The Addition of Active Stretching to Balance Strategy Exercise is the Most Effective as a Home-Based Exercise Program in Improving the Balance of the Elderly

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**Background:** The decreased balance in the elderly increases the risk of falling. An effective type of exercise is needed to improve balance for the elderly. **Aims:** The purpose of this study was to determine the difference in the effectiveness of adding active stretching with dynamic stretching to balance strategy exercise as a home-based exercise program in improving the balance for the elderly.

**Participants and Methods:** This research was a randomized control trial. The participants were 36 elderly selected based on the inclusion and exclusion criteria, divided into three groups. Group 1 was given dynamic stretching exercises to balance strategy exercises, Group 2 was assigned active stretching exercises to balance strategy exercises, and Group 3 was given balance strategy exercise only as a control group. Each group was given different exercises three times a week for 6 weeks. The balance ability of the elderly is measured using a Berg balance scale (BBS).

**Results:** The mean difference scores of BBS before and after exercise with paired sample t-test increased in both groups with P < 0.05. It means that all groups had a significant impact, where the highest different score is in Group 2. The one-way ANOVA test showed a significant difference in the average posttest BBS value between the groups. Furthermore, the data were analyzed by the LSD post hoc test, where the results showed that all groups have significant differences against other groups (P < 0.05), with the best group being Group 2.

**Conclusion:** According to the results, the addition of active stretching exercise to the balance strategy exercise as a home-based exercise program is the most effective in improving balance for the elderly.

**Keywords:** Active stretching, balance, balance strategy exercise, Berg balance scale, dynamic stretching, elderly

**Introduction**

The aging process decreases muscle mass by 1%–2% after the age of 50 and decreases muscle strength by 12%–15% every 10 years after a person reaches the age of 50. Muscle flexibility reduces by 50% in the extensor trunk at 70 years, resulting in the center’s displacement of mass to the heel. At 55 years and above, ankle flexibility decreased by 50% in women and 35% in men. Those problems will increase the risk of falling.[¹]

About 28%–35% of older adults aged 65 years and over experience falls each year, and that number increases by 32%–42% in older adults aged 70 years and over.[²] In Indonesia the prevalence of injuries caused by falls in older adults over 55 years old reached 49.4% and over 65

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years old was 67.1%.[1] Based on these data, a balanced exercise program is needed. A strategy contains ankle, hip, and stepping strategy exercises that are easy to implement and practical to do in the long term by the elderly.[4]

Research conducted by Choi proves that ankle strategy exercise can increase walking speed, improve stride length, increase step length, and shorten stepping time, where these components affect increasing balance in the elderly.[5] In addition, Choi and An’s research also proves that ankle strategy exercise can increase the limits of stability to increase the strength of the ankle joint.[6]

In practice, balance strategy training requires muscle strength and a good range of motion to improve balance more effectively in the elderly.[7] Thus, it is necessary to add dynamic stretching or active stretching exercises to increase muscle strength and flexibility for the elderly.[8]

Research conducted by Zhou et al. showed that dynamic stretching could increase joint range of motion more effectively in hip flexion and extension than static stretching because rhythmic and repetitive movements and changes in the angle of the greater joint range of motion during dynamic stretching contribute to an increase in the range of active joint motion and muscle performance.[9]

However, other studies that conducted by Gallo et al. about the effect of active static stretching exercises on the community of older women showed that there is an increase in the range of motion and joint flexibility after active static stretching exercises, as well as an increase in functional capacity, strength, and muscle endurance so that these components can maintain balance more effectively.[10,11]

Based on this background, this study compares a combination of exercises, namely dynamic stretching exercise with active stretching exercise to balance strategy exercise.

**Participants and Methods**

**Ethics**

We conducted this research after obtaining approval from the Research Ethics Commission of the Faculty of Medicine, Udayana University/Sanglah Central General Hospital Denpasar, with the ethical clearance number: 109/UN14.2.2.VI.14/LT/2021 with protocol number: 2020.02.1.1099.

**Study design**

This research is an experimental study with a randomized pre- and post-test group design conducted in Banjar Munang Manning, West Denpasar, Bali, in January–March 2021. We selected the research participants through the inclusion criteria; elderly aged 60–74 years, elderly with Berg balance scale (BBS) scores between 21 and 40, active range of motion at ankle dorsiflexion 20° and plantar flexion 40°. The exclusion criteria were elderly with a history of neurovestibular, neurovascular, neuromusculoskeletal, and cardiopulmonary disease, elderly having hearing loss (cannot hear and do not use hearing aids) and visual impairment (cannot see) through assessment, elderly with mild physical activity level, independent elderly without equipment auxiliary, elderly with body mass index (BMI) in normal and overweight categories, elderly having a FRAX value with a risk of mild osteoporotic fracture and a normal kyphosis index, elderly who will not be research participants by filling out and agreeing to informed consent.

We selected the participants following the inclusion and exclusion criteria and conducted a random selection with a simple random sampling technique to select 36 participants. Simple random sampling was done by first counting the number of participants in the affordable population, which will then be selected as research participants according to the inclusion and exclusion criteria.

After we met the research participants, a random allocation was conducted. Random distribution was done by drawing lots to divide the participants into three groups. The draw was made on rolled paper and marked with the numbers 1, 2, and 3. Then, it was put into a box. Participants who received lottery number 1 joined Group 1, participants who received lottery number 2 joined Group 2, while participants who received lottery number 3 joined Group 3. At the time of the measurement, the physiotherapist who measured the balance of the participants did not know which group the participants were in (single-blind).

**Intervention**

The total number of the participants was 36 elderly divided into three groups. Group 1 received the addition of dynamic stretching to balance strategy exercise; Group 2 received active stretching to balance strategy exercise, and Group 3 received balance strategy exercise only as a control group.

The inactive and dynamic stretching movements are the same, namely stretching on the dorsiflexor and plantar flexor of the ankle, stretching on the hip extensor and hamstring, and stretching on the hip flexor; the difference is the duration of the exercise. The time of active stretching in each movement is done for five repetitions, where in each repetition, the stretching movement is held for 20 s, and the rest in each repetition is done for 10 s. The exercise duration on dynamic stretching is five sets in each movement, where one group of the movement consists of 20 repetitions and is interspersed with rest for 10 s in each set.

All training begins with a warm-up and ends with a cool-down. All training is carried out with a home-based
exercise program. Each selected participant was then given training guidelines and training videos related to the training provided, which will later be carried out at home with the supervision of his family. During the training, elderly families are required to send photographs/videos of the elderly while doing the exercises. Researchers will visit three times in the 1st, 3rd, and 5th week.

Assessment of outcome parameters
Balance measurements were carried out before and after 6 weeks of exercise using the BBS using 14 measurement items with a score of 0–4. A score of 0 was given if the patient was unable to perform the assigned task, and a value of 4 was given if the patient could complete the task according to the criteria, which is given. The maximum value for this measurement is 56. The test is relatively easy to perform and only requires a stopwatch, a ruler, two chairs, and a small stool (for stepping).

Measurement of joint range of motion was determined using a validated goniometer. Measurement of BMI was carried out using the BMI formula specifically for the elderly. Measurement of physical activity was calculated using the International Physical Activity Questionnaire–Short Form. The risk of osteoporotic fractures was measured using the FRAX® TOOL application (https://www.sheffield.ac.uk/FRAX/tool.aspx?country=9), the kyphosis index was measured using the Flexi curve, data of cardiopulmonary history were collected using the PAR-questionnaire Q and YOU, and data collection of vertigo history was done using a vertigo questionnaire.

Measurements of joint range of motion, BMI, physical activity, risk of osteoporosis fracture, kyphosis index, cardiopulmonary history, and history of vertigo were performed only once before starting the training.

Statistical analyses
Data collected were preceded by editing, coding, processing, tabulating, entering, and cleaning. We performed statistical analyses using SPSS version 16.0. A $P < 0.05$ was considered to indicate statistical significance. A normality test on balance data using the Shapiro–Wilk test was used to examine data distribution. The homogeneity test on balance data using the Shapiro–Wilk test was considered to indicate statistical significance. A normality test on balance data using the Shapiro–Wilk test was used to examine data distribution. The homogeneity test on balance data using the Shapiro–Wilk test was considered to indicate statistical significance.

Different tests in Groups 1, 2, and 3 using paired sample $t$-test seek to analyze the difference in balance before and after training between groups. The difference test between groups used one-way ANOVA and then carried out a post hoc test to see which groups differed. A $P < 0.05$ was considered to indicate statistical significance.

RESULTS
Table 1 shows the characteristics of the participants from a total of 36 elderly, dominated by older women. All study participants did not have a history of heart, lung, and blood vessel disease through the PAR-Q and You questionnaire and did not have a history of vertigo based on a vertigo assessment. The level of physical activity of all research participants was low. Based on the characteristics of the research participants, it can be concluded that all research participants have the same features of gender, age, BMI, ankle joint range of motion, kyphosis index, FRAX value, and BBS pretest values between Group 1, Group 2, and Group 3 ($P > 0.05$).

The data of this study are normally distributed and homogeneous. It is concluded that the test used for hypothesis testing is a parametric statistical test.

Table 2 shows that the posttest data obtained $P < 0.05$ in the three groups. This indicates that there are significant differences between the three groups.

Table 3 shows that the postexercise data obtained $P < 0.05$. This indicates a significant difference in the average BBS value data after exercise between Group 1, Group 2, and Group 3.

Table 4 shows a further test of the results of the average difference between groups after exercise using the post hoc LSD test. The post hoc LSD test was used to determine whether one group had a significant difference from another group. The results of the post hoc LSD test analysis as a whole in the study showed a $P < 0.05$. This indicates that all groups have significant differences from other groups.

DISCUSSION
Reasonable balance control requires muscle strength and flexibility and accurate visual, vestibular, and proprioceptive input. Thus, stretching training to a balance training program can improve balance postural control in the elderly.[12]

In this study, the addition of active stretching exercise to the balance strategy exercise was more effective than the addition of dynamic stretching workout to the balance strategy exercise in improving balance in the elderly. An active stretching routine can increase flexibility and optimal muscle strength through autogenic and reciprocal inhibition mechanisms.

Autogenic inhibition, also known as the inverse myotatic reflex, will occur in a stretched muscle by reducing muscle excitability due to increased inhibitory input arising from the Golgi tendon organ (GTO). This mechanism begins with a stretched muscle triggering a GTO-mediated impulse through Ib-afferent nerve fibers sent to the posterior horn of the spinal cord. After synapsing, impulses continue to travel through spinal afferent nerves to the cerebral cortex and cause the sensation of tension.
The cerebral cortex then processes information from the GTO to generate motor signals. Motor signals leave the cortical area to the spinal cord via the corticospinal tract. The main pathway for motor impulses is called the pyramidal tract. This motor signal will end up in the anterior horn of the spinal cord to inhibitory interneurons, which impact the motor neuron nerves, thereby reducing motor nerve activity and efferent motor performance. The reduced delivery of motor efferent stimuli to the muscle with this autogenic inhibition mechanism causes a decrease in the tension of the stretched muscle so that the power can elongate effectively. Muscle tension will decrease when GTO is activated intensely and continuously, both in the agonist and antagonist muscles. Thus, it can increase the elongation of the antagonist’s muscle and maximize the strength of the agonist’s muscle.

Reciprocal inhibition is a phenomenon that occurs in muscle spindles in contracting agonist muscles that can decrease the level of activation and increase inhibition of proprioceptive structures in the antagonist’s muscle so that the antagonist muscle can be adequately stretched. The decrease in activation in the antagonist’s muscles occurs through a reciprocal inhibition mechanism. The descending pathway input activates motor neurons in the agonist’s muscle and provides excitatory input to Ia-inhibitory interneurons that synapse to motor neurons in the antagonist’s muscle. The resulting inhibition of antagonistic muscle motor neurons can be further enhanced by increasing the excitatory input arising from Ia-afferents in the contracting agonist muscle to the same Ia-inhibitory interneurons. This will lead to inhibition of the antagonist muscle’s alpha motor neurons, which decreases the level of muscle activation and facilitates stretching of the antagonist’s muscle.

Thus, the mechanism of autogenic inhibition and reciprocal inhibition will maximize the contraction ability of the agonist muscle and stretch of the antagonist’s muscle so that with active stretching exercise, maximum muscle strength and muscle flexibility will be formed. This is in line with Regima, who showed that inactive stretching, contraction of the agonist muscle held for 20 s was more beneficial in

### Table 1: Characteristics of the participants

| Characteristic                        | Group 1 | Group 2 | Group 3 |
|---------------------------------------|---------|---------|---------|
| Gender (%)                            |         |         |         |
| Male                                  | 16.7    | 33.3    | 25.0    |
| Female                                | 83.3    | 66.7    | 75.0    |
| Age (years), mean±SD                  | 66.0±5.02| 65.2±5.10| 68.2±3.88|
| BMI (kg/m²), mean±SD                  | 22.13±2.37| 23.55±1.51| 23.64±1.11|
| Range of motion of the ankle (mean±SD)|         |         |         |
| Right ankle dorsiflexion (°)          | 18.83±1.03| 18.67±0.98| 18.92±0.90|
| Left ankle dorsiflexion (°)           | 18.08±1.44| 18.50±0.79| 19.17±1.03|
| Right ankle plantar flexion (°)       | 40.25±5.73| 44.50±6.54| 41.58±4.27|
| Left ankle plantar flexion (°)        | 43.08±7.29| 46.00±6.36| 42.25±7.41|
| Index of kyphosis (cm), mean±SD       | 10.68±0.98| 11.19±1.06| 11.27±1.26|
| FRAX value (mean±SD)                  | 3.72±1.23| 3.20±1.04| 3.02±1.02|
| Osteoporosis mayor                    | 1.05±0.40| 0.90±0.46| 0.93±0.42|
| Hip fracture                          | 35.17±1.58| 35.25±1.65| 34.08±1.78|
| BBS pretest (mean±SD)                 |         |         |         |

SD: Standard deviation, BMI: Body mass index, BBS: Berg balance scale, FRAX: Fracture risk assessment tool

### Table 2: Paired sample *t*-test

| Group         | Mean value before exercise | Mean value after exercise | *P* |
|---------------|----------------------------|---------------------------|-----|
| Group 1       | 35.17±1.58                | 38.58±1.31                | 0.000 |
| Group 2       | 35.25±1.65                | 40.17±2.12                | 0.000 |
| Group 3       | 34.08±1.78                | 35.33±1.72                | 0.001 |

### Table 3: Comparative test of the average balance of the elderly before and after exercise

| Group         | Mean±SD       | *P* |
|---------------|---------------|-----|
| Pretest       |               |     |
| Group 1       | 35.17±1.58    | 0.180 |
| Group 2       | 35.25±1.65    |     |
| Group 3       | 34.08±1.78    |     |
| Posttest      |               |     |
| Group 1       | 38.58±1.31    | 0.000 |
| Group 2       | 40.17±2.12    |     |
| Group 3       | 35.33±1.72    |     |

SD: Standard deviation

### Table 4: Differences in means between groups after exercise with post hoc test

| Number | Group | *P* |
|--------|-------|-----|
| 1      | Group 1 versus Group 2 | 0.034 |
| 2      | Group 1 versus Group 3 | 0.000 |
| 3      | Group 2 versus Group 3 | 0.000 |

LSD: Least significant difference
The effects of stretching on the flexibility, muscle performance, and coordination improves postural control reactions and increasing the flexibility of the antagonist’s muscle through autogenic inhibition and reciprocal inhibition mechanisms. \[10\]

When the muscle is actively stretched slowly and gently, the Golgi tendon will be optimally stimulated and inhibit the tension in the muscle so that stretching will occur in the muscle fibers and fascia where the number of sarcomeres increases the fascia is stretched. Holding the stretching position at the end of the movement for some time will cause passive torsion and muscle tension to decrease so that muscle tendon unit (MTU) causes stress relaxation.\[4\] Stress relaxation can continue as long as stretching is maintained. Most stress relaxation occurs for 20–30 s when the stretch is maintained at the end of the movement. This duration is suggested as the most effective hold on stretching to improve flexibility and muscle performance.\[17\]

Research conducted by Kaya et al. regarding static stretching that is carried out actively for 6 weeks can improve balance. This is because the muscle spindle becomes more sensitive to muscle elongation, resulting in an increase in the speed and strength of muscle contraction, which will lead to improvements in balance control.\[12\]

In dynamic stretching training, the postactivation potentiation mechanism occurs, characterized by increased muscle tension and strength so that muscle flexibility happens very minimally. Thus, the addition of active stretching exercise to the balance strategy exercise as a home-based exercise program will synergize in creating stability and balance for the elderly effectively through increasing muscle flexibility and muscle performance, resulting from active stretching exercise training, as well as increasing the limits of functional stability, increasing motor system (strength and coordination), and improving postural control reactions, resulting from balance strategy exercise training.

### Strength and limitations

This study was a randomized controlled trial conducted for 6 weeks. These exercises were performed with a home-based exercise program, so the elderly can do exercises by themselves safely. Despite its strength, this study also has some weaknesses. The limitation of this study was that research was conducted during the COVID-19 pandemic, so it was not possible to carry out face-to-face training programs (offline) with the elderly. This makes it difficult for researchers to supervise the elderly during the given exercise program.

### Conclusion

The addition of active stretching to balance strategy exercise is the more effective in improving balance than the addition of dynamic stretching to balance strategy exercise as a home-based exercise program for the elderly in Banjar Munang Maning, West Denpasar.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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