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Original Research Article

The implementation of square step exercise is as good as tandem walking exercise on dynamic balance of the elderly in the Kedungwuni II health center area

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ABSTRACT

Background: The aging process can cause various problems including physical decline that impacts balance. Balance disorders are often found in the elderly caused by the nervous system, sensory system and musculoskeletal system. Square step and tandem walking exercises are implemented to improve dynamic balance in the elderly so that the activities of the elderly are not hampered and their mobility can be increased. The purpose of this study was to prove that square step exercise (SSE) was as good as tandem walking exercise in improving dynamic balance in the elderly.
Methods: This study was experimental research with a two-group pretest and posttest design. The research sample consisted of 26 people who were divided into two groups; group I was given a SSE, and group II was given a tandem walking exercise. Both groups received training 2 times a week for 8 weeks. The dynamic balance of the participants was measured through the timed up and go test.
Results: This study found that both SSE and tandem walking exercise could significantly improve the dynamic balance of the elderly, p=0.000. This study also found that there was no significant difference between SSE and tandem walking exercise in improving dynamic balance in the elderly with p=0.103.
Conclusions: SSE was as good as tandem walking exercise in improving dynamic balance of the elderly in the integrated health care of Kedungwuni health center II area.

Keywords: Elderly, Dynamic balance, SSE, Tandem walking exercise, Time up and go test

INTRODUCTION

The elderly phase is part of a natural process of growth and development. Humans will not suddenly grow old, but develop according to the stages starting from birth, children, adolescents, adults, and finally becoming old. This process is followed by physiological and psychological changes that can be different to each person.[1]

The aging process is not a disease, although many elderlies have several diseases. Aging is a life cycle experienced by every individual which is marked by a decrease in the ability of body functions that are physiological in terms of both physical and psychological. An example of the decreased physical abilities of the elderly in the lower extremities is the problem of decreased strength in the muscles resulting to the inability of the feet to set strongly and the tendency of the feet to be wobbly. These signs make the elderly experience balance disorders, when the balance begins to decline it will result in an increasing risk of falling.[2]

Balance disorder was often experienced by elderlies. Based on the initial observations conducted at Kedungwuni II health center, the number of active elderlies at the area was greater than the elderlies at the area of Kedungwuni I health center, with a total of 50 elderlies. The balance test on the elderly revealed that 34 (68%) of them experienced balance disorders. Another survey found that a third of respondents aged 65-75 years had balance disorders that could affect their quality of life.[3]

Balance is an important aspect in performing daily activities involving the musculoskeletal system and nerve system. The balance component consists of a sensory information system, central processing, and effectors. The sensory information system includes the visual, vestibular, and somatosensory systems in the form of tactile and proprioceptive; while the central processing determines the fulcrum of the body, the alignment of the body's gravity, and the effectors that include the response of the postural muscles, muscle strength, adaptive system, and joint of motion that will affect every movement in daily activities.[4] When the visual, vestibular, and musculoskeletal systems work well together, they can maintain body position in accordance with a symmetrical body alignment and improve the balance system of the elderly. However, when the elderly body experiences a decrease in physical condition, the neurologic system decreases, the sensory and musculoskeletal systems decline, it will cause additional problems to balance disorders, namely the risk of falling during activities.[5]

Based on the current global data, it is estimated that there are 500 million people with an average age of 60 years, and by 2025 this number will increase to 1.2 billion.[6] The number of elderly people in Indonesia is the third highest in the world after India and China.[6] In 2020, Indonesia was estimated to have a total elderly population of 27.1 million.[6] The central Java region was ranked second from the highest elderly data in Java, which was 25.86%. Meanwhile, at Pekalongan, 21.97% of the total population were elderly.[6]

According to previous research, the incidence of falls in the elderly was 45% with an average number of falls once a year.[7] The prevalence of injury in the elderly over 55 years was 22%, where 65% of them was caused by falls.[8] The percentage of the elderly who experienced a fall at home was around 47.7% and the elderly who experienced a fall outside their home were 52.3%.[9] These data confirms that problems faced by the elderly caused by balance disorders are quite high.

To improve dynamic balance, there are several exercises that can be applied such as standing tree pose, single leg deadlift, bosu ball squat, learning star pose, high knee walking, semi tandem walking exercise and SSE. Among those exercises, the semi-tandem walking exercise is often used and is easy to implement, because it only uses a straight line, with a distance of 3 meters. However, it is monotonous and the elderly can get bored easily. This exercise has a function to improve lateral postural balance and train the proprioceptive system to keep the body position under control by walking slowly to increase the proprioceptive response to determine the fulcrum of the body and the alignment of gravity on the body so that good posture control can be established, and to organize sensory-motor responses in the body to create stability on the move.[10]

Tandem walking exercise can handle the risk of falling which involves the visual role by expanding the direction of the forward view. Besides, the vestibular and somatosensory systems will also work in an effort to perform the correct gait pattern to keep the body position upright while walking.[11] Tandem walking exercise can improve coordination, proprioception and ankle stabilizing muscles by activating contractions automatically through the central pattern generator.[11]

Researcher was interested in proposing another alternative, namely the SSE. This exercise seems more complicated because it requires 40 templates or gribs with a diameter of 25 cm and requires special attention from the outside and direction to complete the program. The advantage of the SSE is that it requires cognitive understanding, memory, and coordination of the musculoskeletal system to complete the program. The pattern of the foot step in this exercise is to the left, right, and forward with a forward view.[12]

SSE can improve fitness and coordination because the exercise requires more concentration that coordinates visual and auditory to produce movements that have been designed. This study used 3 types of SSE: type 1 was light (step forward, left and right), type 2 was moderate (step diagonally), type 3 was heavy (step backward). These three types were combined with a dual task step where clients were asked step on a certain number of upper limbs, they must move to the abduction and clap.[13]

SSE can also improve dynamic balance because each exercise involves body components in the form of the visual system (visual acuity), the vestibular system (hearing), and the musculoskeletal system in the lower extremities (muscles, joints, bones). After doing this for 4 weeks with 12 meetings, the 27 elderlies' balance increased.[14] In addition, this exercise can be combined with music so that it has an impact on the elderly in the form of enthusiasm and pleasure in doing the exercise program.

Based on the background and supported by government regulation number 43 of 2004 concerning the implementation of efforts to improve the welfare of the elderly, especially in preventive and curative efforts, the researchers are interested in researching and studying further about "the effect of giving SSE and tandem walking exercise equally good in improving dynamic balance in the elderly.

METHODS

This research was an experimental study with a two-group pretest and posttest design by dividing into 2 groups: group I SSE and group II walking semi tandem exercise. The total population in the study was 50 female elderly in integrated health care of Kedungwuni health center II area. For a sample of 26 using simple random sampling method, each group received 13 samples which were distributed by random allocation in each group. This research was conducted in May-28 June 2022.

The inclusion criteria were 60-70 years old, female, balance score 15-20 seconds using the time up and go test (TUGT) measuring instrument and normal LGS values and muscle strength 3+. The data were analyzed by using statistical descriptive tests in the form of sample characteristics based on age, BMI, gender, daily activity, LGS and muscle strength then test for normality and homogeneity of data on dynamic balance variables using the Shapiro Wilk test and Levene's test to find out the distribution of normal and homogeneous data or not in each group. After the data were considered normally distributed, the next analysis test was a paired sample t test to find out whether there was an effect on each group. To find out the difference of the mean in each group, a comparative test was conducted by employing an independent t test.

Time up and go test

The measuring instrument used to measure balance in the elderly was the TUGT. This tool is a simple balance test that has been developed by Podsiadlo and Richardson since 2000. The TUGT has been proven valid and reliable to measure balance in the elderly.[15] The interpretation of this test was normal if the value was 10 seconds; good, if the subject could walk alone without assistance and the score was 20 seconds; having problems and needing assistance when walking and the value was 30 seconds; and require supervision because the risk of falling was high if the value wass 40 seconds.

SSE

SSE is an exercise using a square grid pattern with a size of 25 cm as many as 40 squares with a certain pattern according to the stages. This exercise requires the elderly to take steps forward, right side and left side. This exercise program was carried out in 1 set of 10 repetitions for 15 minutes and was carried out for 2 days a week for 8 weeks with a 5 second rest each step change.

Tandem walking exercise

Tandem walking exercise is an exercise that is done by narrowing the area of support, by walking in a straight line in a position where the heel of the foot touches the other finger.[16] This exercise program was performed in 1 set of 5 repetitions.

RESULTS

The subjects of this study were female elderlies in the integrated health care of Kedungwuni public health center II, aged 60-70 years old, totaling 50 people selected using simple random sampling based on inclusion and exclusion criteria, to obtain a sample of 26 elderly with a sample calculation formula. To fully describe the results of the study and to strengthen the interpretation of hypothesis testing, it is necessary to describe the characteristics of the research sample data from both group I and group II in the form of age, body mass index, gender, ADL, muscle strength, LGS TUGT values pretest, posttest, and the difference (Table 1).

Table 1: Distribution of research respondents characteristics based on age, gender, ADL, LGS and muscle strength.

Variables	Group I		Group II		P value
	F	Mean± SD	F	Mean± SD	
Age (Years)	13	66.62± 2.02	13	66.15± 2.30	0.411
IMT					
Normal	2	26.11± 2.49	1	25.04± 1.23	0.411
Under-weigh	-		-		
Over-weight	2		3		
Obesitas I	8		9		
Obesitas II	1		-		
Gender					
Female	13	-	13	-	-
ADL	13	-	13	-	-
LGS					
Ankle	13	44.62± 2.46	13	45.00± 2.04	0.66
Knee	13	115.77± 3.44	13	115.77± 3.44	1.000
Muscle strength	13	3.69± 0.480	13	3.77± 0.439	0.674

Dynamic balance measurements were performed using a TUGT measuring instrument in both group I and group II. Data collection was carried out pre-test and post-test intervention and the dynamic balance data in group I and group II respectively 1.19 and 0.66 seconds. Average increased in dynamic balance in group I had greater value than group II post intervention test (Table 2).

Table 2: Distribution of pre-test and post-test intervention dynamic balance measurements.

Score TUGT (Dynamic balance)	Group I	Group II
Pre-test (second)	15.78±1.1036	15.62±0.992
Post-test (2nd)	16.97±1.1012	16.28±0.974
Increase diff. (2nd)	1.19±0.0024	0.66±0.018

As a prerequisite for determining the statistical test to be used, a normality test and a homogeneity test of the pre-test and post-test of treatment data were carried out. Normality test using Shapiro Wilk test. The results of the analysis are listed in Table 3.

Table 3: Normality test pre-test and post-test intervention.

Data dynamic balance	Normality data[1]		Homo-geneity[2]
	Group I	Group II	
Pre-test (2nd)	0.149	0.055	0.971
Post-test (2nd)	0.061	0.070	

[1]Shapiro Wilk test, [2]Levene's test.

Based on Table 3 it can be seen that the results of the normality test using the Shapiro Wilk test obtained a probability value for the TUGT pre-test training data group in group I, the p=0.149 (p>0.05) and the post-test research value of p=0.061 (p>0.05), which means that this data was normally distributed, while for group II the pre-test exercise got a value of p=0.055 (p>0.05) and the post-test research value of p=0.070 (p>0.05), which means this data was normally distributed.

To determine the effect of the SSE and semi tandem walking on increasing dynamic balance in the elderly, the paired-Sample T test was used. The test results can be seen in Table 4.

Table 4: The results of the pre and post test of dynamic balance for the elderly group I and group II.

Variables	Pre test, mean±SD	Post test, mean±SD	P value
Group I (2nd)	15.78±1.103	16.97±1.10	0.000
Group II (2nd)	15.62±0.99	16.28±0.97	0.000

Table 4 shows the results of different tests using the paired Sample T test which is used to determine the effect of each intervention given in group I, SSE, while in group II semi tandem walking exercise, the p value results in groups I and II respectively was 0.000 (p<0.05) indicating that the exercise for each intervention was given for 2 months with a frequency of 1 week 2 times, a total of 16 meetings increased dynamic balance in the elderly.

To test the comparison of the average increase in dynamic balance pre-test and post-test treatment in both groups, the independent t-test was used. The results are listed in Table 5.

Table 5 shows the results of the independent t test in group I and group II, the p=0.695 (p>0.05) which means that there was no significant difference between the mean TUGT pre-test training values between the two groups, while for the post-test results the treatment in group I and group II obtained p=0.103 (p>0.05) meaning that there was no significant difference between the average TUGT value of the two groups, so it can be concluded that group I was as good as group II in improving dynamic balance in the elderly.

Table 5: Differences in dynamic balance in group I and II.

Dynamic balance	N	Mean±SD	P value
Pre-test group I (2nd)	13	15.78±1.10	0.695
Pre-test group II (2nd)	13	0.15.62±0.99	
Post-test group I (2nd)	13	16.97±1.27	0.103
Post-test group II (2nd)	13	16.28±1.18	

DISCUSSION

Characteristics of research subjects

Based on the results of this study, the research subjects were 26 female elderly and there was no difference in terms of age between groups I and II, age was the main factor in the decline in balance disorders in the elderly, usually at the age of 60 the balance disorders occurred.[17] The effect of increasing age results in changes in the neurological system, the musculoskeletal system decreases which will have an impact on the balance of the elderly body.[17] There was no difference in the body mass index of the two groups. BMI is a factor in decreasing body balance. It will affect the center of gravity and the fulcrum to maintain body position when moving, while balance itself requires three systems, namely the sensory, motor and central nervous systems.[18]

Gender shows that all samples were women from group I and group II. This factor is one of the factors that are usually compared where it is often found that women have more problems than men, one of the problems is the problem of the greatest risk of falling due to balance disorders with a percentage of 80% and men 20% this is due to problems hormonal, lifestyle, muscle mass, resting metabolic, body fat and psychological state.[19] Postmenopausal female elderly will experience a decrease in hormones, such as estrogen, which reduces calcium so that bone density decreases, this will have an impact on dynamic balance so that they have a greater risk of falling than men.[20] Another impact that can occur due to the lack of estrogen is causing osteoclastogenesis and loss of bone mass so that deformity of posture occurs in women more quickly which results in elderly women experiencing failure to maintain body balance and causing falls.

Activity daily living (ADL) is a factor related to daily activities, this has an impact on endurance, strength, flexibility and balance when moving. Physical activity is a movement that can make muscle contractions so that it can improve the coordination of muscle strength which has a direct impact on the position in balancing the body. These muscle contractions make contractile protein synthesis faster which will make the actin and myosin

filaments in the myofibrils increase and make muscle mass increase so that muscle strength in addition to the range of motion of the joints is the main component and synergizes with each other so that the optimal impact is to be able to maintain body balance.[20]

SSE can improve dynamic balance in the elderly

The SSE was implemented regularly for 8 weeks in 16 meetings, where the average value of increasing dynamic balance was 15.78±1.103 seconds during pre-test and 16.97±1.10 seconds during post-test. Statistical analysis with paired sample t test showed p=0.000. Because the p<0.05, it can be concluded that there was an increase in dynamic balance in the elderly or in other conclusions there was a significant difference in the mean value of dynamic balance in the elderly before and after the intervention.

This result is in line with the TUGT pre-test value of 12.03±1.80 and post-test 8.67±1.23, which means that the SSE intervention improves dynamic balance in the elderly.[14] The SSE is an active training method by following a predetermined pattern, this exercise requires coordination between the sensory system in the form of a visual, propeoceptive system so that it increases the input processed in the brain, this impulse is transmitted to the body to create stability which will produce a fulcrum so that balance the body rises when moving and makes it easier to recognize the area around it, this exercise uses a pattern of left and right sloping footsteps, forward on a template with a diameter of 25 cm each box in the temple so that it activates the body's multisensory balance so that the body does not fall, the body adapts to activate motor repair and central cortex and affect vestibular and speed control thereby increasing the speed of information processing to perform precise and fast steps in any condition when slipping to aid balance and prevent falls.[21]

Another result that was proven from previous studies with TUGT values before exercise 15.66±0.95 and after exercise 10.51±1.56 which means that the SSE intervention increases muscle strength in the lower extremities by Sulfitra et al. Movement in this exercise activates the muscle which recruits a unique anterior motor so that an action potential occurs at the axon terminal which results in stimulation of actin and myosin through the sarcoplasmic retinaculum which forms calcium ions in a concentric phase in the exercise program.[22]

Semi tandem walking can improve dynamic balance in the elderly

Based on Table 4, it shows significant results for semi-tandem walking to improve dynamic balance, resulting in an increase in lateral postural balance and training the proprioceptive system to maintain a controlled body position. The movement of walking on a tandem path was carried out slowly in order to increase the proprioceptive response and sensory input which was processed by the brain as central processing to determine the fulcrum of the body and the alignment of gravity on the body which forms posture control and organizes the sensory motor responses needed by the body to create stability when moving.[10]

Another researcher using the walking tandem heel raise exercise method with TUGT results before 20.65±2.548 and after exercise 13.82±2.215 with the conclusion that it improves coordination and balance in the elderly because walking tandem exercise activates the pronator and supinartor muscles of the legs, this activation is attempted to occur independently semi-automatic because the actual activation of the stabilization is a system that takes place on the central pattern generator. This activation involves the central patterns generator and the integrity of neural circuits with central brain input to achieve semi-automatic movement through the proprioceptive system with slow movements during positional changes to allow the subcortical nuclei and basal ganglia to analyze position sensation and send feedback in the form of expected muscle contractions. This exercise will then be adapted to the central pattern's generator as a new functional stability so that it can increase proprioception and motor activation to signal joint stability and improve balance in the elderly.[10]

Walking semi tandem exercise could improve dynamic balance and environmental recognition because this exercise stimulates prospective enhancement through mechanoreceptors (Rufini, pacini, golgi tendon muscles and muscle spindles), visual and vestibular. This stimulation is brought to the brain and processed by the cerebellum to form information related to balance, this form of information is carried by afferents which will be given to the muscular spindle so as to form coordination between muscles in the lower extremities, postural and upper extremities so that dynamic stabilization as well as the body position recognition are formed on the environment.

SSE is as good as walking semi tandem to improve dynamic balance in the elderly

Based on the results of the independent t test on the results of the TUGT pre-test and post-test exercise in both groups, the p>0.05, meaning that SSE and walking semi-tandem exercise both could improve dynamic balance in the elderly, which was characterized by reduced time in doing TUGT. SSE is a type of exercise that involves a lot of sensory systems, namely the proprioceptive system which when properly stimulated can maintain balance in the elderly, besides involving the proprioceptive system, this exercise also involves visuals so that the elderly can move correctly according to the sequence of numbers in the template.[5] SSE can also improve motor function by engaging the cortical centers. Improvements in the cortical centers will affect vestibular

and directional control so that balance and mobility will improve in the elderly.[23] SSE can also improve body coordination in the elderly due to an exercise program that requires visuospatial memory with a stepping response (mind-motor training) which requires participants to memorize and carry out increasingly complex foot placement patterns by stepping movements to the right, left and forward using patterned template while semi tandem walking is one of the exercises that can create habitual patterns when individuals walk, especially to control body posture in stepping which is assisted by coordination of the trunk, lumbar spine, pelvic, hip and muscles in the abdominal area and the ankle. This exercise is carried out slowly to increase proprioception so as to increase sensory input that will be processed in central processing so that it can determine the fulcrum on the body and the alignment of gravity to control posture when moving.

Walking semi tandem exercise is a walking exercise that follows a straight line while the SSE is a walking exercise following the movement pattern that has been provided in the template with forward, right side and self-movements. Although the movement of the semi tandem walking exercise is simple and easy to do, it has the same effect of increasing dynamic balance as the SSE. This is supported by a comparative test between the two groups using an independent t test, the results obtained $p>0.05$ on the change in TUGT, which means that there is no significant difference in the increase in dynamic balance in the two groups.

Both of these exercises have something in common, namely to improve dynamic balance by activating sensory and motor skills, but have differences in the exercises and different levels of understanding in doing them. the SSE requires the median in the form of a template that has been designed and measured correctly and for the semi tandem walking exercise only a marker is needed. The level of alertness in these two exercises is also different, in which the SSE is difficult to do and falls easily compared to semi tandem walking.

Limitations

This study had a limitation in sleep patterns of the elderly who had not been controlled which would interfere with the research process because it interfered the concentration.

CONCLUSION

SSE is equally good in improving dynamic balance in the elderly than walking semi tandem exercise by activating sensory, motor and coordination systems.

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