to the seven experts. The results from both administrations were statistically analyzed for correlation using SPSS 24.0, yielding a Pearson correlation coefficient of 0.856. A reliability coefficient above 0.8 indicates that the reliability of this scale is fairly good.

3.2.3.2 Health questionnaire of the subjects

To select eligible elderly participants for the experiment, a health status questionnaire survey was conducted. The Mini-Mental State Examination (MMSE) accurately reflects the cognitive status and degree of cognitive impairment of subjects and is the preferred screening tool for dementia. The PAR-Q (Physical Activity Readiness Questionnaire) is applicable to individuals aged 15-69 and is designed to assess physical activity readiness. By answering the seven questions in the PAR-Q, participants will determine whether they need to consult a physician before beginning exercise; only those who pass this questionnaire can participate in the exercise.

Before the experiment, elderly individuals with cognitive and mental health issues were screened out using the MMSE (Appendix G). Subsequently, the PAR-Q questionnaire (Appendix H) was administered to the elderly individuals aged 60-69. Those who passed both screenings were eligible to participate in the experiment. The distribution and collection status of the questionnaires is presented in Table 4.

Table 4 Distribution and Collection Overview of the Survey Questionnaire

| Questionnaire Name | Quantity of copies distributed | Quantity of copies collected | Quantity of valid copies | Collection rate of the questionnaire (%) | Valid rate of the questionnaire (%) |
|---|---|---|---|---|---|
| Mini-mental State Examination (MMSE) | 56 | 56 | 54 | 100 | 96.4 |
| Physical Activity Readiness (PAR-Q) | 56 | 52 | 50 | 92.9 | 96.2 |

The Mini-mental State Examination (MMSE) was conducted prior to the experiment by Ms. You and Ms. Li, medical staff from the Hongshan Community Elderly Service Center in Chongqing, testing 56 elderly individuals aged 60-69 who volunteered to participate in the experiment. The elderly participants answered questions, and the medical staff scored their responses. The PAR-Q questionnaire was distributed on-site to the same 56 elderly participants, who responded to seven questions based on their personal situations, marking their answers with "√" for "Yes" or "No." The valid questionnaires collected from the MMSE and the Physical Activity Readiness Questionnaire (PAR-Q) were 54 and 50, respectively.

3.2.3.3 Survey on Activity Balance Confidence of Experimental Subjects

The Activity Balance Confidence Scale (ABC) is an assessment tool for individual balance confidence, consisting of 16 items related to daily indoor and outdoor activities. This study utilized the Chinese version of the ABC scale provided by Hong Kong Polytechnic University. To understand and evaluate the daily activity levels and balance confidence of the elderly individuals aged 60-69 participating in the experiment, the 48 elderly participants completed the Chinese version of the ABC scale questionnaire before the experiment, and 43 elderly individuals were evaluated after the experiment. Participants selected their percentage of balance confidence (0%-100%) based on their actual situation. A higher percentage indicates greater balance confidence, meaning that the elderly individuals feel more assured in maintaining their balance while engaging in these activities. The distribution and collection status of the ABC scale before and after the experiment for elderly individuals aged 60-69 is shown in Table 5.

Table 5 Distribution and Collection Overview of Activity Balance Confidence Scale (ABC)

| ABC Scale | Quantity of copies distributed | Quantity of copies collected | Quantity of valid copies | Collection rate of the scale (%) | Valid rate of the scale (%) |
|---|---|---|---|---|---|
| Before experiment | 48 | 48 | 48 | 100 | 100 |
| After experiment | 43 | 43 | 43 | 100 | 100 |

Initially 48 elderly individuals participated in the experiment, but during the process, 5 participants dropped out due to health and personal reasons. Ultimately, 43 elderly individuals completed the experimental content. Both pre- and post-experiment assessments were conducted by physicians holding elderly capability assessment certificates from the Hongshan Community Elderly Service Center in Chongqing. The physicians distributed the questionnaires and provided guidance on a one-on-one basis. Participants indicated their level of confidence in each activity by selecting a percentage from a scale of 0% to 100%, marking their choice with a "√" in front of the corresponding percentage box. Finally, a comparative analysis was conducted based on the pre- and post-experiment selections of the Activity Balance Confidence Scale (ABC) for elderly individuals.

**3.2.4 Experimental method**

Elderly individuals aged 60-69 from the Hongshan Community Elderly Service Center in Chongqing were selected as the experimental subjects. Based on the inclusion and exclusion criteria, 48 elderly individuals were screened and then randomly and evenly divided into an experimental group and a control group, with 24 participants in each group, regardless of gender. The experimental group engaged in Pilates exercises, while the control group continued their normal daily activities, with the experiment lasting for 12 weeks.

Prior to conducting the experiment on the impact of Pilates on balance ability in the elderly, both groups underwent assessments of their physical morphology indicators and pre-experimental balance ability levels. A difference test was performed to ensure that the capability levels of the two groups were comparable.

After the experiment, 5 participants who had dropped out were excluded, leaving 43 elderly individuals for subsequent testing of various indicators. The testing results were then compared and analyzed both within and between the groups.

**3.2.5 Mathematical statistics**

To compare the pre- and post-test results of balance ability in elderly individuals aged 60-69 from the Hongshan Community Elderly Service Center in Chongqing, as

well as the test results between the experimental group and the control group, the relevant data from the experiment were entered into the SPSS 24.0 statistical software. After processing, analyzing, and conducting difference tests on the pre- and post-data for both groups, the analyzed data for each group were expressed as mean ± standard deviation (x ± s).

Statistical graphs were then created using Graph Pad Prism 8.0. Within-group comparisons of pre- and post-test data used paired t-tests, while between-group comparisons between the experimental and control groups employed independent samples t-tests to assess significant differences. A p-value of $< 0.05$ indicated a significant difference between the two groups, while a p-value of $< 0.01$ indicated a very significant difference.

### 3.3 Experiment Implementation

#### 3.3.1 Experimental subjects

3.3.1.1 Selection of experimental subjects

By contacting Chongqing Hongshan Community Elderly Care Service Center, and recruit 60-69 at site.There were 56 elderly between 60 - 69 years old who volunteered to participate, in which 48 met the inclusion criteria and exclusion criteria. The proposed number of people for this experiment is 40, 20 people in each group. Considering there's possibility for elderly to drop out due to personal reasons, accidents, etc, therefore, considering a dropout rate of 20%, an additional 4 individuals were added to each group, resulting in 24 participants in the control group and 24 participants in the experimental group, for a total of 48 individuals selected. The screening criteria are as follows:

**Inclusion Criteria**

(1) Elderly aged 60-69 years;

(2) Physically normal, no major diseases or cognitive impairments, no contraindications for physical activity, able to participate in exercise and experimental procedures;

(3) Willing to participate and cooperate with the experiment, (for the experimental group only) declaring commitment to ongoing participation in Pilates classes, with family informed and consenting, and signing an informed consent form;

(4) Have not engaged in regular exercise for a long time;

(5) No falls in the past year, no injuries to the vestibular, proprioceptive, visual organs, or nervous system, and no stage 2 or above hypertension (for the classification of hypertension and risk levels, see Appendix L);

(6) Pass the Mini-Mental State Examination (MMSE);

(7) Pass the Physical Activity Readiness Questionnaire (PAR-Q) health screening.

Figure 2 Signing Informed consent form

Figure 3 (MMSE) Test

Figure 4 Explaining PAR-Q questionnaire

Figure 5 Blood Pressure Test

**2. Exclusion Criteria**

(1) History of other special medical conditions (such as heart disease, central nervous system diseases, vestibular disorders, severe mental disorders, etc.);

(2) Recent surgery, currently in recovery, or conditions that affect participation in exercise;

(3) Physical injuries (such as vertebral fractures, ankle fractures, arm fractures, etc.);

(4) Poor mental state (such as depression).

（5） The use of benzodiazepines, antiepileptic drugs or potent sedatives, etc. within the past six months (drugs that affect the nervous system related to balance;

（6） The dosage of antihypertensive or hypoglycemic drugs has been adjusted more than twice in the past three months.

**3. Dropout Criteria**

(1) Participants who have signed the informed consent form and passed the screening to enter the clinical trial but do not complete the experimental content or withdraw midway.

3.3.1.2 Sampling of Experimental Subjects

According to the screening criteria for experimental subjects, a total of 48 healthy elderly volunteers were selected, including 16 males and 32 females. They were assigned to the experimental group and the control group in the order of their registration, ensuring a balanced distribution of genders in both groups, with 24 participants in the experimental group and 24 in the control group. The control group maintained their existing exercise routines without intervention, while the experimental group underwent a Pilates intervention for a total of 12 weeks.

After the 12-week experiment, some participants were unable to complete the entire study due to health or personal reasons, failing to meet the study criteria. As a result, 5 participants dropped out,in which 3 from the Pilates group and 2 from the free activity group. Ultimately, there were 43 remaining participants: the Pilates

practice group had 21 participants (7 males and 14 females), and the free activity group had 22 participants (6 males and 16 females).

**3.4 Experimental time, location, and equipment**

Experimental time: July 1, 2024 to September 26, 2024, a total of 12 weeks. Pre-experimental tests were conducted on July 1 and July 2, and post-experimental tests were conducted on September 25 and September 26 to collect data. The training time was 12 weeks, twice a week (Tuesday and Thursday), 60 minutes each time. In order to take into account the time of the subjects, two Pilates exercise time periods were set for the subjects to choose, namely 9:30-10:30 and 15:00-16:00. If the subjects were unable to participate in the exercise on Tuesday or Thursday due to personal reason, they could freely choose to make up for the missed class hours that week in these two time periods on Friday to ensure the same weekly training volume.

Experimental location: Activity Hall of Hongshan Community Elderly Care Service Center, Baosheng Lake, Chongqing.

Experimental instruments: Pilates mat, stopwatch, height and weight measuring instrument, ruler, ground balance beam, chair, index test record sheet, signature pen, chalk.

**3.5 Experimental Test Indicators and Methods**

3.5.1 Main Physical Morphology Indicators Testing

Before the experiment, measurements of height, weight, and MMSE assessments were conducted for all 48 experimental subjects. Identification cards were checked to confirm age, and the collected information was organized accordingly. Detailed data can be found in Appendix K.

3.5.2 Balance Ability Test Indicators and Methods

As the elderly represent a special demographic, evaluating balance ability is more challenging than assessing other physical qualities, being influenced by multiple factors. To ensure the authenticity and objectivity of balance evaluation, and to adequately reflect balance ability, the experiment selected four balance test indicators

and one activity balance confidence scale after reviewing relevant literature, books, and expert interviews.

Static balance testing was based on the closed-eye single-leg stand balance test from the National Physical Fitness Measurement Standards, with an additional open-eye single-leg stand balance test included. The dynamic balance tests included walking on a balance beam and the timed Standing up and walk test. The activity balance confidence was assessed using the ABC scale. The open-eye single-leg stand reflects static standing balance, while the closed-eye single-leg stand eliminates visual influence, assessing the ability to maintain posture without interference, primarily evaluating sensory, proprioceptive, and vestibular functions. Walking on the balance beam is an effective method to detect body balance control during active movement when faced with external disturbances, reflecting dynamic and disturbance-resistant balance control ability and primarily testing proprioception. The Standing up and walk timed test combines lower limb strength, balance, and gait assessments to quickly and quantitatively evaluate the balance and functional ability of the elderly.

To ensure the safety of elderly participants during balance testing, medical personnel and safety assistants were arranged in advance, and adequate safety measures were implemented.

**1. Static Balance Ability Testing**

During the static balance ability testing, all experimental subjects underwent one-on-one testing in the same location, starting with the open-eye single-leg stand balance test, followed by the closed-eye single-leg stand balance test. Prior to testing, the area was cleared, and all subjects were required to remain quiet throughout the session to minimize interference and enhance the reliability of the data.

(1) Standing on One Leg with Eyes Open Balance Test

- Testing Equipment: Stopwatch, non-slip rubber mat

- Testing Method: The subject stands with both hands naturally at their sides, eyes open. To prepare, one leg is lifted, and the other is bent at the knee, with the toe touching the ground. When ready, the toe of the bent leg lifts off the ground, and

timing begins. The bent leg cannot rest against the standing leg, and the eyes can focus straight ahead. Timing stops immediately if the bent leg touches the ground, the standing leg moves, or if body sway exceeds 15%.

- Testing Requirements: The test is conducted indoors in a quiet environment, with participants barefoot. The test is recorded in seconds, conducted three times, and the maximum time is taken.

- Evaluation: The test duration is positively correlated with balance ability; longer standing time on single-leg with eyes open or closed indicates better balance. Detailed description was listed below:

(2) Standing on One Leg with Eyses Closed Balance Test

- Testing Equipment: Stopwatch, non-slip rubber mat

-Testing Method: Conducted according to the "National Physical Fitness Measurement Standard Manual." The subject stands in an anatomical position with palms facing forward. To prepare, one leg is lifted, and the other is bent at the knee, with the toe touching the ground. When ready, the toe of the bent leg lifts off, and the subject closes their eyes while timing begins. The lifted foot cannot touch anything. Timing stops immediately if the lifted foot contacts the ground, there is noticeable body sway, the support foot moves, or it rolls over.

- Testing Requirements: To improve data reliability, the test is conducted indoors in a quiet environment, with participants barefoot. The test is recorded in seconds, conducted three times, and the best result is taken.

- Evaluation: According to the results published in the "Fifth National Physical Fitness Monitoring Bulletin" by the National Physical Fitness Monitoring Center in December 2021, the average closed-eye single-leg stand times for elderly individuals (aged 60-69) are as follows: males aged 60-64 average 11.3 seconds, 65-69 average 10.3 seconds; females aged 60-64 average 10.9 seconds, 65-69 average 9.9 seconds.

Figure 6 Single leg standing balance test with opened eyes Test

Figure 7 Single leg standing balance test with closed eyes Test

**2. Dynamic Balance Ability Testing**

During the testing, all experimental subjects underwent one-on-one testing in the same location, conducted in sequence by the same instructor. Throughout the entire process, all subjects were required to remain quiet and actively cooperate in the testing.

(1) Ground Balance Beam Walking Test

Testing Equipment: Stopwatch, balance beam (3 meters long, 10 centimeters wide, 2 centimeters high), chalk

Testing Method: The participant stands at one end of the balance beam. Upon hearing the command "Start," they immediately begin to walk quickly, and timing starts at that moment. The participant walks to the other end, turns around, and walks back. Timing stops immediately if the toe of either foot crosses the "exit line." The time taken to walk back and forth once on the balance beam is measured.

Testing Requirements: Mark the exit point. All participants start from the same starting line, with the exit point kept consistent before and after testing. To ensure participants are familiar with the entire testing process, each elderly participant must practice once before the formal test. The test time is recorded in seconds, rounded to one decimal place. Each participant completes the test three times, and the maximum value is taken.

Evaluation: The test duration is inversely related to balance ability; shorter times to walk back and forth on the balance beam while maintaining normal body posture indicate better balance ability.

Figure 6 Ground Balance Beam Walking Test

(2) “ Standing up and walk” Timing Test

Testing Equipment: Chair, stopwatch, scoring sheet, measuring tape

Testing Method: Participants should wear their usual comfortable shoes and sit upright in a chair with a seat height of 45 centimeters and armrest height of 20 centimeters, with their back against the chair. A thick line is drawn in front of the chair as the first exit line, and participants must ensure their toes do not cross this line while seated. The second exit line is drawn 3 meters away from the first. When participants hear the command "Start," they stand up and walk 3 meters forward, turning around after crossing the second line, and sit back down in the chair with their back against the backrest. The timer records the time taken for the participant to leave the backrest, walk 3 meters forward, return, and sit back down with their back against the backrest, measured in seconds.

Testing Requirements: No physical assistance is to be provided during the test, but safety measures must be in place to prevent falls. Before the actual test, each elderly participant must practice once to ensure they understand the entire testing process, enhancing the accuracy of the results. The formal test consists of three trials, with the maximum time recorded. A one-minute rest period is allowed between tests. The tester should observe for any signs of instability, abnormal gait, or body deviation during the test.

Evaluation: Longer test times indicate higher fall risk. Detailed evaluation metrics are provided in Table 6.

Table 6 Evaluation Indicators of the“Standing up and Walk” Timing Test results

| Time indicator evaluation | Scoring criteria for gait and possible fall risk during the test | Normal reference time for age group |
|---|---|---|
| *h*<10sec :Free movement | 1 point: Normal | Age between 60-69：7.1∽9.0sec |
| *h*<20sec:Can move independently most of the time | 2 points:Very slight abnormality | Age between 70-79：8.2～10.2sec |
| 20-29sec:Unstable movement | 3 points::Mild abnormality | Age between 80-89:10.0～12.7sec |
| *h*>30sec:Movement disorder exists | 4 points: Moderate abnormality | |
| | 5 points: Severe abnormality | |

Figure 7 “Standing up and Walk” Timing Test

**3.6 Experimental process**

1. Pre-experiment: A two-week pre-experiment was conducted from June 17 to June 30, 2024. In the pre-experiment, three 69-year-old and one 68-year-old were recruited according to the screening requirements of subjects, and the pre-experiment

test, two weeks of Pilates related posture practice and post-experiment test were conducted. The pre-experiment results showed that the elderly could smoothly complete the four balance ability tests, but due to the short practice time, the balance ability of the elderly did not change significantly after the experiment. The pre-experiment also tested whether the content of Pilates poses selected after literature review and expert interview was actually consistent with the exercise of 60-69 year old people. In the pre-experiment, each class practiced 3-4 individual poses, each pose 6-10 times, do 2 sets, 4 classes in two weeks to complete the practice test of Pilates poses for the elderly. According to the actual completion of Pilates poses by 4 elderly people, Supine Spinal Twist and Roll up postures were eliminated, and the other 13 individual poses could be completed by 4 elderly people. During the pre-experimental process, it was found that to better monitor exercise intensity and ensure the safety of elderly participants, the following methods could be implemented: 1) Observation Method: This involves observing the facial expressions of elderly participants, their breathing rate, and whether they are lightly sweating. 2)Self-Perception Method: Participants should be informed in advance to immediately communicate any discomfort they experience during the exercises. Instructors should also frequently ask about the participants' feelings regarding the exercise. 3)Heart Rate Monitoring: By combining the observation method and feedback from the elderly participants about their exercise experiences, measuring their heart rate for 10 seconds can help in better controlling exercise intensity.

2. Basic Information Collection: Before officially starting the experiment, the primary physical morphology data and other relevant information of the experimental subjects were collected. Additionally, pre-tests were conducted for both groups of subjects. Based on the pre-test data for the static and dynamic balance abilities, independent samples t-tests showed no statistically significant differences in balance ability between the two groups ($P > 0.05$).

3. Experimental Schedule: This experiment divided the Pilates practice into three phases.

- Phase One (Weeks 1-4): Basic Adaptation Period. During this phase, participants primarily learned lateral breathing, abdominal breathing, and nasal

breathing techniques, along with adaptive exercises transitioning from sitting to standing positions and starting supine positions with a larger contact area on the mat. The focus was on simple, low-intensity movements. The purpose was to help the elderly adapt to Pilates practice, experience the control of their bodies through the nervous system and muscles, and grasp the basic principles and movement requirements of Pilates.

- Phase Two (Weeks 5-8): Progressive Improvement Period. Following a gradual progression principle and building on the foundation established in Phase One, this stage included movements with larger ranges of motion and various trajectories, increasing the difficulty and requiring some core strength. In this phase, seniors practiced larger and more varied movements, enhancing the nervous system's control over the muscles, maintaining precision and stability in movements, thereby improving the coordination control of proprioceptors, vestibular organs, and the nervous system. This progression was beneficial for enhancing the elderly participants' core strength and balance abilities.

- Phase Three (Weeks 9-12): Consolidation and Development Period. This phase centered on the movements from Phase Two and included the single-leg lift from the kneeling position learned in Phase One, along with newly added single-leg extension exercises. The practice progressed from small to larger ranges of motion, from single trajectories to multiple trajectories, and from low to moderate loads in compound movements. This further deepened the stimulation of the participants' muscle and nervous sensory systems, maintaining correct movements and the proper alignment of the kinetic chain, enabling a more fluid and coordinated integration of movement with the body, enhancing the efficiency of the mind-body connection, and promoting a harmonious unification of body, mind, and spirit. This approach aids in improving the elderly's control, balance, and coordination.

4. After the Experiment: Data collection for balance ability testing was conducted post-experiment. After completing the Pilates exercises, the same testing methods were employed once again to collect data. The pre-test and post-test data were analyzed and compared both inter-group and intra-group to derive experimental results and evaluations.

### 3.7 Experimental Content

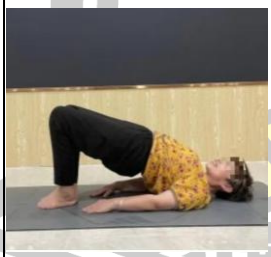
3.7.1 Pilates practice content

In this experiment, the Pilates practice content was primarily selected based on interviews and literature to identify applicable Pilates movements for elderly individuals. Following the characteristics of older adults and the principles of physiological adaptation, gradual progression, and holistic approaches, the Pilates practice was organized reasonably.

The practice load and movement difficulty were structured from easy to more challenging, primarily utilizing moderate to low-intensity exercises. The arrangement of poses emphasized both overall participation and symmetry, ensuring that all body parts were engaged while also addressing specific balance issues common among the elderly. This included strengthening core muscle strength, lower limb strength, and ankle joint stability while maintaining a focus on the comprehensiveness, scientific basis, and rationality of the practice content.

Therefore, this study initially identified 20 Pilates poses with varying starting positions based on literature and the aforementioned requirements. These 20 poses were then categorized and ranked. Experts were interviewed to evaluate the suitability of each pose for balance training in elderly individuals, using a scale of "Very Applicable, Applicable, Averagely Applicable, Not Quite Applicable, Not Applicable at all," with a checkmark ("√") corresponding to their assessment. Experts were invited to share their opinions freely during the discussions, with further details available in Appendix C. Based on the collected evaluations from experts, the top 15 Pilates movements were selected, with more details provided in Appendix D. However, following the results of the pre-experiment and the actual completion status of the subjects, only 13 of these poses were ultimately adopted for the main experiment. Specific information about these poses can be found in Table 7, and detailed movement requirements for the Pilates exercises are available in Appendix E.

Table 7 List of Pilates Exercise Contents

| NO. | Posture Name | Exercise purpose/effect | Contraindications and precautions |
|---|---|---|---|
| 1 | Breathing | Breathing makes people focus, helping the elderly to master their inner rhythm, relax their body and mind, and calm their mind. | Avoid hyperventilation, breath holding and holding your breath; the breathing speed should be consistent with the form and rhythm of the movements. |
| 2 | Windmill (standing  position) | Increase body coordination, improve shoulder and back circulation, and increase body stability and control. | Elderly people who experience pain or problems during shoulder and lower back exercises should practice with caution. |
| 3 | Glute bridge (supine position)  | Strengthens the back extensor muscles, gluteal muscles, and hamstrings; improves spinal flexibility and strength. Strengthen the core control. | When falling, the movement of the spine is emphasized section by section. If you feel uncomfortable in your waist, you should slow down the movement or return to the starting movement. Note that when you raise your hips, your knees can easily open outwards. Make sure your knees and toes are in the same direction, so that both feet receive equal |

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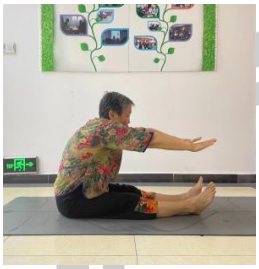
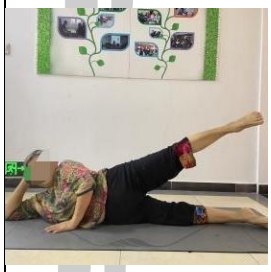
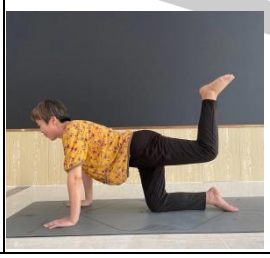
| | | | force. |
| 4 | Spinal extension<br>  <br>(sitting postion) | Stretches the spine, stimulates deep back muscles, and promotes spinal flexibility and core stability. | Those with lower back or hip problems can do knee bending exercises to reduce pressure on the lower back and hips. |
| 5 | Side leg raise（side-<br>  <br>lying position) | Strengthen the outer thigh muscles, improve hip and pelvic stability and leg control. | People with sciatic nerve problems or other hip joint diseases should exercise caution. |
| 6 | Single leg balance (standing position)<br>  | Tighten the core of the waist and abdomen to enhance the control of the hip, knee, and ankle joints and the stability of the lumbar and pelvic area. | Avoid tilting the pelvis, change the position of the back, do not move too fast, tighten the core of the waist and abdomen, control the coordination and stability of the lower limbs, and lift the legs alternately at a constant speed. |
| 7 | Kneeling position<br>  | Strengthen the stability of shoulder joints, knee joints and core, strengthen hip and thigh muscles, and improve lower | Tighten your abdomen to avoid back and lumbar pain caused by slumping. Pay attention to when lifting one foot, control the lower limb on a flat |

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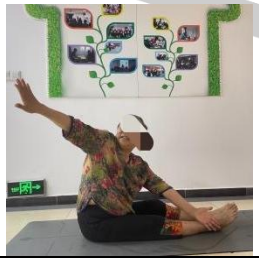
| | with one leg raise | limb strength. | surface, and then lift it upward. |
| 8 | Prone hip lift (prone  position) | Improve pelvic stability, strengthen hip abduction, External rotator muscles, improve hip circulation. If you experience back pain during practice, stop practicing immediately. | Check whether there is any error in the operation. Those with hip joint problems will be less likely to Small range of motion and reduced reps. |
| 9 | Four-legged swimming  (kneeling position) | Strengthen the strength and awareness of lumbosacral stability and increase Pelvic and hip dynamic stability. | Avoid swinging your weight from side to side on your shoulders and hips when practicing. Stabilize your core and focus on extending your hands and feet far away without It's elevation. |
| 10 | Side Leg Circles(side-lying position)  | strengthen hip abduction and external rotation muscles and improve your torso.Stabilize the shaft and pelvis in lateral decubitus position. | People with shoulder and neck problems can place a towel under their head to reduce neck pressure. People with hip problems can reduce the range of motion and the number of repetitions. |
| 11 | Sitting and upper  | Improve spinal rotation, balance muscle tension on both sides of the back, and stretch the hamstrings on the back of the thigh. | Keep the pelvis in the same position when turning the body and stretching forward. People with herniated disc or osteoporosis should |

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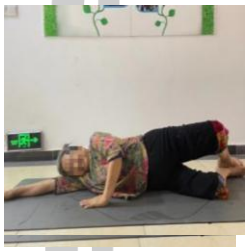
|---|---|---|---|
| | body rotating | | practice with caution. |
| 12 | Simplified The<br>  <br>Hundred (supine and knees bending) | Strengthen the abdominal muscles and tighten the core muscles; strengthen movement coordination and improve shoulder girdle and trunk stability. | If you have neck or shoulder injuries or pain, you can adjust the difficulty and place your hands behind your headrest. |
| 13 | Clam opening and closing (side-lying<br>  <br>position) | Strengthen the hip external rotation muscles, enhance pelvic stability, and tighten the buttocks. | Elderly people with hip joint problems should practice with caution. During the exercise, keep your pelvis in a neutral position and do not tilt it backwards. |
| 14 | Single leg extension (supine position)<br>  | Improve pelvic stability and core control, knee, ankle, and hip joint stability and coordination. | If you feel discomfort in your waist or experience pain or weakness in your waist during practice, you should stop practicing. |

3.7.2 Pilates exercise program for assessing its impact on balance ability in the elderly

The Pilates practice course is primarily divided into three parts:

(1) Warm-Up (10 minutes): This section involves activities that mobilize the upper and lower limbs, including the shoulders, neck, spine, hips, knees, and ankles, to activate the relevant muscles.

(2) Learning and Practicing Pilates Content (45 minutes): Each session includes a 5-minute focus on breathing techniques, aiming to shift from shallow and rapid chest breathing to deep and slow abdominal breathing. Additionally, the nasal breathing technique coordinated with the "Hundred" exercise is practiced to enhance the elderly participants' control over their breathing. This helps them experience changes in body stability during breathing, allowing for a smoother entry into the practice and better integration of movement and breath, thus increasing the effectiveness of the exercises. The specific poses practiced in each class are adapted for the elderly, progressing from easier to more challenging movements. Initially, modified or scaled-down exercises are performed, and once the elderly participants have adapted, they move on to the full poses, emphasizing precision and control of the movements.

(3)Stretching and Relaxation (5 minutes): This section focuses on static stretching, performed at a moderate intensity without causing significant pain, allowing for a slow and gentle stretch of the muscles.

The determination of the appropriate intensity for Pilates exercises for the elderly is based primarily on the following methods:

- Target Heart Rate Method: Using the Karvonen formula to establish an appropriate target heart rate for elderly participants during exercise.

- Self-Perception Method: Assessing the subjective feelings of participants and inquiring the next day if they experience any discomfort, pain, or fatigue.

- Observation Method: Observing the participants' overall condition during the exercises.

Given that elderly individuals represent a special population, adjustments to the exercises must be made based on their actual conditions. The teaching plan for Pilates exercises in the experimental group can be found in Appendix F, and the Pilates practice program is detailed in Table 8.

Table 8 Pilates exercise program

| NO. | Posture Name | Exercise load | Interval time | Exercise weeks |
|---|---|---|---|---|
| 1 | Breathing | 5 minutes | none | 1-12 weeks |
| 2 | Windmill (standing position) | 6-8 times/2 sets, alternating between left | 15 seconds | 1-12 weeks |
| 3 | Glute bridge (supine position) | 6-8 times/2 sets | 15 seconds | 1-12 weeks |
| 4 | Spinal extension (sitting position) | 6 times/2 sets | 15 seconds | 1-4 weeks |
| 5 | Side leg raise (side-lying position) | 6-10 times per side / 2 sets | 15 seconds | 1-4 weeks |
| 6 | Single leg balance (standing position) | 15 times/3 sets, alternating left and right | 15 seconds | 1-4 weeks |
| 7 | Kneeling position with one leg raised | 6 times per side / 2 sets | 20 seconds | 1-4 weeks & |
| 8 | Prone hip lift (prone position) | 6-8 times/2 sets, alternating left and right | 15 seconds | 5-8weeks |
| 9 | Four-legged swimming | 6 times per side / 2 sets | 15 seconds | 5-8weeks |
| 10 | Side leg circles (side-lying position) | 6-8 times per side / 2 sets | 20 seconds | 5-8 weeks |
| 11 | Upper body rotating (sitting position) | 6 times/2 sets, alternating left and right | 15 seconds | 5-12 weeks |
| 12 | Simplified The hundred (supine and | Pump up and down 20-30times/2sets | 30 seconds | 5-12 weeks |
| 13 | Clam opening and closing (side lying | 10 times per side / 2 sets | 20 seconds | 5-12 weeks |
| 14 | Single leg extension (supine position) | 6 times/2 sets, alternating left and right | 20 seconds | 5-12 weeks |

**3.8 Experimental Control**

In this experiment, the dependent variables are the changes in static balance ability, dynamic balance ability, and scores from the Activity Balance Confidence

Scale in elderly individuals. The independent variable is the Pilates mat exercises and the 12-week duration of the intervention. Efforts will be made to control other factors that may influence the experimental results.

1. Pre-Experiment Control:

(1) Basic Knowledge Introduction: Prior to the experiment, participants will receive a theoretical introduction to help them understand the content of their practice, including the origins, characteristics, principles, functions, and significance of Pilates for the body. Emphasis will be placed on safety precautions during Pilates practice. Through professional, specific guidance, individual assessments, and recognition and encouragement of participants' efforts, the goal is to increase their motivation and trust in the experiment, resulting in a better adherence to the program for improved experimental outcomes.

(2) Consistent Testing Methods: The methods, indicators, locations, and tools for testing balance ability for both groups will be the same, conducted by the same instructor. The balance ability tests will be administered by the testing instructor, while support personnel will oversee the recording of results. Pre-experimental testing will show no significant differences between the two groups regarding their balance ability metrics.

(3) Communication with Participants: Prior to the experiment, participants will be informed that aside from the twice-weekly Pilates sessions, they should not engage in other forms of balance training nor privately increase their Pilates practice duration during the experimental period.

2. In-experiment Control:

(1) Attendance Monitoring: Attendance will be recorded for each Pilates session. Elderly participants who miss a session due to special circumstances can make up for it during one of the two time slots on Fridays, ensuring that all participants have the same practice duration and frequency. The practice will take place indoors, unaffected by weather conditions.

(2) Individual Attention: Based on the results of the PAR-Q questionnaire and the Mini-Mental State Examination, the physical and mental conditions of the participating elderly individuals meet the required standards. Each participant will receive attention, guidance, and assistance during the exercises. The 24 elderly participants will be divided into two groups for Pilates sessions, with morning sessions from 9:30 to 10:30 AM and afternoon sessions from 3:00 to 4:00 PM, allowing for more guidance for those with weaker abilities to ensure that everyone can successfully participate and complete the exercises, thus maintaining the quality and effectiveness of the experiment as much as possible.

(3) Control of Exercise Intensity: The exercise intensity will primarily be moderate to low. The target heart rate will be calculated as: Target Heart Rate = (Maximum Heart Rate - Resting Heart Rate) × K + Resting Heart Rate. Here, Maximum Heart Rate is determined by the formula 220 - age; for the 24 elderly participants, the average resting heart rate is 76 beats per minute. The K value will be set at 50%-70% (for elderly individuals and beginners). K represents the percentage of target training intensity. Based on calculations, the target heart rate will be maintained between 113.5 and 128.5 beats per minute, while (220 - age) × 80% will serve as the safety threshold for heart rate during exercise.

During Pilates practice, the instructor will observe each participant's condition, including facial expressions, breath rate, and sweating. Two participants will be randomly selected to monitor their heart rates for 10 seconds to assist in controlling exercise intensity. In addition, instructors will regularly inquire about participants' subjective feelings, reminding them to report any discomfort such as unstable breathing or rapid heart rates, allowing for immediate action if necessary. The instructor or on-site medical personnel will promptly check the heart rate for 10 seconds, communicate with the participant, reduce exercise intensity, increase rest periods, and keep their heart rates below the safety threshold while maintaining continuous monitoring.


Figure 8 Practice guidance during experiment

(4) Medical Monitoring: For each Pilates practice session, the Hongshan Elderly Service Center will have a medical staff member present on-site to ensure participants' safety during the exercises.

3. Post-Experiment Control: The measurement tools, testing standards, personnel, test locations, and environmental conditions used for the pre- and post-test balance ability assessments for both groups will remain consistent throughout the experiment.

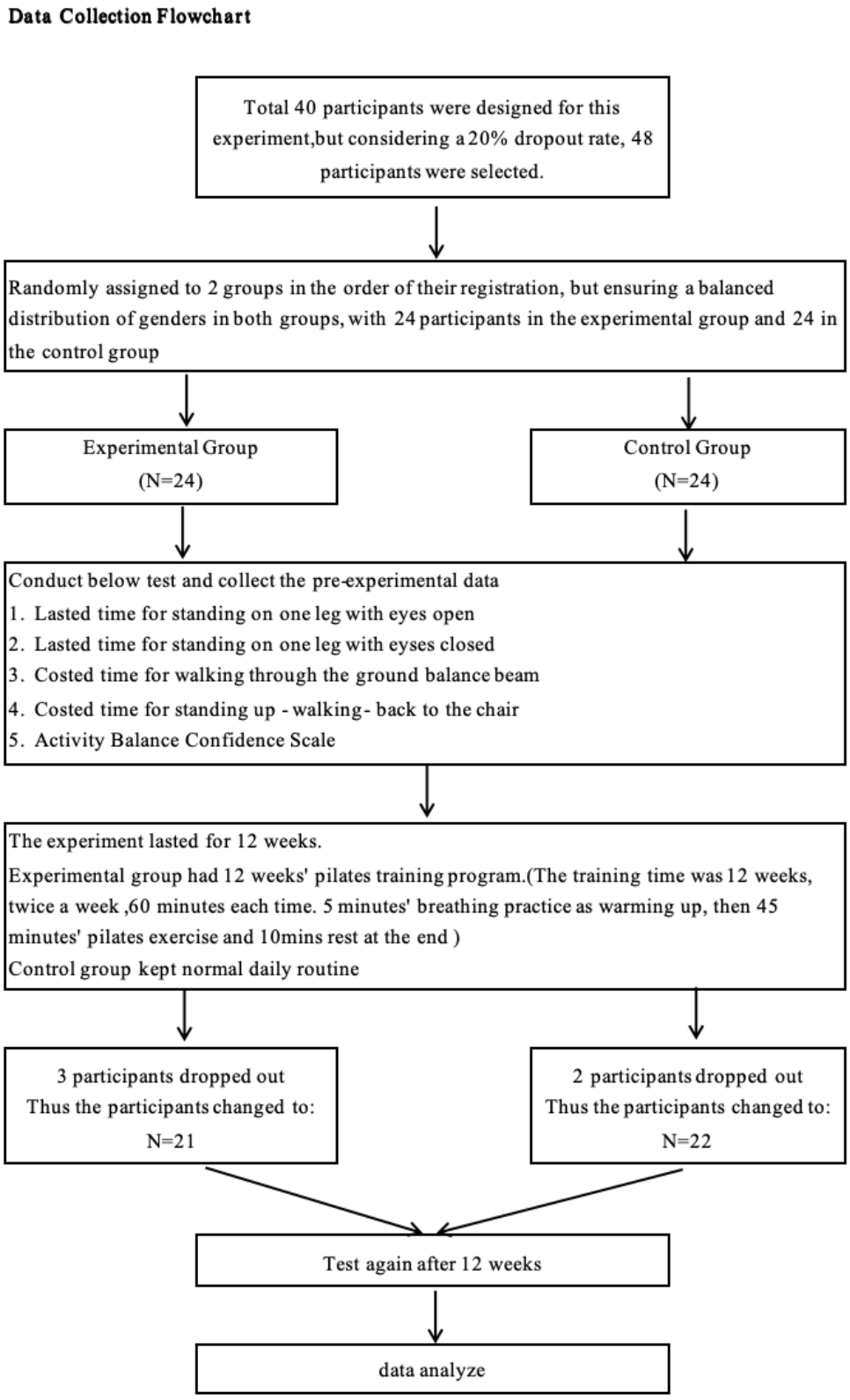



Figure 9 Data Collection Flowchart

# CHAPTER IV
# EXPERIMENTAL RESULTS AND ANALYSIS

This chapter mainly analyzes the test results of pilates exercise on static balance ability, dynamic balance ability and balance confidence of the elderly.

1. Symbols used in data analysis
2. The steps of data analysis results
3. Data analysis results

**Symbols used to present the results of data analysis:**

s Represents time unit: seconds

n Reoresents the sample size

($\bar{x}$±s) Represents the average value and its standard deviation range

P Represents significance value

Intra-group Represents within groups

Inter-group Represents between groups

**The steps of data analysis results**

1. Calculate the average and standard deviation of the time spent on the 4 tests of two groups: standing on one leg with eyes open and closed, Ground balance beam walking and Standing up and walk timing test. As well as the balance confidence questionnaire results.
2. Compare the data before and after the experiment within groups
3. Compare the data before and after the experiment between groups

**Data analysis results**

Table 9 Basic information of subjects

| Group | Age (years) | Height (*cm*) | Weight (*kg*) | BMI ($kg/m^2$) | MMSE (points) |
|---|---|---|---|---|---|
| Experimental Group (*n*=21) | 64.43±2.87 | 158.03±6.39 | 59.93±5.81 | 23.98±1.58 | 28.29±0.85 |
| Control Group (*n*=22) | 64.27±2.91 | 158.82±6.79 | 59.01±6.42 | 23.32±1.03 | 28.27±0.88 |
| *F-Value* | 0.010 | 0.737 | 0.162 | 1.981 | 0.001 |
| *P-Value* | 0.861 | 0.687 | 0.622 | 0.113 | 0.961 |

After conducting homogeneity of variance tests and independent samples t-tests, there were no statistically significant differences between age, height, weight, BMI, and MMSE scores of elderly individuals aged 60-69 years (P > 0.05).

Table 10 Comparison of static balance ability, dynamic balance ability and balance confidence of the elderly within and between groups before and after 12 weeks' experiment

| | | | Control Group (*n*=22) (mean±SD) | Experimental Group (n=21) (mean±SD) | *P-Value* |
|---|---|---|---|---|---|
| Standing on left foot with eyes open | Before (*s*) | Experiment | 22.29±4.57 | 21.67±3.27 | 0.612 |
| | After Experiment (*s*) | | 21.53±4.28 | 28.34±5.11 | <0.001 |
| | *P-Value* | | 0.113 | <0.001 | |
| Standing on right foot with eyes open | Before (*s*) | Experiment | 24.57±5.01 | 23.16±6.00 | 0.412 |
| | After Experiment (*s*) | | 23.44±4.27 | 30.16±5.84 | <0.001 |

| | | | | | |
|---|---|---|---|---|---|
| | *P-Value* | | 0.095 | <0.001 | |
| Standing on left foot with eyes closed | Before （*s*） | Experiment | 5.34±1.20 | 5.20±1.24 | 0.722 |
| | After Experiment（*s*） | | 5.20±1.43 | 6.19±1.22 | 0.019 |
| | *P-Value* | | 0.251 | <0.001 | |
| Standing on right foot with eyes closed | Before （*s*） | Experiment | 5.37±1.35 | 5.60±1.55 | 0.604 |
| | After Experiment（*s*） | | 5.35±1.18 | 6.49±1.73 | 0.015 |
| | *P-Value* | | 0.887 | <0.001 | |
| Ground Balance beam walking test | Before （*s*） | Experiment | 8.26±0.98 | 8.23±1.36 | 0.916 |
| | After Experiment（*s*） | | 8.31±1.13 | 7.45±1.23 | 0.022 |
| | *P-Value* | | 0.639 | <0.001 | |
| “stand-up and walk” timing test | Before （*s*） | Experiment | 8.46±0.74 | 8.65±0.81 | 0.445 |
| | After Experiment（*s*） | | 8.53±0.78 | 7.93±0.85 | <0.021 |
| | *P-Value* | | 0.546 | <0.001 | |
| Activity Balance Confidence(ABC) scale index | Before （*s*） | Experiment | 16 Items | 16 Items | P＞0.05 |
| | After Experiment（*s*） | | 16 Items | 16 Items | P＜0.05 |
| | *P-Value* | | P＞0.05 | P＜0.05 | |

**4.1 Within and between groups comparison of the static balance tests results of standing on one leg with eyes open and standing on one leg with eyes closed**

As shown in Table 10, results of Standing on one leg with eyes open balance test: In the experimental group, the standing time of left and right leg with eyes open before and after the experiment was significantly increased ($P < 0.01$), while there was no significant change in the control group ($P > 0.05$). After the experiment, the experimental group's standing time with eyes open on one leg was significantly better than that of the control group ($P < 0.01$).

As shown in Table 10, results of Standing on one leg with eyes closed balance test: When within group comparison was used, the standing time of left leg and right leg with eyes closed in the experimental group was significantly increased before and after the experiment ($P < 0.01$), while there was no significant change in the control group ($P > 0.05$). After the experiment, the time of standing on one leg with eyes closed in the experimental group was significantly better than that in the control group ($P < 0.05$).

From the above 2 test results, it could be told that Pilates exercise significantly helped improving the static balance ability of the elderly, especially in the closed eye state, indicating that pilates has a positive effect on vestibular receptors and central nervous system regulation.

**4.2 Within and between groups comparison of the dynamic balance tests results of ground balance beam walking test and standing up and walking timing test**

As shown in Table 10 and Figure 12, the result of the ground balance beam walking test in the experimental group was significantly shortened before and after the experiment ($P < 0.01$), while there was no significant change in the control group ($P > 0.05$). After the experiment, the walking time of the balance beam in the experimental group was significantly better than that in the control group ($P < 0.05$).

As shown in Table 10 and Figure 13, the results of standing up and walking timing test showed the experimental group significantly shortened the standing up and walking time before and after the experiment ($P < 0.01$), while the control group had no significant change ($P > 0.05$). After the experiment, the "standing up and walking"

time of the experimental group was significantly better than that of the control group ($P < 0.05$).

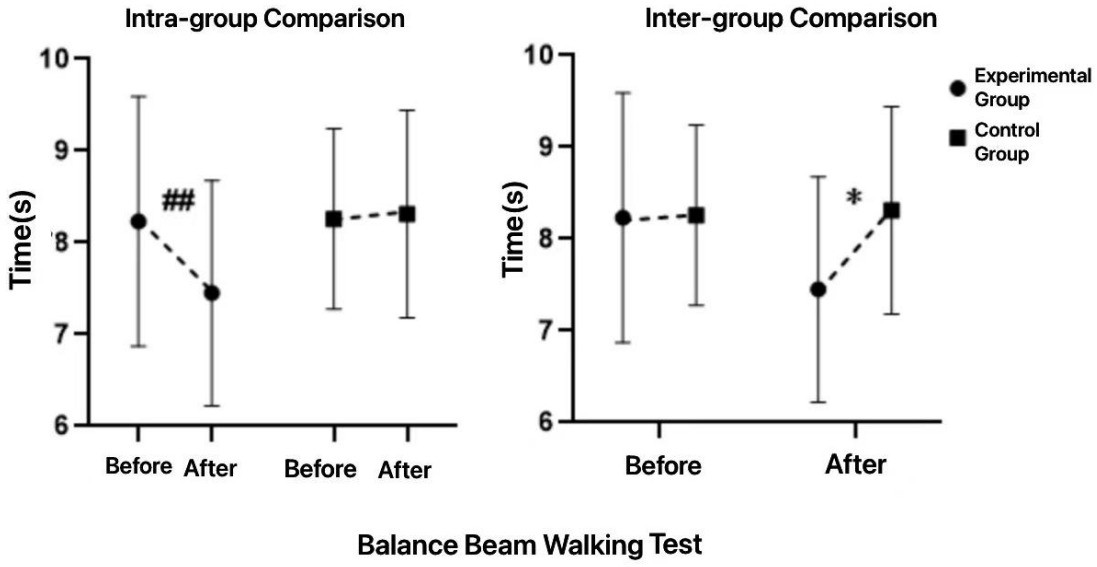



Figure 10 Comparison of ground balance beam walking test results

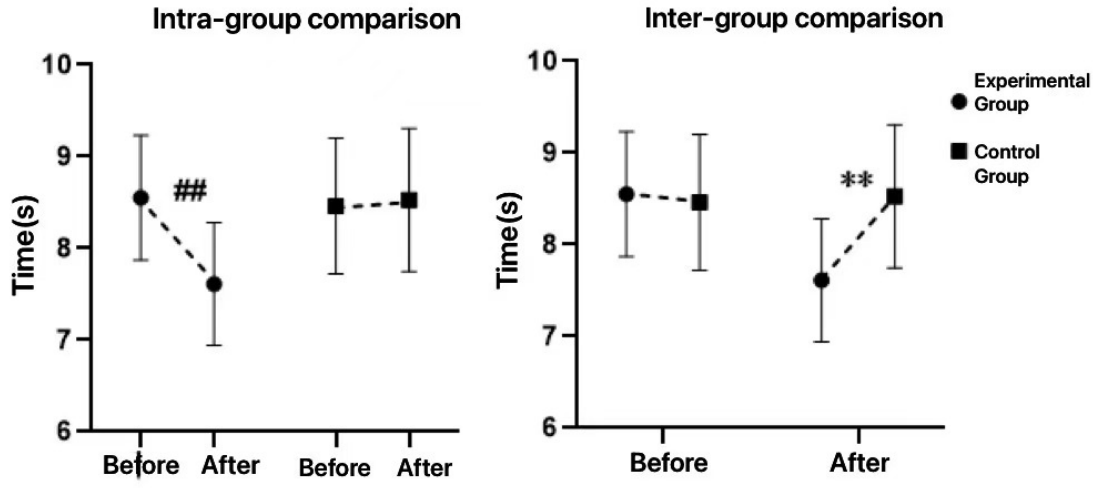



Figure 11 Comparison of "standing up and walking" timing test results

From the above 2 test results, it could be told that Pilates exercise significantly helped improving the dynamic balance ability of the elderly, especially in the case of

external interference, the coordination and control ability of the elderly to the body was improved.

**4.3 Within and between groups comparison of activity balance confidence score results of ABC scales**

*4.3.1* Comparison of test results before and after the experiment of the Activity Balance Confidence Scale scores of the experimental group

As shown in Table 11, a paired samples t-test was conducted on the pre-test and post-test results of the 21 elderly individuals in the experimental group who participated in Pilates exercises. The comparative analysis indicated a significant increase in the mean scores for all items on the ABC Scale. The results suggest that after 12 weeks of Pilates exercise, elderly individuals aged 60-69 in the experimental group experienced enhanced balance confidence during related daily activities, reduced fear of falling, and promoted psychological well-being.

Table 11 The results of balance confidence within the experimental group

| Activity Balance Confidence Scale Activities | Experimental group Before experiment *(n=21)* | Experimental group After experiment *(n=21)* | *P-value* |
|---|---|---|---|
| 1. Walk around the house? | 91.90±7.49 | 95.71±5.07 | 0.002 |
| 2.Walk up or down stairs? | 81.90±10.30 | 88.57±6.55 | <0.001 |
| 3.Bend over and pick up a slipper from the front of a closet floor? | 85.71±8.70 | 92.86±6.44 | <0.001 |
| 4.Reach for a small can off a shelf at eye level? | 92.38±7.00 | 94.24±6.80 | 0.038 |
| 5.Stand on your tiptoes and reach for something above your head? | 86.67±9.13 | 91.43±7.93 | 0.002 |
| 6.Stand on a chair and reach for something? | 81.43±10.14 | 86.67±7.96 | <0.001 |
| 7.Sweep the floor ? | 80.95±9.44 | 87.62±8.89 | 0.001 |
| 8.Walk outside the house to a car parked in the driveway? | 87.62±7.68 | 90.95±7.00 | 0.005 |
| 9.Get into or out of a car? | 84.29±9.78 | 89.52±8.05 | 0.001 |

| | | | |
|---|---|---|---|
| 10.Walk across a parking lot to the mall? | 84.29±9.26 | 90.00±7.07 | <0.001 |
| 11.Walk up or down a ramp? | 83.33±10.17 | 88.09±8.73 | 0.002 |
| 12.Walk in a crowded mall where people rapidly walk past you? | 83.26±9.66 | 89.05±7.00 | <0.001 |
| 13.Are bumped into by people as you walk through the mall? | 71.43±12.36 | 77.62±10.91 | <0.001 |
| 14.Step onto or off an escalator while you are holding onto a railing? | 82.86±9.02 | 87.62±7.00 | <0.001 |
| 15.Step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? | 73.81±10.71 | 79.52±10.71 | <0.001 |
| 16.Walk outside on icy sidewalks? | 62.86±10.56 | 64.05±9.95 | <0.023 |

*4.3.2* Comparison of test results before and after the experiment of the Activity Balance Confidence Scale scores of the control group

As shown in Table 12, the results of the pre-experiment and post-experiment tests of 22 elderly people in the control group were subjected to t-tests. The comparative analysis showed that the average scores of each item in the ABC scale were not statistically significant. The results showed that after 12 weeks' experiment for the elderly aged 60-69 in the control group, there were no significant changes in balance confidence and fear of falling during daily activities (P > 0.05)

Table 12 The results of balance confidence within the control group

| Activity Balance Confidence Scale Activities | Control group before experiment (*n*=22) | Control group after experiment (*n*=22) | *P-value* |
|---|---|---|---|
| 1. Walk around the house? | 92.27±6.12 | 91.82±6.65 | 0.816 |
| 2.Walk up or down stairs? | 84.55±8.00 | 83.64±8.48 | 0.716 |
| 3.Bend over and pick up a slipper from the front of a closet floor? | 86.82±9.95 | 87.27±9.85 | 0.881 |

| | | | |
|---|---|---|---|
| 4.Reach for a small can off a shelf at eye level? | 91.36±5.60 | 89.55±6.53 | 0.329 |
| 5.Stand on your tiptoes and reach for something above your head? | 85.45±6.71 | 85.91±7.97 | 0.837 |
| 6.Stand on a chair and reach for something? | 82.27±8.13 | 80.45±7.85 | 0.454 |
| 7.Sweep the floor ? | 81.36±8.34 | 81.06±10.90 | 0.919 |
| 8.Walk outside the house to a car parked in the driveway? | 86.36±9.02 | 84.55±9.12 | 0.512 |
| 9.Get into or out of a car? | 83.18±7.80 | 81.82±9.07 | 0.597 |
| 10.Walk across a parking lot to the mall? | 85.00±6.73 | 85.15±8.58 | 0.949 |
| 11.Walk up or down a ramp? | 83.64±10.02 | 82.27±10 | 0.652 |
| 12.Walk in a crowded mall where people rapidly walk past you? | 84.09±9.59 | 83.46±10.49 | 0.836 |
| 13.Are bumped into by people as you walk through the mall? | 72.27±10.66 | 70.45±11.33 | 0.586 |
| 14.Step onto or off an escalator while you are holding onto a railing? | 81.82±7.95 | 80.91±6.84 | 0.686 |
| 15.Step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? | 71.81±8.53 | 72.27±9.22 | 0.864 |
| 16.Walk outside on icy sidewalks? | 60.91±8.68 | 61.82±7.33 | 0.709 |

***4.3.3*** Comparison of Activity Balance Confidence Scale test results before the experiment between the experimental group and the control group

As shown in Table 13, an Independent Samples T-test was conducted on the evaluation results of the 16 items of the Activity Balance Confidence Scale for elderly individuals aged 60-69 in the control and experimental groups before the experiment. The results indicated that there was no statistically significant difference between the two groups ($P > 0.05$). This suggests that there was no significant difference in balance confidence during indoor or outdoor activities between the elderly

participants in the experimental and control groups, which meets the requirements of the experiment.

Table 13 The results of balance confidence between groups of pre-test

| Activity Balance Confidence Scale Activities | Control group *(n=22)* | Experimental group *(n=21)* | *P-value* |
|---|---|---|---|
| 1. Walk around the house? | 92.27±6.12 | 91.90±7.49 | 0.861 |
| 2. Walk up or down stairs? | 84.55±8.00 | 81.90±10.30 | 0.352 |
| 3. Bend over and pick up a slipper from the front of a closet floor? | 86.82±9.95 | 85.71±8.70 | 0.701 |
| 4. Reach for a small can off a shelf at eye level? | 91.36±5.60 | 92.38±7.00 | 0.603 |
| 5. Stand on your tiptoes and reach for something above your head? | 85.45±6.71 | 86.67±9.13 | 0.621 |
| 6. Stand on a chair and reach for something? | 82.27±8.13 | 81.43±10.14 | 0.764 |
| 7. Sweep the floor ? | 81.36±8.34 | 80.95±9.44 | 0.880 |
| 8. Walk outside the house to a car parked in the driveway? | 86.36±9.02 | 87.62±7.68 | 0.625 |
| 9. Get into or out of a car? | 83.18±7.80 | 84.29±9.78 | 0.684 |
| 10. Walk across a parking lot to the mall? | 85.00±6.73 | 84.29±9.26 | 0.773 |
| 11.Walk up or down a ramp? | 83.64±10.02 | 83.33±10.17 | 0.922 |
| 12.Walk in a crowded mall where people rapidly walk past you? | 84.09±9.59 | 83.26±9.66 | 0.798 |
| 13. Are bumped into by people as you walk through the mall? | 72.27±10.66 | 71.43±12.36 | 0.811 |
| 14. Step onto or off an escalator while you are holding onto a railing? | 81.82±7.95 | 82.86±9.02 | 0.690 |
| 15. Step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? | 71.81±8.53 | 73.81±10.71 | 0.503 |
| 16. Walk outside on icy sidewalks? | 60.91±8.68 | 62.86±10.56 | 0.511 |

4.3.4 Comparison of Activity Balance Confidence Scale test results after the experiment between the experimental group and the control group

As shown in Table 14, after 12 weeks of Pilates intervention, there were significant changes in the activity balance confidence of elderly individuals aged 60-69 in both the experimental and control groups. The scores for all 16 items showed varying degrees of improvement. The results of the independent samples t-test on the evaluations of the 16 items for both groups indicated a significant difference ($P < 0.05$). Elderly individuals aged 60-69 who practiced Pilates demonstrated a noticeable enhancement in their confidence in maintaining physical balance during activities, which was higher than that of those who only participated in routine daily living interventions.

Table 14 The results of balance confidence between groups of post-test

| Activity Balance Confidence Scale Activities | Control group *(n=22)* | Experimental group *(n=21)* | *P-value* |
|---|---|---|---|
| 1. Walk around the house? | 91.82±6.65 | 95.71±5.07 | 0.037 |
| 2. Walk up or down stairs? | 83.64±8.48 | 88.57±6.55 | 0.039 |
| 3. Bend over and pick up a slipper from the front of a closet floor? | 87.27±9.85 | 92.86±6.44 | 0.033 |
| 4. Reach for a small can off a shelf at eye level? | 89.55±6.53 | 94.24±6.80 | 0.018 |
| 5. Stand on your tiptoes and reach for something above your head? | 85.91±7.97 | 91.43±7.93 | 0.028 |
| 6. Stand on a chair and reach for something? | 80.45±7.85 | 86.67±7.96 | 0.014 |
| 7. Sweep the floor ? | 81.06±10.90 | 87.62±8.89 | 0.023 |
| 8. Walk outside the house to a car parked in the driveway? | 84.55±9.12 | 90.95±7.00 | 0.013 |
| 9. Get into or out of a car? | 81.82±9.07 | 89.52±8.05 | 0.005 |
| 10. Walk across a parking lot to the mall? | 85.15±8.58 | 90.00±7.07 | 0.045 |
| 11.Walk up or down a ramp? | 82.27±10.20 | 88.09±8.73 | 0.047 |
| 12.Walk in a crowded mall where people rapidly walk past you? | 83.46±10.49 | 89.05±7.00 | 0.043 |
| 13. Are bumped into by people as you walk through the mall? | 70.45±11.33 | 77.62±10.91 | 0.041 |
| 14. Step onto or off an escalator while | 80.91±6.84 | 87.62±7.00 | 0.003 |

| | | | |
|---|---|---|---|
| you are holding onto a railing? | | | |
| 15. Step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? | 72.27±9.22 | 79.52±10.71 | 0.022 |
| 16. Walk outside on icy sidewalks? | 61.82±7.33 | 64.05±9.95 | 0.046 |

From above result it could be told that : The scores of all items of activity balance confidence scale in the experimental group were significantly increased before and after the experiment ($P < 0.05$). After the experiment, the activity balance confidence scale score of the experimental group was significantly better than that of the control group ($P < 0.05$).

Pilates exercise significantly helped improving the activity balance confidence of the elderly, reducing their fear of falling, and promoted mental health.

# CHAPTER V
# CONCLUSION，DISCUSSION AND SUGGESTIONS

## 5.1 Conclusions

1. Pilates exercises can improve both the static and dynamic balance abilities of elderly individuals aged 60-69, reducing the risk of falls among this population. These exercises can be recommended as part of the physical training regimen for the elderly.

2. Pilates can enhance the exercise confidence of elderly individuals. After 12 weeks of Pilates training, there is a noticeable increase in activity balance confidence among elderly individuals aged 60-69, leading to an improved level of balance self-efficacy. This allows them to engage in related activities with greater confidence. However, the value of using the ABC scale to assess fall risk requires further validation.

3. Implementing Pilates exercises with different starting positions for elderly individuals aged 60-69 over a 12-week period, with practice sessions occurring twice a week and heart rate controlled between 110 to 130 beats per minute, demonstrates effectiveness in delaying the decline of balance ability in the elderly.

## 5.2 Discussion

The purpose of this study is to investigate the effect of Pilates exercise could on the static and dynamic balance ability as well as the balance confidence. And the findings from the study indicated that Pilates exercises are effective in enhancing both static and dynamic balance abilities among elderly individuals aged 60-69, thus significantly reducing their risk of falls. Meanwhile, balance confidence was also improved after the 12 week's Pilates exercise.

### 5.2.1 Analysis of the effect of Pilates on the static balance ability of the elderly aged 60-69 years old

When maintaining body balance, the human body does not require conscious thought and regulation from the brain; it primarily relies on automatic adjustments by the nervous system and subcortical structures. However, as individuals age, their nervous system gradually deteriorates and the function of nerve tissues declines,

necessitating compensation from other systems to maintain balance. The visual system plays a crucial role in maintaining body balance by perceiving the body's position and orientation through changes in the surrounding environment, thus ensuring stability. The decline in bodily functions increases elderly individuals' reliance on visual input to gather information and maintain balance.

In conditions where the eyes are closed, the visual system's influence on elderly balance ability is temporarily blocked. Through inputs from the vestibular system and proprioceptors, the body senses external stimuli and changes, transmitting this information to the central nervous system for regulation. This process ultimately enables the motor system to control muscle contractions to maintain balance through deep and positional movement control.

In this study, the test for static balance ability was enhanced by including the standing on one leg with eyes open test, which showed that elderly participants could significantly extend their standing time under visual influence. This indicates that vision has a profound effect on static balance ability. Tests comparing the ability of elderly individuals to maintain balance while standing on one leg, with both eyes open and closed, were conducted to more effectively reflect their static balance capability.

Elderly individuals aged 60-69 improved their static balance functions through Pilates exercises. Research by Liang, X. (2016) showed that the closed-eye single-leg standing time for a square dance group was longer than that of a group practicing the simplified 24-form Tai Chi, indicating that square dance was more effective than Tai Chi in improving static balance in the elderly.Gao,H.,Qu,F.,Zhang,X.,et al.(2019). and others found that the stability of closed-eye single-leg standing significantly improved in the Pilates group compared to the square dance group. These studies suggest that Pilates may be more applicable than square dance and simplified Tai Chi for enhancing static balance in elderly individuals.

International data indicate that Pilates is a mind-body exercise that focuses on muscle control, posture, and breathing, which can accelerate the recovery of function in injured bodies, improve body alignment, enhance core strength, and refine coordination and balance(Bowman,J.2015). It also improves lumbar bone density

(Oliveira R,et al.2021) and positively affects cardiopulmonary function (Souza,C.,et al.2020). David Suárez Iglesias (David S., et al,2019) and others found that Pilates is more effective than traditional training programs in improving lower limb function. These improvements positively impact static balance ability in the elderly.

**5.2.2 Analysis of the effect of Pilates on the dynamic balance ability of the elderly aged 60-69 years**

Dynamic balance ability in elderly individuals requires higher demands on visual judgment, muscle strength, joint stability, coordination, and the integration of information from various sensory organs with the nervous system. The improvement in walking speed on the balance beam for elderly individuals aged 60-69 may be related to the physiological and psychological changes resulting from Pilates practice. While performing Pilates movements, elderly individuals consistently activate the central nervous system's control of body movement, transforming initially unfamiliar Pilates poses into familiar ones, even leading to muscle memory development, thus enhancing the sensitivity and precision of nervous system regulation.

For example, during the "Windmill" pose, the elderly stand with their feet positioned one in front of the other, with the front foot fully grounded and the back foot on its toes. The contact area of the body is small, and the arms are extended forward and backward like "wheels," causing the waist to twist left and right. Initially, elderly individuals may struggle with coordination and experience instability while practicing the "Windmill." However, with repeated practice, their control abilities improve, allowing them to perform the movements successfully and enhance both muscle coordination and confidence.

Through Pilates exercises, elderly individuals continuously gain self-awareness, actively engage in exercise and communication, reducing their fear of physical activity. This psychological adjustment improves muscle system efficiency and exercise confidence, enabling them to maintain body stability even under the challenge of the balance beam, thus accelerating walking speed and promoting improvements in dynamic balance ability.

The results of this study are similar to those from international research indicating that Pilates can improve dynamic balance in the elderly. However, this study focuses more on the changes in balance quality among elderly individuals, while international studies often explore the relationship between Pilates and the prevention of falls in the elderly. For instance, Bird,M.L.,&Fell,J.(2013) and colleagues investigated the effects of a 5-week initial Pilates intervention on fall risk factors over 12 months, finding that elderly individuals exhibited marked improvements in postural sway, dynamic balance, and functionality that were sustained for 12 months. Dugosz-Bo, M., Filar-Mierzwa, K., Stawarz, R., *et al*. (2021) also confirmed the effectiveness of Pilates in improving balance and minimizing fall risk among older women.Vieira,N.D.,Testa,D.,Ruas,P.C.,*et al*. (2017) conducted research that also validated the beneficial effects of Pilates on dynamic balance, leg strength, and fitness.

The volunteers aged 60-69 who participated in this study experienced improvements in both dynamic and static balance ability after 12 weeks of Pilates exercise, which aligns with the results from other researchers, confirming Pilates' positive effects on enhancing balance in the elderly. Based on the analyses and discussions, it remains unclear whether this specific Pilates exercise program is more beneficial for improving balance in elderly individuals compared to other forms of exercise. However, as an emerging exercise method, Pilates can diversify exercise options for the elderly, providing a good alternative to some monotonous and challenging activities. Research by Antonino,P., Zangla,D.,Sahin,F.N., *et al*. (2021) has shown that physical activity can improve balance, and their data suggests that Pilates has a greater impact on these physical abilities than general exercise programs, indicating that Pilates may be particularly effective in enhancing balance in the elderly.

**5.2.3 Analysis of the effect of Pilates exercise on activity balance confidence of the elderly**

The Activity Balance Confidence Scale reflects self-assessed balance abilities and is commonly used to evaluate aspects of balance in elderly individuals or patients with illnesses. It often indicates the elderly's self-awareness regarding their balance

confidence and their fear of falling. Falls are a significant psychological factor that instills fear of movement in the elderly. After 12 weeks of Pilates practice, the results of the Activity Balance Confidence Scale showed an optimistic trend, with increased confidence in completing activities they previously hesitated to undertake, whether indoors or outdoors.

Comparative analysis of the scores before and after the experiment revealed very significant differences ($P < 0.01$) in the elderly's ability to bend down to pick up a pair of shoes, stand on a stool to reach for items, and sweep indoors; as well as significant improvements ($P < 0.01$) in outdoor activities, such as navigating stairs, crossing parking lots, and going up or down escalators while holding items without being able to grasp the handrail. Additionally, other activities showed significant differences ($P < 0.05$) in the balance scale tests.

Balance ability is directly proportional to activity balance confidence. The better the elderly individuals' balance, the lower their fear of falling. Conversely, a decline in balance ability causes some concerns before engaging in physical activities, leading to increased vigilance in their environments. As bodily functions gradually decline, muscle strength and the nervous system's regulatory effects weaken, resulting in stiffness in the limbs, impeded movement, and decreased balance ability, which increases the risk of falls. This fear of falling often escalates, causing elderly individuals to lose confidence even in tasks within their capability.

Because falls lead to not just physical pain but can also trigger various illnesses, some elderly individuals experience psychological stress, worrying about burdening their children and feeling guilt or self-blame. Thus, they might reduce outings or decrease their daily activity frequency to avoid the risk of falling, which indicates a lack of activity confidence. Pilates exercises primarily involve mat-based movements, with a focus on gradual progression and slow speeds, stimulating deep muscles, emphasizing body control and precision, activating core strength, and enhancing the nervous system's regulation over motor functions to improve balance ability in elderly individuals.

The mat exercises primarily involve positions such as supine, side-lying, and sitting, which maintain a low center of gravity, thereby reducing elderly individuals' fear of falling during practice. Additionally, each successful completion of a Pilates session increases their movement confidence. Group Pilates sessions also encourage communication among elderly participants, leading to improved moods. Most elderly participants form camaraderie, making plans to accompany each other before and after each Pilates session, which promotes social interaction, alleviates feelings of isolation, and further enhances their mental well-being. This, in turn, increases their confidence in participating in various activities, helps them overcome fears, and enhances their quality of life in their later years.

Research by Kara,B.,Fadime,P.,Poyraz,E.C., *et al*.(2017.) indicates that Pilates is more effective than aerobic exercise in reducing fatigue and depression in patients with multiple sclerosis. Aibar-Almazán,A., Martínez-Amat,A.,Cruz-Díaz,D., *et al*(2019) explored the impact of Pilates on fall risk factors in community-dwelling elderly women and found beneficial effects on balance confidence, fear of falling, and postural stability following a 12-week Pilates training program.Hita-Contreras,F.,Martínez-Amat,A.,Cruz-Díaz,D., *et al*(2016) noted that Pilates is considered an effective method for improving physical and psychological aspects related to falls among postmenopausal women, alleviating fear of falling and depressive states, and improving quality of life.Bullo,V.,Bergamin,M.,Gobbo,S.,*et al*(2015) also indicated that regular Pilates practice can reduce the risk of depression and enhance elderly individuals' well-being and independence in daily activities.

In summary, after 12 weeks of Pilates training, the participation of elderly individuals aged 60-69 resulted in significant improvements in the scores on the Chinese version of the Activity Balance Confidence Scale (ABC) across various activity items. Participants expressed increased confidence in engaging in related physical activities, likely linked to the confidence gained through Pilates and enhanced social interactions. The improvement in balance ability among elderly individuals aged 60-69 may also correlate with the increase in balance confidence. The enhancement of activity balance confidence in the elderly suggests that Pilates

has a regulatory effect on mental health, allowing participants to relax and actively manage negative emotions and fears.

**5.3 Suggestions**

1. As it could be told that the result data for this research was high, it could be the correct Pilates exercise content and experimental control, but it also may related to the psychological reasons.Future researches can further explore personalized intervention plans for different groups of people (such as different age groups and disease types), and compare the long-term effect differences between Pilates and other forms of exercise.

2. The Activity Balance Confidence Scale has a certain degree of subjectivity, as elderly individuals select responses based on their own circumstances. This can reflect their current level of balance confidence and indicate their self-perceived understanding of fall risk and self-efficacy. However, it primarily focuses on psychological assessment and has limited value in fall risk evaluation. Therefore, it is recommended to use it as a supplementary tool to assess fall risk in elderly individuals.

3. It is advised that community instructors and relevant elderly care institutions promote Pilates exercise within the elderly population, as it is beneficial for improving their exercise methods, enriching health activities, and promoting healthy aging.

4. However, for future researches,it is suggested that the testing methods would better be changed to quantitative ones, such as the study of some objective data in biology.

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## REFERENCES


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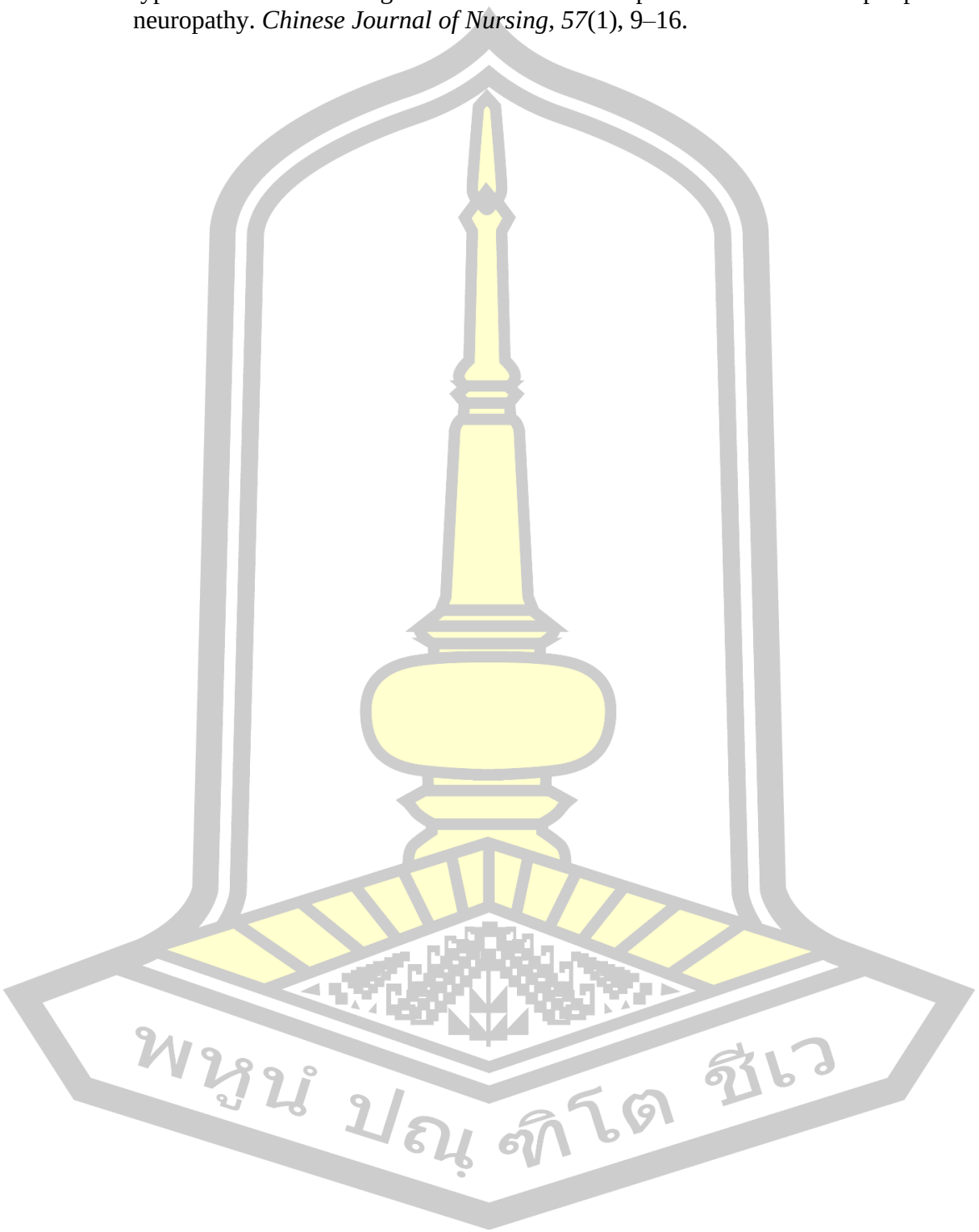


# APPENDIX

# Appendix A

## Ethic Certificate

MAHASARAKHAM UNIVERSITY ETHICS COMMITTEE FOR
RESEARCH INVOLVING HUMAN SUBJECTS

Certificate of Approval

Approval number: 380-165/2024

**Title :** The Effect of Pilates Exercise on the Static & Dynamic Balance Ability and Balance Confidence in the Elderly.

**Principal Investigator :** Li Jiang
**Responsible Department :** Faculty of Education
**Research site :** Hongshan Community Aged Care Service Center, Chongqing, China

**Review Method :** Expedited Review

**Date of Manufacture : 27 June 2024** **expire : 26 June 2025**

This research application has been reviewed and approved by the Ethics Committee for Research Involving Human Subjects, Mahasarakham University, Thailand. Approval is dependent on local ethical approval having been received. Any subsequent changes to the consent form must be re-submitted to the Committee.

Ratree S.
.....
(Assistant Professor Ratree Sawangjit)
Chairman

Approval is granted subject to the following conditions: (see back of this Certificate)

**Appendix B**
**Interview Outline**
**(English version)**

Dear experts,

I am Li JIANG, a master's degree student at Mahasarakham University in Thailand. The student ID is 63010556005. I am currently conducting a thesis research. The title of my thesis is "The Effect of Pilates Exercise on the Static and Dynamic Balance Ability and Balance Confidence in the Elderly". This paper conducts a Pilates intervention experiment on the elderly to study its effect on the balance ability and balance confidence of the elderly. In order to improve the authenticity and scientificity of the paper, the design of the experimental content requires an interview with you. Your valuable opinions play a vital role in my paper. Thank you very much!

Name: Title: Work Place:

1. What do you think about the use of Pilates to improve the balance ability of the elderly?

2. According to the results of domestic and foreign literature on the balance ability of the elderly, do you think it is reasonable to set the experimental time of Pilates exercise on the balance ability of the elderly as 12 weeks?

3. According to the characteristics of the elderly, the practice time of this experiment is twice a week, 60 minutes each time, on Tuesdays and Thursdays respectively. Do you think it is feasible?

4. When guiding the elderly to do Pilates exercises, how should we handle the exercise load and intensity? In which heart rate range is better please?

5. When the elderly are doing Pilates exercises, how should we determine the number and time of exercises for the balance ability of the elderly, as well as the interval time of each group?

6. Do you think that the Pilates exercises selected by the literature method in this experiment are applicablefor improving the balance ability of the elderly? Can you please share about your opinion?

7. What are the issues should be paid attention to when doing Pilates exercises for the elderly?

8. What suggestions do you have on the way to test the balance ability of the elderly and the evaluation method of the improvement effect?

9. Do you think it is reasonable to use a ground balance beam with a width of 10 cm, a height of 2 cm, and a length of 3 meters for the balance ability test of the elderly?

10. Please give valuable suggestions on the shortcomings in the experimental design of this experiment.

## Appendix B

## Interview Outline

## (Chinese version)

### 访谈提纲

尊敬的专家，

您好！

我是泰国玛哈沙拉堪大学教育学院硕士研究生江丽，我的学号是 63010556005，正在进行论文研究，我的论文题目是《普拉提运动对老年人静态、动态平衡能力及平衡信心影响的实验研究》，本文通过对 60-69 岁老年人进行普拉提运动干预实验，研究其对老年人平衡能力及平衡信心的影响，为了提高论文的真实性和科学性，实验内容的设计需要对您进行访谈，您的宝贵意见对我的论文起着至关重要的作用，非常感谢您！

姓名：　　职称：　　工作单位：

1.您对采用普拉提运动改善老年人平衡能力这个问题有什么看法？

2.经国内外对老年人平衡能力研究的文献结果来看，将普拉提运动对 60-69 岁老年人平衡能力影响的实验时间定为 12 周，您认为是否合理？

3.根据老年人的特点，本次实验练习时间是一周两次，每次 60 分钟，分别为每周周二和周四，您认为是否可行？

4.在指导老年人进行普拉提练习时，应该如何把握运动负荷和强度?心率保持在哪个范围较好？

5.老年人在进行普拉提体式练习时，针对老年人平衡能力的体式练习次数和时间，以及每组的间歇时间，我们应该如何确定呢？

6.您认为本实验经文献资料法选取的普拉提练习体式是否适用于提高 60-69 岁老年人平衡能力的锻炼？谈谈您的意见？

7.在对老年人进行普拉提项目练习时，需要注意哪些问题？

8.您对老年人平衡能力测试的方式和改善效果的评价方法有什么建议？

9.您认为采用宽 10 厘米，高 2 厘米，长 3 米的地面平衡木，用于老年人平衡能力测试是否合理？

10.请您对本实验的实验设计中您认为不足之处给出宝贵建议

**Appendix C**

**Pilates exercise experiment content selection questionnaire**

(English version)

Dear experts,

I am Li JIANG, A master's degree student at Mahasarakham University in Thailand. The student ID is 63010556005. I am currently conducting my thesis research. The title of my thesis is "The Effect of Pilates Exercise on the Static and Dynamic Balance Ability and Balance Confidence in the Elderly". In order to improve the scientificity and effectiveness of this thesis, it is necessary to screen and validate the experimental exercise content. I hereby ask you to evaluate it. You can choose a "√" under the corresponding degree indicator of whether each posture is applicablefor the balance ability exercise of the elderly according to your own opinions. You can express your opinions independently. Your valuable opinions play a vital role in my thesis. Thank you very much for your guidance!

Pilates postures for the degree of applicability of balance training for the elderly

| Pilates Content | Is it applicable for balance training for the elderly? | | | | |
|---|---|---|---|---|---|
| Posture names | Very applicable | applicable | Averagely applicable | Not quite applicable | Not applicable at all |
| Spinal extension (sitting postion) | | | | | |
| One leg balance (standing position) | | | | | |
| Rolling like a ball （supine position) | | | | | |
| One leg extension (standing position) | | | | | |
| Simplified The hundred (supine position and knees bending) | | | | | |
| Clam opening and closing (side-lying position) | | | | | |
| Side leg raise （side-lying position) | | | | | |
| Glute bridge (supine position) | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Side Leg Circles （side-lying position) | | | | | |
| Windmill (standing position) | | | | | |
| Prone hip lift (prone position) | | | | | |
| Kneeling position with one leg raised | | | | | |
| Four-legged swimming (kneeling position) | | | | | |
| Side lying rotating | | | | | |
| Single leg extension ( prone position) | | | | | |
| Spinal Twist (supine position) | | | | | |
| Single toe tap （supine position) | | | | | |
| Roll up (supine position) | | | | | |
| Marching (supine position) | | | | | |
| Criss Cross （supine position) | | | | | |

Note: "Very applicable" is 5 points, "applicable" is 4 points, "averagely applicable" is 3 points, "not quite applicable" is 2 points, and "not applicable at all" is 1 point; these points will be used to calculate the score for each posture when the final expert evaluation opinions are summarized and counted.

**Appendix C**
**Pilates exercise experiment content selection questionnaire**

(Chinese version)

**普拉提的练习实验内容选择问卷**

尊敬的专家，您好！

我是泰国玛哈沙拉堪大学教育学院硕士研究生江丽，我的学号是 63010556005,正在进行论文研究，我的论文题目是《普拉提运动对老年人静态、动态平衡能力及平衡信心影响的实验研究》。为了提高本论文的科学性和有效性，故需对实验练习内容进行筛选和效度检验，在此恳请您对其进行评定，您可根据自己的意见在每个体式动作是否适用于老年人平衡能力练习对应的程度指标下选择一个画上“√”。您可以自主发表意见，您的宝贵意见对我的论文起着至关重要的作用，衷心感谢您的指导！

普拉提体式对老年人平衡能力训练的适用程度选择表

| 普拉提练习内容 | 是否适用于老年人平衡能力练习 | | | | |
|---|---|---|---|---|---|
| 体式名称 | 非常适用 | 适用 | 一般 | 不适用 | 非常不适用 |
| 四足游泳（跪姿） | | | | | |
| 单腿伸展（站姿） | | | | | |
| 仰卧脊柱扭转 | | | | | |
| 百次拍击（仰卧屈膝） | | | | | |
| 侧卧单腿上抬 | | | | | |
| 侧卧单腿画圈 | | | | | |
| 俯身提臀（俯卧） | | | | | |
| 行军踏步（仰卧） | | | | | |
| 脊柱前伸（坐姿） | | | | | |
| 长躯席卷（仰卧） | | | | | |
| 滚动如球 | | | | | |
| 足尖点地（仰卧） | | | | | |
| 跪姿单脚上提 | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 臀桥（仰卧） | | | | | |
| 风车（站姿） | | | | | |
| 蚌式开合（侧卧） | | | | | |
| 旋体拉锯（坐姿） | | | | | |
| 单腿平衡（站姿） | | | | | |
| 单脚朝天（仰卧） | | | | | |
| 十字交叉（仰卧） | | | | | |

注：“非常适用”为 5 分，“适用”为 4 分，“一般”为 3 分，“不太适用”为 2 分，“不适用”为 1 分；在最后专家评定意见汇总统计时，用于每个体式的算分。

พหุน ปณ ฑิโต ชีเว

**Appendix D**

**Applicability of Pilates exercises to balance training for the elderly**

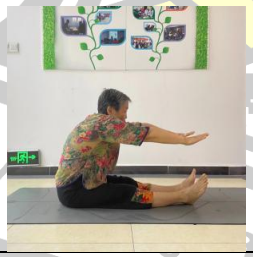
(English and Chinese version)

Applicability of Pilates exercises to balance training for the elderly

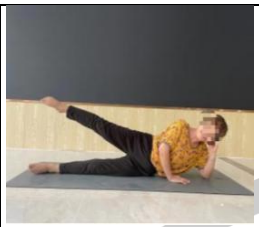
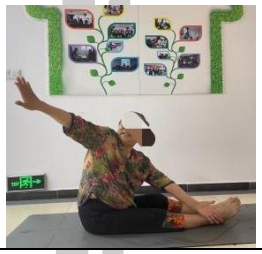
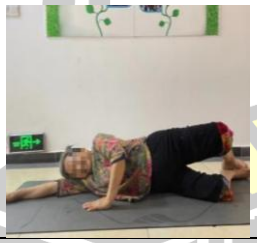
| 体式名称<br>Posture names | 非常适用<br>Very applicable | 适用<br>Applicable | 一般<br>Averagely applicable | 不适用<br>Not quite applicable | 非常不适用<br>Not applicable at all | 总分<br>Total points | 排名<br>Ranking |
|---|---|---|---|---|---|---|---|
| 脊柱前伸（坐姿）<br>Spinal extension (sitting postion) | 2 | 4 | 1 | 0 | 0 | 29 | 1 |
| 单脚平衡（站姿）<br>One leg balance (standing position) | 2 | 3 | 2 | 0 | 0 | 28 | 2 |
| 单腿伸展（仰卧）<br>One leg extension (supine position) | 2 | 3 | 1 | 1 | 0 | 27 | 3 |
| 百次拍击（仰卧屈膝）<br>Simplified the Hundred (supine position and knees bending) | 2 | 3 | 1 | 1 | 0 | 27 | 4 |
| 侧卧单腿上抬<br>Side leg raise （side-lying position) | 2 | 2 | 2 | 1 | 0 | 26 | 5 |
| 侧卧单腿画圈<br>Side Leg Circles （side-lying position) | 1 | 4 | 1 | 1 | 0 | 26 | 6 |
| 臀桥（仰卧）<br>Glute bridge (supine position) | 2 | 2 | 2 | 1 | 0 | 26 | 7 |
| 蚌式开合（侧卧）<br>Clam opening and closing (side-lying position) | 1 | 3 | 2 | 1 | 0 | 25 | 8 |
| 四足游泳（跪姿）<br>Four-legged swimming (kneeling position) | 1 | 2 | 4 | 0 | 0 | 25 | 9 |
| 旋体拉锯侧卧<br>Side lying rotating | 2 | 1 | 2 | 2 | 0 | 24 | 10 |
| 风车（站姿）<br>Windmill (standing position) | 1 | 2 | 2 | 2 | 0 | 23 | 11 |
| 俯身提臀（俯卧）<br>Prone hip lift (prone position) | 1 | 2 | 1 | 3 | 0 | 22 | 12 |
| 跪姿单脚上提<br>Kneeling position with one leg raised | 0 | 3 | 2 | 2 | 0 | 22 | 13 |
| 仰卧脊柱扭转<br>Spinal Twist (supine position) | 1 | 1 | 3 | 2 | 0 | 22 | 14 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 足尖点地（仰卧）<br>Single toe tap<br>（supine position) | 1 | 1 | 2 | 3 | 0 | 21 | 15 |
| 行军踏步（仰卧）<br>Marching<br>(supine position) | 0 | 1 | 5 | 1 | 0 | 21 | 16 |
| 单脚朝天（仰卧）<br>Single leg extension<br>( prone position) | 0 | 1 | 4 | 2 | 0 | 20 | 17 |
| 长躯席卷（仰卧）<br>Roll up(supine position) | 0 | 1 | 3 | 3 | 0 | 19 | 18 |
| 十字交叉<br>Criss Cross<br>（supine position) | 0 | 0 | 3 | 3 | 1 | 16 | 19 |
| 滚动如球<br>Rolling like a ball（<br>supine position) | 0 | 0 | 2 | 4 | 1 | 15 | 20 |

# Appendix E
## Pilates Postures Movement Requirement Details

| NO. | Posture Name | Exercise purpose/effect | Movement requirement |
|---|---|---|---|
| 2 | Windmill<br>(standing position)<br>  | Increase body coordination, improve shoulder and back circulation, and increase body stability and control. | Keep the pelvis and spine in a neutral position during the exercise, slide your left foot back on the ground, touch the toes, and turn right. Raise your right arm and turn your left arm downward until both arms are perpendicular to the ground. Then move your body forward and turn left again until both arms are raised horizontally with the palms facing downward. Then raise your left hand and turn your right hand downward. Repeat the action 6-10 times, then switch positions to practice.<br>If there is obvious shaking in the standing position, you can start the practice from the sitting position and then do the full standing position. |
| 3 | Glute bridge<br>(supine position)<br>  | Strengthens the back extensor muscles, gluteal muscles, and hamstrings; improves spinal flexibility and strength.Strengthen the core control. | Lie on your back, bend your knees 90 degrees, keep your knees and toes in the same direction, and use equal force on both feet; pay attention to tightening your abdomen and buttocks, stretching your neck, and placing your hands on your sides. Roll your spine section by section to avoid lifting or lowering the whole body. When lifting your hips, do not open your knees outward. |
| 4 | Spinal extension (sitting postion)<br>  | Stretches the spine, stimulates deep back muscles, and promotes spinal flexibility and core stability. | Simlified exercise: Place your hands above your legs, move forward and backward naturally or bend your knees appropriately, and relax the muscles on the back of your thighs to practice.<br><br>Normal exercise: Pay attention to extending the arms forward, rolling the spine segment by segment, stretching the back into a natural arc, and stabilizing the pelvis. |
| 5 | Side leg raise<br>(side-lying position)<br>  | Strengthen the outer thigh muscles, improve hip and pelvic stability and leg control. | Simplified exercise: Keep the body stable and lower the leg lift angle.<br>Normal exercise: Throughout the exercise, maintain the shoulders and hips in a straight line to avoid twisting the body back and forth. Raise the legs as high as possible, extending and elongating them, while tightening the abdomen. Exhale, and with control, lower the legs while bringing them together to |

| | | | |
|---|---|---|---|
| | | | return to the starting position. |
| 6 | Single leg balance (standing position)<br>  | Tighten the core of the waist and abdomen to enhance the control of the hip, knee, and ankle joints and the stability of the lumbar and pelvic area. | Simplified exercise: Stand on one foot, with the knee of the lifted foot off the ground at a height of 5-10 cm from the floor. Maintain body stability, then slowly retract the calf backward.<br>Normal Exercise: The toes of the supporting foot should grip the ground, with the core and lower back engaged. Activate the glutes of the supporting leg, keeping the ankle, knee, and hip joints stable to maintain overall body stability; the calf of the bent knee should be parallel to the ground. |
| 7 | Kneeling position with one leg raise<br>  | Strengthen the stability of shoulder joints, knee joints and core, strengthen hip and thigh muscles, and improve lower limb strength. | Simplified exercise: Lay the knees flat on the mat in a "small table" position, tighten the abdomen, feel the stability of the waist and pelvis, and avoid relaxing down the waist.<br><br>Normal exercise: Kneeling position is stable, keep your knees bent at 90 degrees, lower the shoulders, extend the neck, tighten the abdomen, actively contract the gluteal muscles, lift and lower the thighs with control, and keep the body stable. |
| 8 | Prone hip lift (prone position)<br>  | Improve pelvic stability, strengthen hip abduction, External rotator muscles, improve hip circulation.<br>If you experience back pain during practice, stop practicing immediately. | Prone posture, support the upper torso with the forearms so to lift off the mat. Put the feet together, straighten them on the mat, and slightly point the toes. Inhale, lift one leg up, bend the knee, and bring the heel toward the buttocks. Tightening the gluteus maximus and abdominal muscles.Exhale, straighten the leg while switching to the other leg at the same time. Do not shake the body, and try to move with even speed and with control. |
| 9 | Four-legged swimming (kneeling position)<br>  | Strengthen the strength and awareness of lumbosacral stability and increase Pelvic and hip dynamic stability. | Simplified exercise: Keep the waist and pelvis stable, first keep the arms still and only stretch one leg each time. Then keep the legs still and only stretch the one arm each time.<br>Normal exercise: keep the pelvis and spine in a neutral position, tighten the abdomen, lower the shoulders and neck, and stretch the opposite leg and arm at the same time with controlled speed. |
| 10 | Side Leg Circles | strengthen hip abduction and external rotation muscles and improve your torso.Stabilize the shaft and pelvis in lateral decubitus position. | Simplified exercise: Keep the body stable and reduce the range of the circle.<br>Normal exercise: Keep the shoulders, torso and hips stable when drawing circles, tighten the abdomen, and avoid twisting the |

| | | | |
|---|---|---|---|
| |  (side-lying position) | | body forward and backward. Stretch the neck, stabilize and support the shoulder joints, and the upper leg keeps stretching. |
| 11 | Sitting and upper body rotating  | Improve spinal rotation, balance muscle tension on both sides of the back, and stretch the hamstrings on the back of the thigh. | Simplified exercise: If the hamstrings are too tight, practice with knees slightly bent. Normal exercise: extend both arms, stretch the shoulders, keep the arms in a straight line, tighten the abdomen, and straighten the legs. When twisting from the waist, the pelvis is stable, the hips cannot leave the mat, the back of the hand is stretched along the outside of the instep, and eyes looking at the back hand. |
| 12 | Simplified The Hundred (supine and knees bending)  | Strengthen the abdominal muscles and tighten the core muscles; strengthen movement coordination and improve shoulder girdle and trunk stability. | Simplified exercise: Keep the feet flat on the mat while tapping the arms. Normal exercise: Lift the legs, bend the knees 90 degrees. Torso curl up a little to allow the head and shoulders leave the mat. Pay attention to stretching the neck while tightening the abdomen.Tapping the arms quickly.Keeping the breathing and movements coordinated. |
| 13 | Clam opening and closing (side-lying position)  | Strengthen the hip external rotation muscles, enhance pelvic stability, and tighten the buttocks. | Simplified exercise: lower the height of the leg lifting. Lift the leg slowly and no rush. Normal exercise: keep the legs together, bend the knees, and keep the pelvis stable and neutral. When opening the knees, keep the pelvis neutral. Always with control and even speed when exhaling and closing the knees. |
| 14 | Single leg extension (supine position)  | Improve pelvic stability and core control, knee, ankle, and hip joint stability and coordination. | Simplified exercise: Keep the torso on the mat and only do leg flexion and extension. Normal exercise: Lift the head and shoulders while doing crunches. Stretch the legs diagonally forward.Hands holding the bent knee with gentle press. Do straight flexion and extension when alternating the legs, and avoid twisting the waist. |

**Appendix F**
**Pilates exercise teaching schedule for the experimental group**

| Period | Week | Teaching Content | Posture pics | Target |
|---|---|---|---|---|
| 1-4 weeks<br><br>Foundation and adaptation period | 1st week | 1. Theory: Basic theory of Pilates. Principles and functions of exercise, etc.<br>2. Practical learning:<br>(1) Pilates abdominal breathing, chest breathing and nasal breathing.<br>(2) Learn Pilates postures Windmill and Spinal extension (sitting postion) | | To understand the principles of Pilates exercises and master 3 breathing methods, which to build a good foundation for the Pilates posture exercises. The "Windmill" allows the elderly to better experience the "neutral position" emphasized in Pilates. The "Spinal extension" allows the elderly to experience the spine segment movement. Also allowing the elderly to learn to use their consciousness to feel and control their bodies. |
| | 2nd week | Review three breathing methods, Windmill and Spinal extension(sitting postion) postures.<br>Learn Glute bridge (supine position) and Side leg raise（side-lying position) postures. | | Review the previous content .<br>Learn the "Glute bridge (supine position)"posture. To experience the stimulation of Pilates postures on the core muscles. And the " Side leg raise" focuses on the neutral position of the pelvic in the side-lying position, the control and stability of the body and legs, and the activation of the oblique abdominal muscles. |
| | 3rd week | 1. Review all the postures learned previously and connect them together. Breathing practice shall be kept throughout the whole process.<br>2. Learn “One leg | | To consolidate what has been learned previously, "One leg balance" and "Kneeling position with one leg raise" can enhance the stability of the middle part of the body, the coordination and |

| | | | | |
|---|---|---|---|---|
| | | balance(standing position)" and "Kneeling position with one leg raise" | | control ability of the lower limbs of the elderly. |
| | 4th week | 1. Breathing practice for 5 minutes.<br>2. Pilates postures sequence practice: Windmill, Glute bridge, Spinal extension(sitting postion) Side leg raise（side-lying position）, One leg balance(standing position), Kneeling position with one leg raise. | | Combining breathing and movements during Pilates sequence practice can improve the fluency of elderly people in practicing postures, as well as their overall coordination and body postures adjustment in different Pilates postures. |
| 5th - 8th week<br><br>Improvement period | 5th week | 1. Breathing practice for 5 minutes. Review windmill and Glute bridge.<br>2. Learn Pilates postures: Prone hip lift (prone position), Four-legged swimming(kneeling position), Side Leg Circles（side-lying position) | | "Prone hip lift (prone position)" is to exercise the hip muscles of the elderly. Combined with "Four-legged swimming(kneeling position)" and "Side Leg Circles（side-lying position)", the core muscles are activated more deeply so that the core stability of the elderly is improved. In addition, "Four-legged swimming(kneeling position)" emphasizes the symmetry of the body and the stability of the joints. The coordination between arms and legs improves the perception hands and feet must be coordinated to promote the development of the elderly's perception in controlling the limbs as well as the whole body. |
| | 6th week | 1. Breathing practice for 5 minutes. Review Windmill, Glute bridge, Prone hip lift (prone position),Four- | | After becoming familiar with the breathing methods and Pilates postures, the postures will be connected. To |

| | | | | |
|---|---|---|---|---|
| | | legged swimming(kneeling position),<br>Side Leg Circles（ side-lying position)<br>2. Learn Pilates postures: Sitting and upper body rotating and Simplified The hundred (supine and knees bending) | | strengthen the combination of breathing and body movements, make the movements precise and smooth, and stimulate the maximum benefit of the exercise. |
| | 7th week | 1. Breathing practice for 5 minutes.<br>Review the series of Windmill, Glute bridges, Prone hip lift , Four-legged swimming, Side leg circles, Sitting and upper body rotating and Simplified The hundred (supine and knees bending)<br>2. Learn Clam opening and closing. | | Practicing in sequence increases the proficiency of movements. Different body positions can enhance the balance and control ability of the elderly. The "clam opening and closing pose" strengthens the hip and leg strength of the elderly and improves the stability of the hip joint. |
| | 8th week | Breathing practice for 5 minutes.<br>Review the series of Windmill, Glute bridges, Prone hip lift , Four-legged swimming, Side leg circles, Sitting and upper body rotating and Simplified The hundred (supine and knees bending),Clam opening and closing. | | In this week, all postures are practiced in sequence,which can improve the overall coordination of the elderly, stimulate the muscles, joints and nerves throughout the body, and further promote the development of dynamic and static balance abilities of the elderly. |
| 9th -12th week<br><br>Maintaining and Strengthen period | 9th week | Breathing practice for 5 minutes. And then review the following postures learned in 1st period: Windmill, Glute Bridge,Kneeling position with one leg raise.<br>Learn“Single leg extension (supine position)”posture (standing position) | | "Single leg stretch" is designed to strengthen the nerve's control ability to the muscles.Improving the coordination of the upper and lower limbs of the elderly, Increasing the perception of body symmetry and deep stimulation of the core muscles.And comprehensively improve the balance |

| | | | | |
|---|---|---|---|---|
| | | | | ability of the elderly. |
| | 10th week | Breathing practice for 5 minutes. Review the following postures learned in 2st period: Sitting and Upper body rotating,Simplified the hundred,Clam opening and closing, and Single leg extension learned. | | Core exercises are mainly used to strengthen core awareness, the strength of the deep spinal stabilizing muscles and the sensitivity of the spinal nerves. |
| | 11TH week | Breathing practice and practice the following postures in sequence: Sitting and Upper body rotating,Glute Bridge,Kneeling position and raise one leg up, Simplified the hundred, Clam opening and closing,Single leg extension. | | These postures in sequence includes: standing posture,sitting posture,supine posture,kneeling posture,side-lying posture,which could improve the balance ability of the elderly during practice. Stimulating overall muscles and nerves ,which helps strengthen the coordination ability at the same time. |
| | 12th week | Breathing practice and practice the all the postures learned in the 3rd period in sequence: Windmill, Glute bridges, Prone hip lift , Four-legged swimming, Side leg circles, Sitting and upper body rotating and Simplified The hundred (supine and knees bending),Clam opening and closing. | | After repeated practice, the combination of breathing and movement can make the movement control of the elderly more precise. The attention could more focused during practice.The integration of consciousness and body could also improve their overall health level. |

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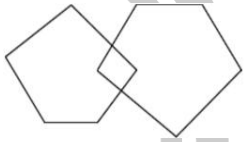
## Appendix G
## Mini-Mental State Examination (MMSE)

| Items | Questions | | Scores |
|---|---|---|---|
| Orientation | What is the year ? | | |
| | What is the season? | | |
| | What is the month? | | |
| | What is the date ? | | |
| | What is the day of the week? | | |
| | Which city are we in? | | |
| | Which district are we in? | | |
| | Which street are we in? | | |
| | What is the name of this place we are staying at? | | |
| | Which floor are we on? | | |
| Registration | I will tell you the names of three things, and after I finish, please repeat what these three things are. 'tree,' 'clock,' 'car.' | tree | |
| | | clock | |
| | | car | |
| Attention and Calculation | Please calculate 100 minus 7, then subtract 7 from the result, and continue this for a total of 5 times (if a mistake is made, but the next answer is correct, only count it as one mistake). | 100-7= | |
| | | 93-7= | |
| | | 86-7= | |
| | | 79-7= | |
| | | 72-7= | |
| Recall | "Now please tell me the three things I asked you to remember earlier. | tree | |
| | | clock | |
| | | car | |
| Language | (Showing a watch) What is this? | | |
| | (Showing a pencil) What is this? | | |
| | Please say '44 stone lions' with me. | | |
| | The examiner gives the participant a card (which says 'Please close your eyes'), and asks them to read the sentence and then follow the instruction. | | |

| | | | |
|---|---|---|---|
| | I will give you a piece of paper; please do as I say. | Hold it with your right hand | |
| | | Fold it in half with both hands | |
| | | Put it on your left thigh | |
| | Please write a complete sentence (the sentence must have a subject, a verb, and be meaningful). | | |
| | Copy the design shown  | | |
| Total score: | | | |

Participant's Name：

Date:

**MMSE Scoring Criteria**

| The total score ranges from 0 to 30, with the cutoff between normal and abnormal related to the level of education. The criteria for classifying dementia are as follows: | Cognitive status assessment | Scoring Criteria and Notes |
|---|---|---|
| uneducated ≤ 17 points | 27–30 points: Normal. | For the first item, a difference of one day in the date and day of the week is considered correct. |
| Primary education level (years of education ≤ 6 years) ≤ 20 points." | 24–26 points: Borderline. | For the second item, immediate recall only allows the examiner to say the items once; the respondent is not required to answer in the order of the items. To prepare for answering the fifth question 'Recall,' the respondent may repeat the learning up to 5 times. |
| Secondary education level (including vocational school) ≤ 22 points. | 13–23 points: Mild. | For the third item, pencil-and-paper calculations are not allowed. If one item is answered incorrectly, points will be deducted for that item. If the following item is answered correctly, points will be awarded for that item. |
| University education level (including junior college) ≤ 23 points. | 5–12 points: Moderate. | For the seventh item, the response may only be said once, and only if it is correct and clearly articulated will it be awarded 1 point. |
| | < 5 points: Severe. | For the eighth item, the order of the instructions must be followed correctly. |
| | | For the ninth item, the sentence must have a subject and a predicate, and it must be meaningful. |

# Appendix H
# Pre-Activity Readiness Questionnaire (PAR-Q)

## (Pre-Activity readiness Questionnaire)

Regular physical activity is fun and healthy, though being more active is very safe for most people, the questions below are designed to assist individuals aged 18 to 75 in determining whether they should see their doctor before increasing physical activity or exercise.

Individuals over 75 years of age, not currently active should check with their doctor.

Common sense is your best guide when you answer these questions. Read the questions carefully and answer each one honestly.

| Yes | No | |
|---|---|---|
| ☐ | ☐ | ●Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor? |
| ☐ | ☐ | ●Do you feel pain in your chest when you do physical activity? |
| ☐ | ☐ | ●In the past month, have you had chest pain when you were not doing physical activity? |
| ☐ | ☐ | ●Do you lose your balance because of dizziness or do you ever lose consciousness? |
| ☐ | ☐ | ●Do you have a bone or joint problem that could be made worse by a change in your physical activity? |
| ☐ | ☐ | ●Is you doctor currently prescribing drugs for a heart condition or ones that affect your blood pressure? |
| ☐ | ☐ | ●Do you know of any other reason why you should not increase your physical activity? |

**IF YOU ANSWERED "YES" TO ONE OR MORE QUESTIONS:**

■ Tell your doctor about the PAR-Q and which questions you answered yes.

■ You may be able to do any activity you want as long as you start slowly and build up gradually or you may need to restrict your activities to those which are safe for you.

■ Talk with your doctor about the kinds of activity you wish to participate in.

■ If you honestly answered **"NO"** to all of the PAR-Q questions, you can be reasonably sure that you can:

- Start becoming more physically active, by beginning slowly and building up gradually. This is the safest and easiest way to begin becoming more active.
- If you are not feeling well because of a temporary illness such as a cold or a fever, wait until you feel better before becoming more active.
- If you are or may be pregnant – please talk to your doctor before you start becoming more active.

■ I have read, understood and completed this questionnaire to the best of my abilities.

NAME:_____ DATE:_____

SIGNATURE:_____ WITNESS:_____

# Appendix I
# Activity Balance Confidence Scale (ABC)

## The Activities-specific Balance Confidence (ABC) scale

What is your gender? How old are you? (years)
Have you had a fall in the past? How long ago? (years)

- For each of the following activities, please indicate your level of confidence in doing the activity, without losing your balance or becoming unsteady. To do so, choose one of the percentage points on the scale from 0 (no confidence) to 10 (complete confidence)
- If you do not currently do the activity in question, try and imagine how confident you would be if you had to do the activity. If you normally use a walking aid to do the activity or hold onto someone, rate your confidence as it you were using these supports.

| | |
|---|---|
| 1. Walk around the house? | |
| 2. Walk up or down stairs? | |
| 3. Bend over and pick up a slipper from the front of a closet floor? | |
| 4. Reach for a small can off a shelf at eye level? | |
| 5. Stand on your tiptoes and reach for something above your head? | |
| 6. Stand on a chair and reach for something? | |
| 7. Sweep the floor? | |
| 8. Walk outside the house to a car parked in the driveway? | |
| 9. Get into or out of a car? | |
| 10. Walk across a parking lot to the mall? | |
| 11. Walk up or down a ramp? | |
| 12. Walk in a crowded mall where people rapidly walk past you? | |
| 13. Are bumped into by people as you walk through the mall? | |
| 14. Step onto or off an escalator while you are holding onto a railing? | |
| 15. Step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? | |
| 16. Walk outside on icy sidewalks? | |

## Appendix J

## Consent Form for Experiment

(English version)

Dear Participant:

I sincerely invite you to participate in an experimental study. This is an informed consent form regarding participation in the research. Please read all the content below carefully to help you decide whether to participate in this study.

1. Research Purpose

The purpose of this experiment is to study and explore the Effect of Pilates exercise on the static and dynamic balance ability and balance confidence of elderly. Pilates emphasizes focus, precision, control, and core strength, which stimulate deep muscles, enhance core musculature, improve core stability, and increase body control. This study aims to validate the effects of 12 weeks of Pilates exercise on the balance ability of the elderly, providing valuable references for more elderly individuals to choose exercise methods.

2. Research Process

If you agree to participate in this study, each participant will have an independent record file. Throughout the research process, professional staff will guide and test participants, assessing static and dynamic balance ability as well as confidence in balance activities. Each person will be tested twice, with an interval of three months. Participants are required to attend Pilates sessions twice a week for 60 minutes each time, over a total of 12 weeks.

3. Risks and Discomfort

During the testing period, you must strictly follow the methods and requirements set by the research and cooperate with the arrangements and guidance of the researchers to avoid unnecessary injuries or accidents. We have already assessed your health and other conditions before the experiment to tailor an appropriate exercise intensity for you. Additionally, we will monitor and maintain a safe exercise environment throughout the process to maximize preventive measures against injuries. Mild muscle soreness may occur during Pilates, which is normal; if the situation worsens or if you experience any discomfort during training, please inform the head researcher immediately.

4. Benefits

By participating in this experimental study, volunteers will receive comprehensive professional training monitoring. These assessments and recommendations will assist in

understanding one's own body, provide references for future training, potentially improve body control and balance functions, and allow for systematic and scientific learning of Pilates, enabling participants to make informed choices in future workouts. At the end of the experiment, participants will receive a Pilates mat as a keepsake.

5. Responsibilities

Participants must proactively provide truthful information about their medical history and current health status. Conditions such as hypertension, orthostatic hypotension, pneumonia, heart failure, heart disease, diabetes, osteoporosis, and Alzheimer's disease should not be concealed, and those individuals are ineligible to participate in this study.

If you experience any discomfort during the study, please inform the researchers promptly.

Participants will strictly adhere to the research process.

6. Privacy

If you decide to participate in this study, your personal information and experimental data will be kept confidential. Your information will not be disclosed to anyone outside of the research team without your permission.

7. Rights

If you are injured during your participation in this study, please inform me immediately so appropriate actions can be taken.

You have the right to know any information and updates related to this experimental study at any time, and you can contact the researchers at your convenience.

I have read this informed consent form.

I have had the opportunity to ask questions, and all my questions have been answered.

I am voluntarily participating in this experimental study.

I can suspend or terminate my participation in this experiment at any time.

If I participate in other research projects or fail to adhere to the plan established by the researcher, the researcher may terminate my participation in this study.

Finally, I have decided to agree to participate in this experimental study.

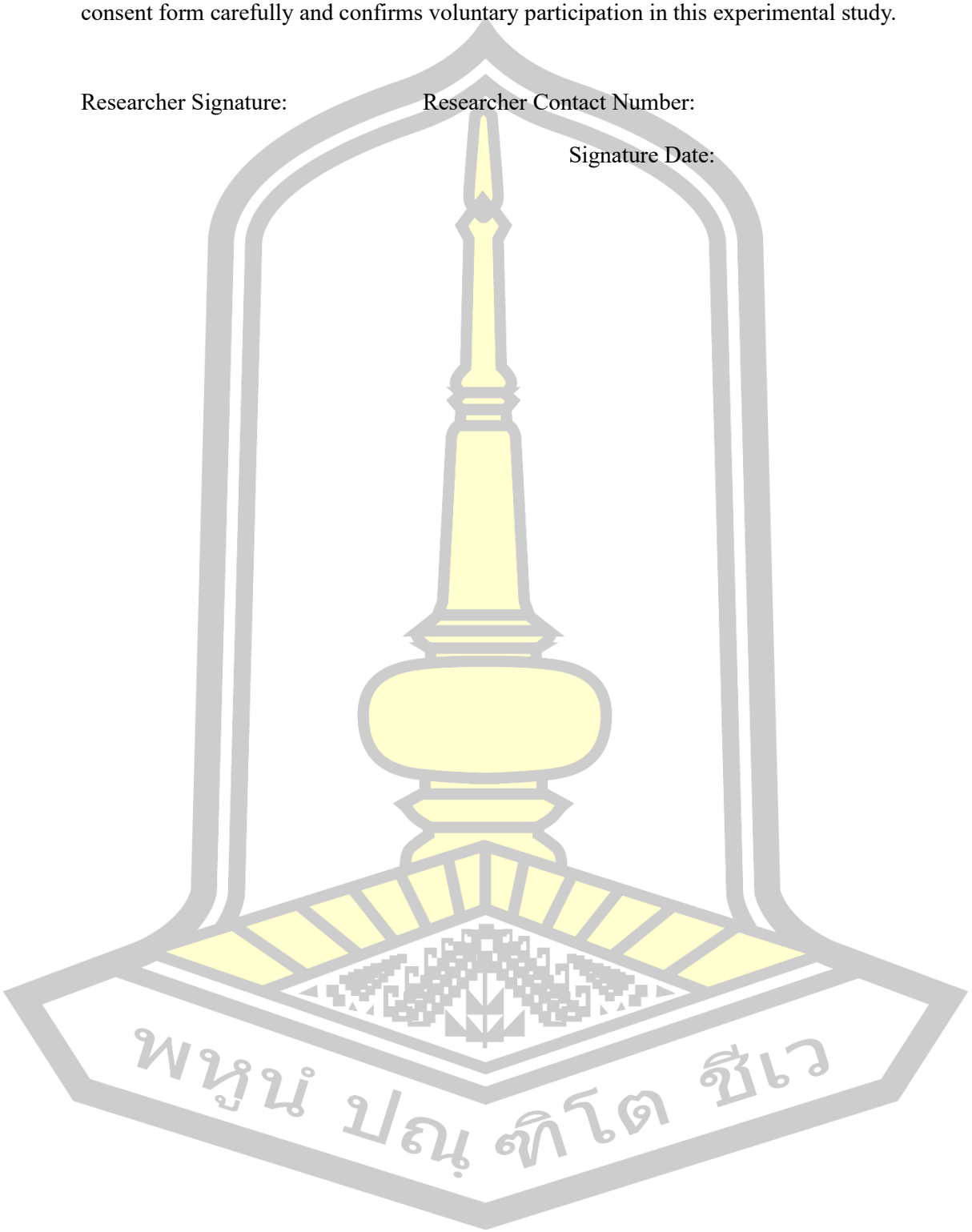
Participant Signature: Participant Contact Number:

Signature Date:

I have fully informed the participant about this informed consent form. He/She has read this consent form carefully and confirms voluntary participation in this experimental study.

Researcher Signature: Researcher Contact Number:

Signature Date:



## Appendix K Consent Form for Experiment

(Chinese version)

### 知情同意书

尊敬的受试者：

我非常真诚的邀请您参与一项实验研究，这是一份关于参与实验研究的知情同意书，请您详细阅读以下全部内容以帮助您决定是否参加此项研究。

研究目的

通过本次实验主要是研究和探索普拉提运动对老年人平衡能力及平衡信心的影响。因为普拉提练习时强调专注、精准、控制和核心，可以刺激深层肌肉，锻炼核心肌群，改善核心稳定性，提高身体控制力。本研究试图通过 12 周的普拉提运动验证其对老年人平衡能力的影响，为更多老年人选择锻炼身体方式提供有价值的参考。

研究过程

如果您同意参与本次实验研究，那么每位受试者都将拥有一份独立的资料档案。在整个研究过程中，由专业人员进行指导与测试，测试静态、动态平衡能力以及平衡活动信心，每个人需要测试两次，间隔时间为三个月。受试者需要在这三个月的时间参加普拉提练习，每周二次，一次 60 分钟，共 12 周。

风险和不适

测试期间，您应严格按照研究设定的方法和要求，配合和听从研究员的安排与指导，以免造成不必要的损伤或意外。我们已通过试验前对您健康等情况的检测与评价针对性的设定适合您的运动强度，并且在运动过程中全程监测和维护练习环境已确保您身体的安全，最大程度做好预防措施，杜绝和避免运动损伤等意外的发生。受试者在进行普拉提运动中可能会出现轻微的肌肉酸痛，为正常现象，若情况严重或在训练中出现任何身体不适，请您立即告知研究负责人。

益处

通过此次实验研究，志愿者会接受一次全面专业运动训练监控，这些监控及建议将有助于对自己身体的了解，为今后的训练提供参考依据，或将改善自身身体控制能力和

提高平衡功能，并能较为系统且科学的学习普拉提，在之后的锻炼中合理选择锻炼本项目。实验结束后会统一赠送普拉提垫子留作纪念。

责任

受试者需主动提供病史和当前身体状况的真实情况,如有高血压、垂直性低压、肺炎、心力衰竭、心脏病、糖尿病、骨质疏松症、阿尔茨海默病等疾病不得隐瞒，且不能参加本次实验。

如若在研究过程中身体出现任何不适，请及时告诉研究者。

受试者将严格按照研究过程来实施。

隐私

如果您决定参加本次研究，您的个人资料及实验数据均保密。除非获得您的许可，否则您的信息将不会透露给研究人员以外的人。

权利

如果您因为参加本次实验研究（实验过程中）受到伤害，请立即告知我，以便进行相应的处理。

您可以随时了解与本次实验研究相关的任何信息和进展情况，并且可以随时与研究者联系。

☐我已阅读了本知情同意书。

☐我有机会提问，且所有问题均已得到解答。

☐我是自愿参加本次实验研究。

☐我可以随时暂停或终止本次实验。

☐如果我参加了其他研究项目，或者没有遵守研究者制定的计划，研究者可以终止我继续参与此次研究。

☐最后，我决定同意参加本次实验研究。

受试者签名：　　受试者联系电话：

签名日期：　年　月　日

我已完整地将知情同意书告知受试者。他/她仔细阅读了这份知情同意书，并证明自愿参加此次实验研究。

研究者签名：　　研究者联系电话：

签名日期：　年　月　日

## Appendix L
## Detailed information of the elderly (experimental group)

| Name | Female | Age | Height(cm) | Weight(kg) | BMI | MMSE |
|---|---|---|---|---|---|---|
| A01 | F | 69 | 168 | 65 | 23.03 | 29 |
| A02 | M | 69 | 152 | 66 | 28.57 | 28 |
| A03 | F | 62 | 156 | 62 | 25.48 | 29 |
| A04 | F | 62 | 154 | 54.5 | 22.98 | 29 |
| A05 | M | 60 | 158 | 64 | 25.64 | 29 |
| A06 | F | 68 | 158 | 59 | 23.63 | 27 |
| A07 | M | 63 | 159 | 63 | 24.92 | 29 |
| A08 | M | 64 | 171 | 66 | 22.57 | 29 |
| A09 | F | 65 | 153 | 54 | 23.07 | 27 |
| A10 | F | 67 | 151 | 50 | 21.93 | 28 |
| A11 | F | 64 | 154 | 57 | 24.03 | 28 |
| A12 | F | 60 | 155 | 56 | 23.31 | 29 |
| A13 | F | 66 | 154 | 53 | 22.35 | 27 |
| A14 | F | 64 | 157 | 56 | 22.72 | 28 |
| A15 | M | 65 | 166 | 65 | 23.59 | 28 |
| A16 | F | 68 | 150 | 53 | 23.56 | 27 |
| A17 | F | 66 | 153 | 62 | 26.49 | 28 |
| A18 | M | 65 | 165 | 67 | 24.61 | 28 |
| A19 | M | 61 | 168 | 68 | 24.09 | 29 |
| A20 | F | 60 | 152 | 52 | 22.51 | 30 |
| A21 | M | 65 | 164 | 66 | 24.54 | 28 |

## Detailed information data of the elderly (control group)

| Name | Female | Age | Height(cm) | Weight(kg) | BMI | MMSE |
|---|---|---|---|---|---|---|
| B01 | F | 65 | 160 | 58 | 22.66 | 28 |
| B02 | F | 61 | 163 | 60 | 22.58 | 29 |
| B03 | M | 66 | 167 | 64 | 22.95 | 28 |
| B04 | F | 60 | 155 | 60 | 24.97 | 30 |
| B05 | M | 67 | 170 | 68 | 23.53 | 28 |
| B06 | F | 69 | 156 | 55 | 22.60 | 27 |
| B07 | F | 68 | 154 | 53 | 22.35 | 28 |
| B08 | F | 64 | 153 | 56 | 23.92 | 28 |
| B09 | F | 63 | 154 | 54 | 22.77 | 29 |
| B10 | F | 61 | 158 | 62 | 24.84 | 29 |
| B11 | M | 66 | 167 | 66 | 23.67 | 27 |
| B12 | M | 65 | 169 | 67 | 23.46 | 28 |
| B13 | F | 63 | 152 | 57 | 24.67 | 28 |
| B14 | F | 61 | 155 | 54 | 22.48 | 29 |
| B15 | F | 65 | 151 | 52 | 22.81 | 28 |
| B16 | F | 64 | 153 | 53 | 22.64 | 28 |
| B17 | F | 65 | 152 | 54 | 23.37 | 28 |
| B18 | F | 64 | 165 | 65 | 23.88 | 29 |
| B19 | M | 68 | 167 | 71 | 25.46 | 27 |
| B20 | F | 60 | 150 | 49 | 21.78 | 30 |
| B21 | M | 69 | 168 | 68 | 24.09 | 27 |
| B22 | F | 60 | 155 | 52 | 21.64 | 29 |

# Appendix M
## Hypertension Classification and Risk Level Table

| Hypertension disease staging | Other risk factors, HMOD, or disease | BP (mmHg) grading | | | |
|---|---|---|---|---|---|
| | | High normal SBP 130-139 DBP 85-89 | Grade 1 SBP 140-159 DBP 90-99 | Grade 2 SBP 160-179 DBP 100-109 | Grade 3 SBP ≥180 or DBP ≥110 |
| Stage 1 (uncomplicated) | No other risk factors | Low risk | Low risk | Moderate risk | High risk |
| | 1 or 2 risk factors | Low risk | Moderate risk | Moderate to high risk | High risk |
| | ≥3 risk factors | Low to Moderate risk | Moderate to high risk | High Risk | High risk |
| Stage 2 (asymptomatic disease) | HMOD, CKD grade 3, or diabetes mellitus without organ damage | Moderate to high risk | High risk | High risk | High to very high risk |
| Stage 3 (established disease) | Established CVD, CKD grade ≥4, or diabetes mellitus with organ damage | Very high risk | Very high risk | Very high risk | Very high risk |

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Note: Risk factors include smoking, blood cholesterol > 220 mg/dL, diabetes, family history of early-onset cardiovascular disease, and males aged > 55 years and females aged > 65 years.

# BIOGRAPHY

| | |
|---|---|
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