RESEARCH PAPER

Effects of Otago Exercise Program on Improving Balance and Reducing Risk of Fall Among Sarcopenic Subjects

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ABSTRACT

Background: Sarcopenia is an age related skeletal muscle disorder which is characterized by accelerated loss of generalized muscle mass & muscle strength. As this disorder progresses, it is more prone for adverse ill effects causing functional decline leading to risk of fall, fractures and may also cause mortality at the severe end. Other than geriatric population, people diagnosed with chronic disease, inactivity or malnutrition are also a known threat for accruing sarcopenia. Hence, the early detection of this condition will pave the way for early treatment modalities improving the quality of life and prevent permanent disability for the patient.

Aim: The aim of the study is to compare the efficacy of otago exercises with the conventional exercises to improve balance & stability in sarcopenia patients.

M&M: A total of 40 subjects who are aged >60 but <75 years participated in the study with no gender specifications. They were categorized into 2 groups, Group A (Experimental group) & B (Control group). Group A underwent an Otago exercise program and Group B received traditional balance exercises thrice a week for eight weeks. The final outcome was analysed via Berg Balance Scale (BBS), Falls Efficacy Scale-International (FES-I) and Timed Up and Go test (TUG).

Results: The intra-group analysis showed both the treatments are effective in terms of changes in the value of all measures (Berg Balance Scale, Falls Efficacy Scale-International, Timed Up and Go test). However, the inter-group analysis demonstrated that the performance of individuals in group A is more effective than group B in terms of average improvement in BBS and average reduction in FES-I and TUG (seconds).

Conclusion: Otago exercises accelerate balance and reduce the risk of fall in sarcopenia patients than the conventional exercise.

Keywords: Sarcopenia, Otago exercise program, Berg Balance Scale (BBS), Falls Efficacy Scale-International (FES-I), Timed Up and Go test (TUG)

How to cite this article: Sharmila S, Senthil Selvam P, Antony Leo Aseer P, Senthil P, Reabeakkal M. Effects of Otago Exercise Program on Improving Balance and Reducing Risk of Fall Among Sarcopenic Subjects. Int J Drug Deliv Technol. 2026;16(22s): 25-36. DOI: 10.25258/ijddt.16.22s.2

Source of support: Nil.

Conflict of interest: None

INTRODUCTION:

Irwin Rosenberg coined the term "sarcopenia" for the first time in 1988 at a conference in Albuquerque, New Mexico. The word "sarcopenia" was derived from the Greek terms "sarx" (flesh) and "penia" (deficiency). Rosenberg described sarcopenia as the progressive decline in muscle mass that accompanies aging and contributes to weakness, reduced mobility, and functional impairment in older adults (1). The nature of this illness is progressive. After which, the definition of sarcopenia was redefined by three major consensus statements. In 2010, The European Working Group on Sarcopenia in Older People (EWGSOP) defined it as 'The presence of low skeletal mass and either low muscle strength or low physical performance; when all three conditions are present, severe Sarcopenia may be diagnosed' (2). In 2011, The International Working Group on Sarcopenia (IWGS) described sarcopenia as 'The age-associated loss of skeletal muscle mass and function' and emphasized that it may occur 'alone or in conjunction with increased

fat mass' (3). In 2014, Asian Working Group for Sarcopenia (AWGS) defined sarcopenia as 'Age-related loss of muscle mass plus low muscle strength and/or low physical performance' (4). Sarcopenia has been designated a disease by the World Health Organization (WHO), and it is included as ICD Code M62.8 in the International Classification of Diseases (5). According to the EWGSOP definition, the prevalence rate of sarcopenia in the senior population ranges from 1 to 29%, and it ranges from 14 to 33% in long-term care populations among western countries (5, 6). Under the AWGS criteria, the prevalence of sarcopenia in Asia ranges from 2.5 to 45.7% (7). Sarcopenia grows from 14% in people who are aging from 65 to 70 years of age to 53% in those who are over 80 years of age (8). 5-13% of those aged 60 to 70 are reported to be affected by sarcopenia (9).

The skeletal muscles are made up of two different types of tissue: connective tissue, which lacks contractility, and muscle tissue, which is contractile by nature. Thick myosin filaments and thin actin filaments make up sarcomeres. These filaments interact, causing the muscle to contract. These actin and myosin alternations give the muscle the appearance of being striated when the full myofibril is examined under a microscope. Moreover, muscle plays a significant role in energy production, has the capacity to store glycogen and 60% of protein molecules, can oxidize lipids, and can release amino acids (10). Muscle is unable to control the normal process of protein depletion as we become older. Moreover, the muscle's capacity to store protein in the contractile tissue and mitochondria declines and the production of new muscle protein is decreased. These physiological alterations result in a loss in muscle mass (11). These changes in the muscle's bulk prevent the muscle from exerting the right amount of force on the bone to achieve the intended movement (12). Because of this condition almost nil physical activity or people may even need bed rest, causing the release of cytokines which is an inflammatory mediator that boosts proteolysis activity (12, 13). The majority of the geriatric population experience co morbidities, likely stroke, hypertension, osteoarthritis, cardiovascular issues, etc.

Previous evidence displays that not just because of age, but a healthy young person who has been in bed rest for 10 days results in a loss of 1 kg of muscle mass and a loss of 9% of quadriceps muscle strength (12–14). According to EWGSOP, the diagnosis of sarcopenia can be carried out by assessing 3 parameters: (i) Gait speed below 0.8 m/s; (ii) Low muscle mass <7.23 kg/m2 (Men) and <5.67 kg/m2 (Women); (iii) Hand grip strength <30 kgs (Men) and <20 kgs (Women). Depending on each person's tolerance, the otago exercise regimen includes walking, balance drills and strengthening exercises (15). This series of exercises lowers the chance of falling by improving muscle strength and balance (16). First established in New Zealand, the risk of fall has been reduced greatly by 35% after otago exercise program (17). It is acknowledged as an effective fall prevention programme by the Centers for Disease Control and Prevention (CDC) (18). Also, this exercise programme significantly enhanced physical performance and decreased death rates by lowering fall risks (19). Hence, the efficacy of otago exercise as a sole treatment of choice for sarcopenia for geriatric patients has not been established yet. We aimed at establishing the aforementioned rationale to improve the utility of otago exercise primarily as compared to conventional exercises from the early stage to severe end in patients with sarcopenia.

NULL HYPOTHESIS & ALTERNATIVE HYPOTHESIS:

Null hypothesis (H_0): There would be no significant difference between the otogo exercise program and conventional exercise therapy in individuals with sarcopenia.

Alternative hypothesis (H_1): There would be significant difference between the the otogo exercise program and conventional exercise therapy in individuals with sarcopenia.

MATERIALS AND METHODS:

Study design & setting:

Thisrandomized controlled trial was performed as an experimental study conducted in C Dot hospital, Perumbakkam & Chamundi Clinic, Thirumullaivoyal; after procuring the approval from Institutional Ethical Committee (IEC) (Ethical clearance number: SOPT/VISTAS/IEC/110/2023). A total of 75 subjects were screened and following a complete evaluation during their hospital visit, a final of 40 subjects were included who fulfilled the inclusion criteria for this current study. The sample size was calculated via G*Power software (version 3.1) with a power of 80% alpha level of 0.05. this yielded a medium effect size (d=0.5), the minimum required sample size to be 34 participants (17 per group). To ensure adequate statistical power, the sample size was increased to 40. The study subjects were categorized into 2 equal groups; Group A & Group B using lottery (LOT) method. 40 identical chits were prepared, with 20 Group A & 20 Group B. The participants were asked to pick one chit randomly and according to their selection they were allocated in the groups respectively. Group A with 20 subjects received Otago exercise programs for 45 minutes per session with training frequency of 3 times per week and Group B received standard conventional exercise programs for 45 minutes per session with training frequency of 3 times per week as a treatment of choice for sarcopeniaEach study

subject completed a course of 8 weeks of the allocated exercise programs but the treatment period extended for 4 months due to the availability of the patientThe study subjects were asked to give a written consent before participating in the study. The study subjects selection process and the participants through different phases of RCT is presented in the CONSORT flow diagram (Figure 1).

Sample selection:

Inclusion criteria:

- Male & Female subjects
- Age group: 60-75 years
- Sarcopenia diagnosed via AWGS criteria (4): ASMI < 7 kg/m2 for male & 5.7 kg/m2 for female; 6-m walk (<1 m/s); handgrip strength (HG <28 kg for male &<18 kg for female.
- Subjects who scored 21 - 40 in Berg Balance Scale (Moderate fall risk) (20).
- Subjects who scored 20 - 27 in Falls Efficacy Scale – International (Moderate concern about falling (21).
- Subjects who completed the task within 20 - 30 seconds in Timed Up and Go test (Medium fall risk) (22).
- Have no muscle or joint limitations in the involved segment.
- Stable metabolic disorders.

Exclusion criteria:

- H/O deep venous thrombosis and/or blood clotting disorders.
- Hypertension (blood pressure > 160/100 mmHg) and Hypotension (blood pressure <90/60 mmHg)
- H/O stroke, heart failure, coronary ischemia, coronary arrhythmias, peripheral arterial disease, pulmonary diseases.
- Recent fractures or dislocations.
- Sensory defects (vision, hearing etc) that affect communication.
- H/O dementia.
- Anemia (hemoglobin<9g/dl)
- Severe cerebrovascular or peripheral venous insufficiency.
- H/O surgery within the past 6 weeks.
- Unstable metabolic disorders.

Tools:

Arm rest chair, Inch tape, Turning fork, Goniometer, Hand held dynamometer, Pins, Weight cuffs and Stop watch were utilized as the study tools for analysing Balance, risk of fall & physical performance. The balance was assessed by Berg Balance Scale (BBS); risk of fall by Falls Efficacy Scale-International (FES-I) & physical performance by Timed Up and Go test (TUG).

Methodology:

***Group A:** The experiment began with a few warm up exercises for the initial 15 minutes which included: Head movements, neck movements, back extension, trunk movements and ankle movements.

Otago Exercise Program

It consists of 5 exercises for strengthening and 12 balance exercises and a walking program. The patient was advised to hold each position for 15 seconds and each exercise were repeated 10 times. Rests of 5 seconds were given between each exercise.

(i) Strengthening Exercises:

0.5 kgs weight cuffs were tied at the ankle till 4 weeks for strengthening the program. After 4 weeks, a 1 kg weight cuff was used to strengthen the muscle.

- **Front knee strengthening exercise:**The subject was asked to sit on the arm rest chair. The weight cuff was tied to the ankle. The subject was asked to extend the knee from a semi flexed position and this was repeated 10 times (Figure 2).
- **Back knee strengthening exercise:** The subject was asked to stand in erect posture. Then the weight cuff was tied to the ankle. Then the subject was asked to flex the knee. This was repeated 10 times (Figure 3).
- **Side hip strengthening exercise:** The subject was asked to stand in erect posture. The weight cuff was tied to the ankle. Now, the subject was asked to abduct and adduct the hip. This was repeated 10 times.
- **Calf rises:** The subject was made to stand in erect posture. Now the subject was asked to raise the heel off the ground and asked to hold for 15 seconds and then relax. It was repeated 10 times.
- **Toe rises:** The subject was made to stand in erect posture. Now the subject was asked to raise the toes off the ground and asked to hold for 15 seconds and then relax. It was repeated 10 times.

(ii) Balance Exercises:

The balance exercises were performed with support till 4 weeks. After the 4th week, the exercises were performed without any support.

- **Knee bends:** The subject was asked to stand in an erect posture. Then, the subject was asked to flex the knee and asked to maintain the position for 15 seconds. This was repeated 10 times.

- **Backwards walking:** A straight line was drawn on the ground for 1 meter. The subject was now asked to walk on the line backwards. Once reaching the end line, the subject should again start from the starting point. This was repeated 10 times.
- **Walking and turning around**: The patient was asked to walk at a regular pace. Then the subject was asked to turn in a clockwise direction. Then the subject was instructed to walk back to the starting position. Again, the subject was asked to turn in a counter-clockwise direction. This was repeated 10 times (Figure 4).
- **Sideways walking:** The subject was asked to walk 10 steps on the right and 10 steps on the left. This was repeated 10 times.
- **Heel toe standing:** The subject was asked to keep one foot in front of the other so that it forms a straight line. The position was asked to maintain for 10 seconds. Then the subject was asked to change the position of the foot (Figure 5).
- **Heel toe walking forwards:** A straight line was drawn on the ground for 1 meter. The subject was asked to keep one foot in front of the other so that it forms a straight line. With this position, the patient was asked to walk for 10 steps forwards on the marked line. After reaching the end point, the subject was asked to start again from the starting point. This was repeated 10 times.
- **Heel toe walking backwards:** A straight line was drawn on the ground for 1 meter. The subject was asked to keep one foot in front of the other so that it forms a straight line. With this position, the patient was asked to walk for 10 steps forwards on the marked line. After reaching the end point, the subject was asked to start again from the starting point. This was repeated 10 times.
- **One leg stand:** The subject was asked to stand with only one leg and asked to maintain it for 15 seconds. The same protocol was maintained for the other leg also. This was repeated 10 times.
- **Heel walking:** A straight line was drawn on the ground for 1 meter. The subject was asked to raise the toes off the ground. With this position, the patient was asked to walk for 10 steps forwards on the marked line. After reaching the end point, the subject was asked to start again from the starting point. This was repeated 10 times.
- **Toe walking:** A straight line was drawn on the ground for 1 meter. The subject was asked to raise the heels off the ground. With this position, the patient was asked to walk for 10 steps forwards on the marked line. After reaching the end point, the subject was asked to start again from the starting point. This was repeated 10 times.
- **Stand to sit:** The subject was asked to sit on an arm rest chair. Then the subject was asked to stand up by pushing up both the hands. This was repeated 10 times (Figure 6).
- **Stair walking:** The subject was asked to get up and down for 10 steps and asked to repeat it for 10 times.

(iii) Walking program:

For 30 minutes, 3 days a week, the participants were instructed to walk on flat ground at a regular speed, with a 2- to 3-minute warm-up and cool-down in between. Walking could also be broken up into shorter intervals, such as 3 sets of 10-minute sessions. Depending on the person's ability, walking speed could be raised after a first month of starting out slowly.

***Group B:** Warm up exercises was performed for the first 15 minutes which includes: Stretches for calves, hamstrings, quadriceps, gluteal muscles, tensor fascia lata for 10 minutes with a slow walking program for 5 minutes.

Traditional Balance Exercise:

The participants were instructed to hold each position for 15 seconds and they were asked to repeat each exercise for 10 repetitions with a 5 seconds rest interval between each exercise. This was followed till 4 weeks. The balance exercises were carried out with support till 4 weeks. After the 4th week, the exercises were performed without any support.

- **Single-leg stance with eyes open:** The subject was asked to stand on one leg with eyes open and asked to maintain it for 15 seconds. The same protocol was maintained for the other leg also. This was repeated 10 times (Figure 7).
- **Single-leg stance with eyes closed:** The subject was asked to stand on one leg with eyes closed and asked to maintain it for 15 seconds. The same protocol was maintained for the other leg also. This was repeated 10 times (Figure 7).
- **Standing on heels:** The subject was made to stand in erect posture. Now the subject was asked to raise the toes off the ground and asked to maintain 15 seconds and then relax. It was repeated 10 times.

- **Standing on toes:** The subject was made to stand in erect posture. Now the subject was asked to raise the heel off the ground and asked to maintain for 15 seconds and then relax. It was repeated 10 times.
- **Tandem foot stance:** The subject was asked to keep one foot in front of the other so that it forms a straight line. The position was asked to maintain for 10 seconds. Then the subject was asked to change the position of the foot.
- **Semi tandem foot stance:** The subject was asked to place one foot near the mid foot of the other foot. The position was asked to maintain for 10 seconds. Then the subject was asked to change the position of the foot.
- **Tandem walking:** A straight line was drawn on the ground for 1 meter. The subject was asked to keep one foot in front of the other so that it forms a straight line. With this position, the patient was asked to walk for 10 steps forwards on the marked line. After reaching the end point, the subject was asked to start again from the starting point. This was repeated 10 times.
- **Walking backward:** A straight line was drawn on the ground for 1 meter. The subject was now asked to walk on the line backwards. Once reaching the end line, the subject should again start from the starting point. This was repeated 10 times.
- **Walking forward:** A straight line was drawn on the ground for 1 meter. The subject was now asked to walk on the line forwards. Once reaching the end line, the subject should again start from the starting point. This was repeated 10 times.
- **Weight shifting:** the subject was to place one foot in front of the other foot so that it forms a straight line (stride position). The subject was asked to transfer the weight from one foot to another. This was repeated 10 times.

Statistical Analysis:A pairedstudent T-test was performed to compare within the groups and an unpaired student T-test was performed to compare between the groups. P value <0.05 was considered to be statistically significant.

RESULTS:

The analysis was performed to compare baseline characteristics, pre & post intervention outcomes in inter & intra groups. Intra-group was analyzed via Paired T-test and Inter-groups were analyzed via Unpaired T-test.

COMPARSION BASED ON INTER-GROUP ANALYSIS:

Age:

The mean age of the study participants of group A& B were67.25 ± 3.697 &67.80 ±4.312 respectively. This was not statistically significant (p = 0.667). The p-value (0.667) is > 0.05, indicating no significant difference between groups at baseline. This confirms that both groups were age-matched.

Baseline outcome measures (Pre-test):

No statistical significance noticed between group A & B at baseline outcome measures.

- **BBS Pre-test:** Group A (37.15 ± 2.87) vs. Group B (37.05 ± 2.417); p = 0.906 (>0.05) → No significant difference, indicating both groups had similar balance abilities at baseline.
- **FES-I Pre-test**: Group A (24.60 ± 2.186) vs. Group B (24.55 ± 2.259); p = 0.994 (>0.05) → No significant difference, indicating similar fear of falling levels at baseline.
- **TUG Pre-test:** Group A (13.65 ± 1.309) vs. Group B (13.45 ± 1.276); p = 0.627 (>0.05) → No significant difference, indicating similar functional mobility at baseline

Baseline outcome measures (Post-test):

No statistical significance noticed between group A & B at baseline outcome measures.

- **BBS Post-test**: Group A (40.30 ± 2.993) showed higher scores than Group B (38.85 ± 2.390), but the difference was not statistically significant (p = 0.099 > 0.05).
- **FES-I Post-test**: Group A (22.60 ± 1.759) showed slightly lower (better) scores than Group B (23.25 ± 2.511); however, the difference was not statistically significant (p = 0.349 > 0.05).
- **TUG Post-test**: Group A (11.05 ± 1.146) performed better than Group B (11.90 ± 1.252), and this difference was statistically significant (**p = 0.031 < 0.05**).

Although both groups were comparable at baseline, Group A demonstrated significantly greater improvements than Group B in all outcome measures (balance, fear of falling, and functional mobility) as evidenced by the difference scores. This suggests that the intervention received by Group A was more effective than that received by Group B (Graph 1). The baseline outcomes of pre-test and post-test are listed in table 1**.**

COMPARSION BASED ON INTER-GROUP ANALYSIS:

Within-Group Comparison for Group A (Paired student T-test)

- **Berg Balance Scale (BBS):** Group A demonstrated a significant improvement in balance, with mean scores increasing from 37.1 ± 2.87 at pre-test to 40.3 ± 2.99 at post-test. The mean improvement of 3.2 points was highly significant (**p < 0.001**), indicating enhanced postural control and reduced fall risk.
- **Falls Efficacy Scale–International (FES-I):** FES-I scores decreased from 24.6 ± 2.19 to 22.6 ± 1.76, reflecting a mean reduction of 2.0 points. This change was statistically significant (**p = 0.003**), indicating a meaningful reduction in fear of falling and improved confidence in daily activities.
- **Timed Up and Go (TUG):** TUG time improved significantly from 13.7 ± 1.31 seconds to 11.1 ± 1.15 seconds, with a mean reduction of 2.6 seconds (**p < 0.001**). This demonstrates a substantial improvement in functional mobility and dynamic balance.

Group A showed statistically significant improvements in all three outcome measures (balance, fear of falling, and functional mobility) from pre-test to post-test. This confirms that the intervention received by Group A was effective in producing positive changes (Table 2).

Within-Group Comparison for Group B (Paired student T-test)

- **Berg Balance Scale (BBS):** Group B showed a significant improvement in balance, with scores increasing from 37.0 ± 2.42 to 38.9 ± 2.39. The mean improvement of 1.9 points was statistically significant **(p < 0.001**), although smaller than that observed in Group A.
- **Falls Efficacy Scale–International (FES-I):** FES-I scores decreased from 24.6 ± 2.26 to 23.3 ± 2.51, with a mean reduction of 1.3 points. This improvement was statistically significant (p = 0.009), indicating reduced fear of falling.
- **Timed Up and Go (TUG):** TUG time improved from 13.4 ± 1.28 seconds to 11.9 ± 1.25 seconds, with a mean improvement of 1.5 seconds. This change was highly significant (**p < 0.001**), reflecting enhanced mobility.

Group B also showed statistically significant improvements in all three outcome measures from pre-test to post-test. This confirms that the intervention received by Group B was effective. However, the magnitude of improvement was consistently smaller than that observed in Group A (Table 3).

ANALYZING TREATMENT OUTCOMES BETWEEN GROUPS:

- **BBS Difference:** Group A improved by 3.15 ± 1.348 points, while Group B improved by only 1.80 ± 0.951 points. This difference was highly significant (**p < 0.001**), indicating that Group A showed significantly greater improvement in balance compared to Group B.
- **FES-I Difference**: Group A reduced their fear of falling by 2.30 ± 0.657 points, while Group B reduced by only 1.05 ± 0.826 points. This difference was highly significant (**p < 0.001**), indicating that Group A experienced a significantly greater reduction in fear of falling.
- **TUG Difference:** Group A improved their mobility time by 2.60 ± 0.754 seconds, while Group B improved by only 1.55 ± 0.759 seconds. This difference was highly significant (**p < 0.001**), indicating that Group A showed significantly greater improvement in functional mobility.

Both interventions were effective in improving balance, reducing fear of falling, and enhancing functional mobility. However, the greater magnitude of improvement observed in Group A across all outcome measures suggests that the intervention administered to Group A was more effective than that provided to Group B (Graph 2).

DISCUSSION:

The alternative hypothesis was proved in our study. there was a signifcicant improvement in individuals with sarcopenia after receiveing otogo exercise program. On evaluating the effect of the otago exercise program for improving balance and reducing risk of falls among sarcopenic subjects, we noticed a drastic improvement in balance and a significant reduction in risk of falls. There was a prominent difference in the mean balance score between the group A and group B at the end of 8 weeks intervention (mean = 40.82) compared to pre-intervention values (mean = 37.64). Also huge improvements were seen in the BBS score of group A than group B. The mean value of BBS for Group A was found to be 3.17 and Standard Deviation was found to be 1.42. This was found to be greater than the mean value of the group B which was found to be 1.83 and SD value was found to be 0.98. This result was concordant with the previous literature evidence. Ingeborg L.Kyrdalen et al. (2014) concluded that otago exercise improved the measure of BBS at the end of the 12-week protocol thereby increasing the balance among the experimental group (19). Seethal Vincent et al. (2017) performed Otago exercise along with Gaze stability exercise for a group of elders and found that the balance was notably better in the experimental group with a greater BBS (Mean = 20.57) than the control group (Mean = 10.43) (23). Another

study by Maria Bjerk et al. (2017) evaluated the effect of fall prevention programs based on Otago exercise programs in a motive to improve the quality of life in older home care recipients. Balance was evaluated via BBS and there was a significant effect found on BBS which had a higher score of 2.4 points (p = 0.047) (24)..

On comparing the groups in the current study, the mean reduction and SD of FES-I for group A were found to be 2.23 and 0.66 respectively. Similarly, the mean reduction and SD of FES-I for group B was found to be 0.94 and 0.80 respectively. This shows that the reduction of FES –I for group A was greater than group B. This shows that the present study was consistent with the literature. Saeide Solatietal. (2019) reported a significant reduction in fear of falling after Otago exercise training, with FES-I scores decreasing from 28.44 to 18.88 (p = 0.001). No significant change was observed in the control group (25). Another study done by Cidoncha-Morena et al. (2022) assessed the risk of all by FES-I for community dwelling older adults and identified the baseline mean difference of FES-I for age 65-71 was 20.28 (p= 0.000 < 0.5) and it was reduced to mean difference of 19.34 (p = 0.000 < 0.5) after the intervention period (26).

We further demonstrated an improved muscle mass and strength by evidently lowering the TUG scores of sarcopenia patients with Otago exercises thereby increasing the functional mobility and physical performance. The mean difference of TUG before intervention was found to be 13.64 seconds and post intervention was found to be 11.11 for group A; 13.27seconds for pre intervention and post intervention was found to be 11.83 seconds for group B. Therefore, both the interventions had a significant effect in reducing TUG scores. It shows that group A is highly significant in improving physical performance than group B by reducing TUG scores. This present study was supported by previous evidence. A study done by Hyun-Seung Song etal. (2016) also evaluated the effect of Otago exercise program on improving balance and gait ability among chronic stroke patients and demonstrated the mean value of TUG was 29.62 seconds & 23.60 seconds pre-intervention & post intervention respectively for group A. TUG scores declined from 33.99 seconds to 28.52 seconds in group B before & after the intervention which concluded that the Otago exercise program improves physical performance(27). Similarly, a study done by Hyun-Seung Song et al. (2020) evaluated the effect of Otago exercise program on improving balance and reducing falls among patients with Total Knee Replacement (28). TUG scores decreased in both groups, with a greater reduction in the experimental group (10.51 ± 0.77 to 9.68 ± 0.60 s) compared to the control group (9.83 ± 1.23 to 9.21 ± 0.94 s). This indicates that the Otago exercise program effectively improves functional mobility. Similarly, another study done by Kanchan A Katre et al. (2019) also concluded that Otago exercise programs reduced TUG scores thereby reducing risk of falls among bilateral knee osteoarthritis patients (29).

Balance is the capability of a human body to maintain the posture during rest or movement. It is a controlled integration between sensory input of vision, vestibular system and proprioception with coordinated muscle responses, This network is highly compromised in sarcopenia patients as age advances and persistent inactivity. As sarcopenia is associated with loss of muscle strength and muscle fibers, balance impairment occurs and when the balance is lost, patients begin to develop the fear of falling without their static and dynamic control. The fear of falling is primarily wired in the limbic system, prefrontal cortex and sensorimotor integration areas (30,31). The otago exercises specifically trains the impaired neuromuscular control and reinforce balance performance in sarcopenia patients thereby imparting the sensory feedback to down regulate the fear center of the limbic system, Amygdala. The motor stability and postural stability improvement via otago exercises will perceive less threat during physical activity thereby declining the fear of fall. As the static and dynamic control increases, the patients will gain more efficiency and movements become faster & stronger integrating high functional mobility. The authors noticed that the focus was given to the lower extremity group of muscles and the upper extremity muscles were not focused to be potential limitation of the study.

CONCLUSION:

There was a significant change in both the groups A & B evaluated via Berg Balance Scale, Falls Efficacy Scale-International, Timed Up and Go test. However, the post intervention performance via Otago exercise program was highly effective in sarcopenia patients on comparing the traditional balance exercise. Hence Otago exercises are recommended for sarcopenia patients for their betterment and enhanced quality of life.

AUTHOR'S CONTRIBUTION:

Author contributions

1. **Conceptualization:** Idea generation, framing the research question - Dr**. sharmila.S**
2. **Data curation:** Maintaining and managing data - Dr**. sharmila.S**
3. **Formal analysis:** Performing analytical or statistical procedures Dr**. sharmila.S**
4. **Investigation:** Conducting research and a formal investigation- Dr**. sharmila.S**
5. **Methodology:** Developing or designing the methods and approach - Dr**. sharmila.S**

6. **Resources:** Providing materials, equipment, or other resources -Dr**. sharmila.S**
7. **Software:** Developing or contributing to computational tools -Dr**. sharmila.S**
8. **Supervision:** Oversight and leadership for the research activity - **Dr. Senthil Selvam.P**
9. **Validation:** Confirming results by checking underlying data.- **Dr. Antony Leo aseer. P**
10. **Writing – review & editing:** Critically reviewing, commenting on, and editing the – manuscript - **Dr. P. Senthil**
11. **Writing – original draft:** Creating the initial draft of the manuscript - **Dr. Rebecakkal**

ETHICS DECLARATIONS:

The approval from Institutional Ethical Committee (IEC) was received on 16.10.2023 - Ethical clearance number: SOPT/VISTAS/IEC/110/2023.

CONSENT FOR PUBLICATION:

A written consent was collected from all the participants before including in the study. Participants were fully informed about the study procedures, objectives, and potential risks, and consent was obtained for the use and publication of their data.

FINANCIAL SUPPORT AND SPONSORSHIP:

Nil

CONFLICT OF INTEREST:

No conflicts of interest.

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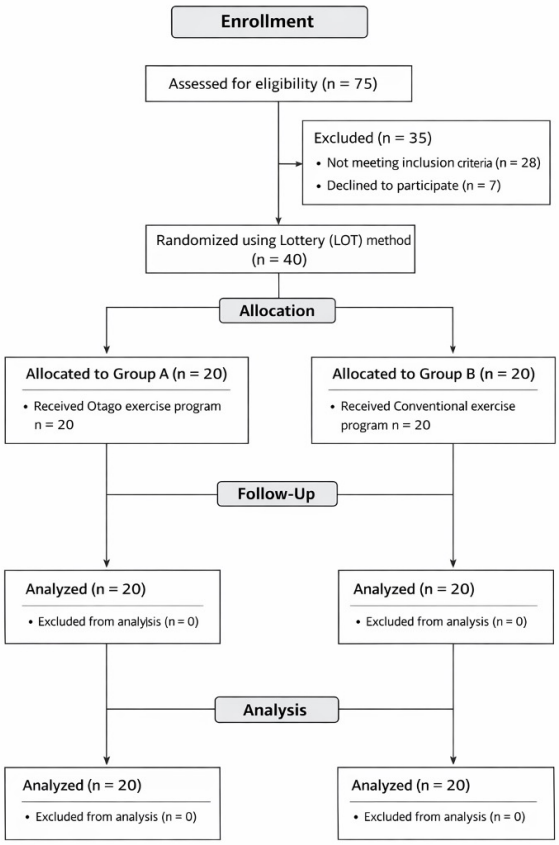


Figure 1: CONSORT flow diagram depicting the progress of study subjects through phases of RCT.

Figure 2: The picture depicts**'front knee strengthening exercise'** – one of the strengthening exercises of group A. The subject is asked to sit on the arm rest chair. Weight cuff is tied to the ankle. The subject is asked to extend the knee from semi flexed position and this is repeated 10 times.

Figure 3: the picture depicts '**back knee strengthening exercise'** – one of the strengthening exercises of group A. The subject is asked to stand in erect posture. Then weight cuff is tied to ankle. Then the subject is asked to flex the knee. This is repeated 10 times

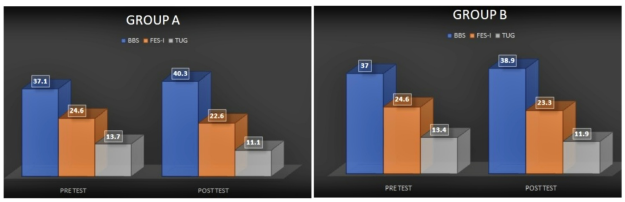
Figure 4: The picture depicts '**walking and turnaround**' - one of the balance exercises of group A. The patient is asked to walk at regular pace. Then the subject is asked to turn in clockwise direction. Then the subject is instructed to walk back to the starting position. Again, the subject is asked to turn in counter-clockwise direction. This is repeated 10 times.

Figure 5: The picture depicts **'Heel toe standing'** - one of the balance exercises of group A. The subject is asked to place one foot directly in front of the other foot so that it forms a straight line. The position is asked to maintain for 10 seconds. Then the subject is asked to change the position of the foot.

Figure 6: The picture depicts **'stand to sit'** - one of the balance exercise of group A. The subject is asked to sit on an arm rest chair. Then the subject is asked to stand up by pushing up both the hands. This is repeated 10 times.

Figure 7: The pictures depicts '**Single-leg stance with eyes open & closed'** - one of the balance exercise of group B. The subject is asked to stand on one leg with eyes open and asked to maintain it for 15 seconds. Same protocol is maintained for the other leg also. This is repeated 10 times. The same exercise to be repeated with the eyes closed.

Graph 1: This graph shows the comparison of BBS, FES-I and TUG scores between group A & B. Both the groups showed betterment after intervention but comparatively group A has proved superior overall effectiveness of the intervention.



Graph 2: This figure illustrates pre-test & post-test scores of group A & B. The magnitude of improvement was greater in Group A compared to Group B across all outcome measures.

Table 1: Comparison of Baseline Characteristics and Outcome Measures Between Groups (Unpaired student t-test)

Variable	Group	N	Mean	Median	SD	p-value
AGE	GROUP A	20	67.25	66.50	3.697	0.667
	GROU	2	67.8	68.50	4.31	

	P B	0	0		2	
BBS PRE TEST	GROUP A	20	37.15	38.00	2.870	0.906
	GROUP B	20	37.05	37.00	2.417	
BBS POST TEST	GROUP A	20	40.30	40.00	2.993	0.099
	GROUP B	20	38.85	39.00	2.390	
BBS DIFF	GROUP A	20	3.15	3.00	1.348	<0.001*
	GROUP B	20	1.80	2.00	0.951	
FES-I PRE TEST	GROUP A	20	24.60	25.00	2.186	0.994
	GROUP B	20	24.55	25.00	2.259	
FES-I POST TEST	GROUP A	20	22.60	23.00	1.759	0.349
	GROUP B	20	23.25	24.00	2.511	
FES-I DIFF	GROUP A	20	2.30	2.00	0.657	<0.001*
	GROUP B	20	1.05	1.00	0.826	
TUG PRE TEST	GROUP A	20	13.65	13.50	1.309	0.627
	GROUP B	20	13.45	14.00	1.276	
TUG POST TEST	GROUP A	20	11.05	11.00	1.146	0.031
	GROUP B	20	11.90	12.00	1.252	
TUG DIFF	GROUP A	20	2.60	3.00	0.754	<0.001*
	GROUP B	20	1.55	1.50	0.759	

Table 2: Within-Group Comparison for Group A: Pre- and Post-Test Scores (Paired Samples t-test)

Variable	Time Point	N	Mean	Median	SD	p-value
BBS	PRE TEST	20	37.1	38.0	2.87	<0.001*
	POST TEST	20	40.3	40.0	2.99	
FES-I	PRE TEST	20	24.6	25.0	2.19	0.003*
	POST TEST	20	22.6	23.0	1.76	
TUG	PRE TEST	20	13.7	13.5	1.31	<0.001*
	POST TEST	20	11.1	11.0	1.15	

Table 3: Within-Group Comparison for Group B: Pre- and Post-Test Scores (Paired Samples t-test)

Variable	Time Point	N	Mean	Median	SD	p-value
BBS	PRE TEST	20	37.0	37.0	2.42	<0.001*
	POST TEST	20	38.9	39.0	2.39	
FES-I	PRE TEST	20	24.6	25.0	2.26	0.009
	POST TEST	20	23.3	24.0	2.51	
TUG	PRE TEST	20	13.4	14.0	1.28	<0.001*
	POST TEST	20	11.9	12.0	1.25	