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Title: A Randomized Controlled Trial Comparing the Effects of Otago Exercise and Circuit Training on Balance and Quality of Life in Patients with Chronic Obstructive Pulmonary Disease (COPD)

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Highlighting:

- Patients with moderate to severe COPD showed significant improvements in their quality of life and balance with both the home-based Otago Exercise Program and the hospital-based Circuit Training.
- The fact that there was no discernible difference between the two interventions indicates that they are both of equal effectiveness.
- For patients with COPD who have limited access to hospital-based rehabilitation, the Otago Exercise Program provides a practical and affordable home-based option.
- Including balance-focused exercise in pulmonary rehabilitation can help people with COPD become more functionally independent and lower their risk of falling.

Plain Language

This research experiment sought to determine if two forms of exercises, Circuit Training (CT) and the Otago Exercise Program (OEP), could enhance balance and quality of life in individua ls with chronic obstructive pulmonary disease (COPD).

In addition to making breathing difficult, COPD is associated with impaired balance and an in creased risk of falls.

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ABSTRACT

Purpose: Chronic Obstructive Pulmonary Disease (COPD) is a leading cause of death worldwide. Beyond pulmonary symptoms, COPD patients also experience systemic manifestations, including impaired balance, leading to falls and reduced quality of life6. This study compares the effects of the Otago Exercise Program (OzeEP) and Circuit Training (CT) on balance and quality of life in COPD patients.

Methodology: In this randomized controlled trial, 42 persons of both sexes with a history of falls and moderate-to-severe chronic obstructive pulmonary disease (COPD) according to GOLD criteria were recruited. Using the sealed envelope approach, participants were randomly assigned into two groups: the Otago exercise group (OEG) and the circuit training group (CTG) with 21 participants per group. For eight weeks (three sessions per week), each group engaged in their assigned exercises in addition to routine pulmonary rehabilitation. The assessments were taken at Baseline, week four, and week eight of intervention. Data was analyzed on SPSS version 20. Normality was assessed through Shapiro wilk test and most of the data was normally distributed so parametric test was applied. Confidence interval was kept at 95% and p value less than 0.05 was considered significant.

Results: The study included 42 COPD patients with a predicted FEV1 of 39.47± 4.95. Both groups demonstrated a significant improvement in balance and quality of life after completing the exercise protocol ($P<0.01$) for within-group differences. However, there were no statistically significant ($P>0.05$) differences between the two groups.

Conclusion: For improving balance and quality of life in individuals with moderate to severe COPD, both circuit training and the Otago exercise program are beneficial, and neither is superior to the other. Patients with COPD can improve their quality of life and balance by participating in the Otago home-based exercise program.

Keywords: COPD, Balance, Otago Exercise program, circuit training exercises, Pulmonary rehabilitation

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Introduction:

Chronic obstructive pulmonary disease, or COPD, is a respiratory condition that causes respiratory discomfort and a progressive restriction of airflow (1, 2). The economic and social effects of COPD are substantial and growing. It is the third most common cause of the morbidity and the mortality worldwide, according o the World Health Organization (WHO) (3, 4). By 2030, COPD will rank as the fourth most prevalent cause of death and the seventh most common factor contributing to disability (5). There is evidence linking increased COPD mortality to the severity of airway obstruction, BMI, dyspnea, exercise capacity, and quantitative severity of emphysema (6). Those over 40 who smoke cigarettes and those exposed to higher levels of biomass are more likely to have it (7). Emphysema and chronic bronchitis are its two primary constituents (9).

For identifying risk variables linked to the incidence and recurrence of COPD episodes has significant clinical and societal implications(11). Another risk factor that might lead to recurrent airflow restriction is asthma and airway hyperreactivity. Additional risk factors include exposure to outdoor and occupational pollution, aging, childhood passive smoking, a history of pulmonary tuberculosis, a genetic tendency to recurrent chest infections, and female gender (9,10). Another study found that exposure to farm animals, especially pigs, poultry, and cattle, was associated with a higher frequency of COPD (12). COPD symptoms include dyspnea, chronic cough, sputum production, and exercise intolerance (13)

Exercise training, education and self-management treatments, behavioral change encouragement, and a stimulus to physical activity are all part of pulmonary rehabilitation (PR), which is an essential aspect of controlling COPD. Pulmonary rehabilitation has been shown to decrease hospitalizations while also improving symptoms, exercise tolerance, and

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overall health-related quality of life (14). To attain maximal community independence and function, it also includes fitness training, psychological support, and patient education (15). The pulmonary rehabilitation is applied to stabilize or reverse the disease's physio-pathological and psychopathological symptoms while also attempting to restore the patient's maximum functional capacity (16). In COPD, pursed lip breathing (PLB) and diaphragmatic breathing (DB) are important because they are widely used for breathing training strategies (17). The core objective of pulmonary rehabilitation (PR) program has been to use prescribed exercise to break the cycle of dyspnea and deconditioning (18). It has been proven that both low-intensity and high-intensity exercise programs improve the functional status and health-related quality of life of individuals with COPD (19). Balance function has significantly and clinically improved in patients with COPD as a result of the addition of balance training to pulmonary rehabilitation, which addressed the unique profile of balance impairments (7). Strong balance control is believed to be necessary for maintaining functional independence in day-to-day tasks (20).

Balance specialized circuit training improves balance in COPD older adults' patients that includes functional strength exercises, stance exercises, transition exercises and gait training (21). Circuit training helps to improve the strength of upper and lower extremities and abdominal muscles. When balance training is paired with pulmonary rehabilitation, balance performance, self-reported physical function, and lower-extremity muscular strength all improve (22). Circuit training is a group workout that takes less than ten minutes to complete each circuit. Multiple stations or posts, each with a unique set of exercises, make up the training methodology. Due to the efficiency of time and variety of exercises, circuit training is suitable for people who are not physically active and for dynamic balance (23).

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The Otago Exercise Program (OEP) is also a research-based intervention that improves balance function in healthy senior citizens living in the community and at home while lowering falls in the elderly. OTAGO is a walking-based strength and balance retraining program (24). Exercises aimed at strengthening lower extremity muscles, being performed predominantly in standing positions, adhering to an organized and progressive intensity plan, and incorporating balance-related obstacles are all necessary for the most effective interventions for people at risk of falling. (25).

The circuit training has been demonstrated to help COPD patients with their dyspnea and quality of life. (26) Improvements in the Berg Balance Scale and other tests linked to balance have demonstrated that balance training significantly enhances balance and lowers the risk of falls in people with COPD (27).

An intervention that can improve balance, lower the risk of falls, and improve general health status is necessary because COPD is a chronic illness that severely compromises physical function and quality of life. Though their relative efficacy in treating COPD patients is yet unknown, both OEP and CT have demonstrated potential in these specific areas. According to prior research, the benefits of combining balance training with traditional pulmonary rehabilitation are higher than those of standard therapy alone (20)(28).

However, no studies to date have directly compared the effectiveness of the Otago Exercise Programme against circuit training specifically in the COPD population.

If this home-based exercise is shown to be just as effective as or even more so, it could improve quality of life by allowing patients to exercise on their own, easing the load of frequent hospital stays, and lowering the demand on medical resources.

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Methods

The study was a randomized clinical trial registered on Clinical trial.gov NCT05044884, ethical approval letter number REC/00960 from Institutional research review board. The study setting was District Headquarter Hospital Haripur and study duration was 1 year (form February 2021 to February 2022). Total forty-two patients were included after sample size calculation from open epi online calculator. The control group that was the Circuit Training Group (CTG) and the experimental group that included the Otago Exercise Group (OEG). The participants were selected based on specific eligibility criteria (as mention below) and a sealed envelope randomization approach. All eligible patients presenting during the recruitment window were approached using a consecutive sampling. Patient select the envelope and got enrolled in exercise plan written on the envelope. The sealed envelopes opened only after baseline assessments were completed. This study is a single-blind design in which the participants were blinded to group distribution. Ethical approval for the study was obtained from the hospital's institutional review board, and written informed consent was acquired from all participants prior to enrollment. Total forty-two patients were recruited by open epi online calculator on the base of inclusion and exclusion criteria. The patients with aged 50-70 years with a clinical diagnosis of moderate to severe COPD according to the GOLD criteria, a history of at least one fall (with-in last one year, self-reported by participants) and who were capable of independent ambulation were included. Patients who required mechanical ventilation, those with musculoskeletal or neurological disorders impacting balance, those with cognitive impairments (e.g., dementia), and patients with unstable cardiovascular conditions were excluded from this study. However, two participants dropped out due to personal reasons from CTG group, leaving a final sample size of 40 (CTG: 19, OEG: 21). Sessions were conducted three times per week for 8 weeks. (Figure: 1)

Circuit Training Group (CTG): Participants in this group underwent a structured circuit training program focused on balance and muscle strengthening exercises. The training included functional strength training, stance exercises (single-leg stance, tandem stance, etc.), and gait training (side walking, reverse walking, and tandem walking over obstacles) (29). A senior physiotherapist oversaw the 45-60 minute sessions, which took place three times a week, with one therapist for every participant. Because of the circuit stations' natural design, exercise intensity increased as task difficulty increased. Participants progressed from activities with

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upper limb support to those without, from stable to unstable surfaces, and from bilateral to unilateral stance. Ankle weights were used to gradually increase the resistance for strengthening exercises in increments of 0.5 kg after participants were able to do 12 repetitions with correct technique. On the basis of individual achievement, progression was standardized and applied every two weeks. (table 1)

Otago Exercise Group (OEG): The OEP (Otago exercise program) balance training program was given at home, which was designed specifically for older adults at risk of falling. Participants in the OEG were provided with a set of exercise templates, with instructions to complete the exercises at home under the supervision of a patient's attendant. (21) A qualified physiotherapist conducted the program's first home visit, giving each participant a set of ankle weights starting at 1 kg and an exercise manual with illustrations. Each session lasted roughly half an hour, and participants were expected to complete the recommended exercises on their own at least three times a week. The capacity of participants to finish activities with little effort served as the basis for progression. Ankle weight resistance was raised in 0.5 kg increments after participants could easily complete the maximum number of suggested repetitions (up to 10 each exercise). Repetitions were then reset to a lower baseline to maintain progressive overload. Weekly phone calls were used to track adherence and development, providing participants with direction and encouraging them to voice any issues. At Week 6, a follow-up home visit was done to review exercise technique and make any required prescription adjustments. As a result, supervision was restricted to one mid-point house visit, weekly phone calls, and the first educational visit (table 1).

Participants were contacted weekly via phone to ensure adherence.

Both groups continued to receive pulmonary rehabilitation, which included breathing exercises such as diaphragmatic breathing and pursed-lip breathing to optimize lung function. Lung volumes and capacities were assessed using spirometer.

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Table:1 Detailed Interventions Protocol

Otago Exercise Group	Circuit Training Group
Type of exercise: Warm-up. Arm swings and Chair March for 30 sec Movement of head, neck, trunk, ankle and back extension 5 times each. Stretch of Back of thigh and calf, hold in stretch position for 8 sec. **Type of exercise: Strengthening** Strengthening of Front knee, back knee and side hip 10 reps and 2 sets for each position Toe standing and heel standing repeat for 10 to 20 times **Type of exercise: Improving balance** 1 leg stand, walk, heel to toe standing and Knee bending 5 sec to 10 sec for each Side walking, heel walking, backward walking, heel to toe walking, sit to stand, walking on stairs walking and turning around (10 steps). **Type of exercise: Cool-down** Stretching of back of thigh and calf. hold in stretch position for 10 to 20 sec and repeat for 1 to 3 times. Conventional treatment protocol Daily breathing exercises which include diaphragmatic breathing and PLB. ·Stretch exercise for upper trapezius, scalene, sternocleidomastoid, levator scapulae and pectoralis minor	**Type of exercise: Functional Strength** Steps up in forward backward and sideways direction, toe raise, heel raise and walking on toes each with 2 sets of 8 repetition **Type of exercise: Stance Exercises** Perform each exercise for 30 seconds in single leg stance, narrow stance, tandem stance, and standing on uneven ground with open eyes. Perform each exercise for 15 seconds in single leg stance, narrow stance, tandem stance, and standing on uneven ground with eyes closed. **Type of exercise: Transition Exercises** For 10 repetitions, sit to stand from a chair with arms supported, then for 5 repetitions without arms supported. Sit on the floor and then stand up, both with and without support. **Type of exercise: Gait Training** Side walking, reverse walking, and tandem walking with arm support Side walking, reverse walk and tandem walk over obstacles. Conventional treatment protocol ·Daily breathing exercises which include diaphragmatic breathing and pursed lip breathing. · Stretch exercise for upper trapezius, scalene, sternocleidomastoid, levator scapulae and pectoralis minor.

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Outcome Measures:

The primary outcome was balance, assessed using the Berg Balance Scale (BBS), which is a validated tool for measuring static and dynamic balance. Scores range from 0 to 56, with higher scores indicating better balance. The Berg Balance Scale exhibits high relative inter-rater reliability (ICC = 0.97; 95%) and intra-rater reliability (ICC = 0.98; 95% CI: 0.97–0.99) (30).

The secondary outcome was quality of life, assessed using the St. George's Respiratory Questionnaire (SGRQ), a disease-specific instrument that measures the impact of respiratory disease on overall health, daily life, and perceived well-being. The SGRQ includes three components: symptoms, activity, and impact. The reliability coefficient of this scale was 0.94, with 0.72 for the "Symptoms," 0.89 for "Activity," and 0.89 for "Impacts" subscales. (31).

Pulmonary function was measured using the digital spirometer as a secondary outcome measure. It includes forced vital capacity (FVC), Forced expiratory volume in 1 second (FEV_1), FEV_1/FVC Ratio and Peak Expiratory Flow Rate (PEFR)

Statistical analysis was conducted using SPSS. Data were checked for normality using the Shapiro-Wilk test. A 3×2 mixed-model analysis of variance (ANOVA) was used to assess changes in BBS and SGRQ scores over time (baseline, 4 weeks, and 8 weeks) between the two groups. The significance level was set at 0.05, and 95% confidence intervals were calculated. Detail illustrations of the study is described in consort diagram (Figure 1).

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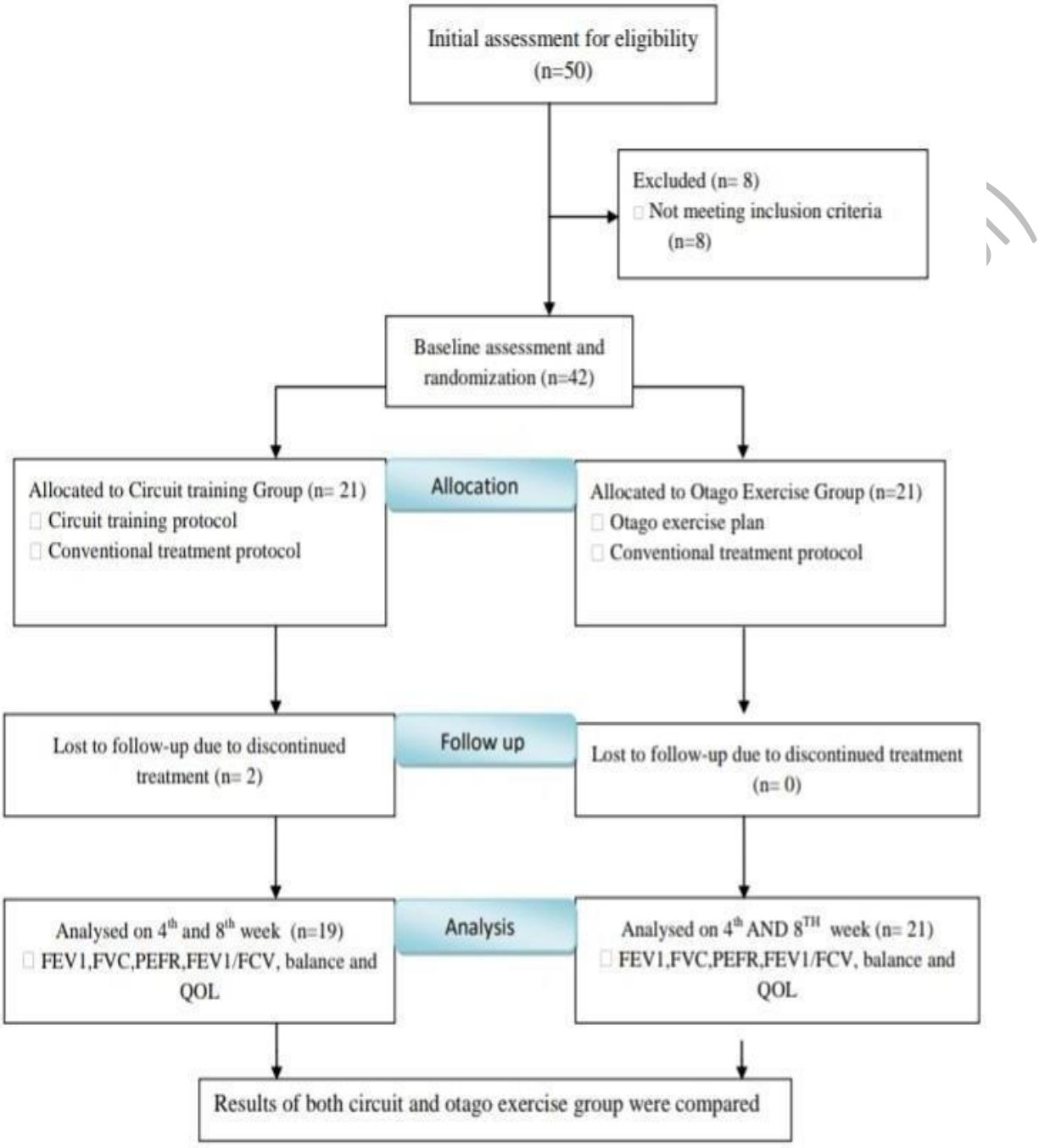
Figure 1: Consort Diagram



Results

All the 40 individuals who finished the study, 62.5% were women and 37.5% were men. Table 2 displays the average age, weight, and height along with the standard deviation. All participants have average Forced Expiratory Volume in 1 second (FEV1) with mean and standard deviation of 39.47 ± 4.95%.

Table 2: Shows mean and standard deviation of demographic variables in circuit training and Otago exercise group

Variables	Circuit training group	Otago exercise group
	Mean±SD	Mean±SD
Age(years)	61.89±7.2	60.52±7.5
Weight (kg)	71.78±10.20	72.47±11.87
Height (inches)	66.39±3.63	65.77±4.04

The BBS scores improvements in mean with standard deviation in both groups for baseline, 4th week and 8th week described in table 2. In the CTG, the mean BBS score increased from 37.21 ± 5.78 at baseline to 40.84 ± 5.16 at the end of the intervention. Similarly, the OEG showed an improvement in mean BBS score from 35.71 ± 9.24 to 39.71 ± 8.28. (Table 3)

However, no statistically significant difference was found between the two groups (P > 0.05), indicating that both interventions were equally effective in improving balance in COPD patients.

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Table 3: Shows mean and standard deviation of BBS, UPST with eye open and close in CTG and OEG at baseline, 4th week and 8th week

Balance component	Base line		4th week		8th week	
	CTG mean ± SD	OEG mean ±SD	CTG mean ± SD	OEG mean ±SD	CTG mean ± SD	OEG mean ±SD
UPST with Eye open	10.7±10.07	8.61±7.29	13.10±9.74	11.04±5.83	16.05±9.25	14.2±6.21
UPST with Eye close	5.0±6.1	3.71±4.29	7.26±8.09	5.19±4.34	8.1±6.7	6.90±4.88
BBS Score	37.21±5.78	35.71±9.24	38.47±5.15	38.00±8.42	40.84±5.16	39.71±8.28

Quality of life improved in both groups, as reflected in the reduction of SGRQ scores. In the CTG, the total SGRQ score decreased from 70.14±13.3 to 58.98±10.21. For OEG also total SGRQ scores decreases from 68.25 ± 16.06 to 58.57 ± 13.60 by the end of the study (Table 4).

Within-group analysis for St George Total Scores, using a mixed-model ANOVA revealed significant effect in respiratory symptoms in both interventional groups. Between the group comparison showed no significant difference in terms of quality-of-life improvements ($P > 0.05$).

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Table 4: Shows mean and standard deviation of St George quality of life variables in CTG and OEG at baseline, 4th week and 8th week

Quality of life using SGRQ	Base line		4th week		8th week	
	CTG mean ± SD	OEG mean ±SD	CTG mean ± SD	OEG mean ±SD	CTG mean ± SD	OEG mean ±SD
Symptom score	70.69±11.97	72.26±15.06	71.02±12.12	70.58±14.05	64.63±11.16	64.37±13.40
Activity score	76.10±17.29	74.70±17.47	67.05±20.79	71.71±15.75	63.81±18.28	67.28±14.85
Impact score	66.46±16.12	63.68±16.07	57.95±11.75	55.54±15.69	54.41± 9.56	51.95±14.38
Total score	70.14±13.3	68.51±15.21	62.93±12.32	62.99±14.16	58.98±10.21	58.75±13.65

According to mixed model of ANOVA there was significant improvement overtime in both interventions including forced vital capacity, forced expiratory volume, peak expiratory flow rate and FEV1/FEV ratio of patients of both groups assessed through spirometer. Between group comparison showed no significant difference between forced vital capacity, forced expiratory volume and peak expiratory flow rate of Otago exercise programme and circuit training group (table 5).

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Table 5: Shows mean and standard deviation of pulmonary components in CTG and OEG at baseline, 4th week and 8th week

Pulmonary component	Base line		4th week		8th week	
	CTG mean ± SD	OEG mean ±SD	CTG mean ± SD	OEG mean ±SD	CTG mean ± SD	OEG mean ±SD
FVC	57.26±10.74	56.57±10.33	57.89±10.74	59.09±9.22	61.36±11.30	65.19±9.86
FEV1	39.47±4.95	39.33±6.90	45.15±8.92	46.95±8.60	49.57±8.80	52.71±8.11
PEFR	39.78±17.18	40.85±13.85	52.57±19.31	53.00±18.70	55.68±19.84	57.95±19.26
FEV1/FVC	0.6±0.07	0.6±0.08	0.7±0.06	0.7±0.08	0.7±0.09	0.7±0.05

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Discussion

The study findings suggest that both the Otago Exercise Program and Circuit Training are associated with improvements in balance and quality of life in COPD patients. These findings are in line with previous research that emphasizes the importance of balance training in reducing fall risk and improving functional mobility in older adults and those with chronic diseases such as COPD.

Although balance impairment is a well-known issue in COPD patients, it is often under-addressed in traditional pulmonary rehabilitation programs. Our study highlights the potential benefits of incorporating balance-specific exercises into COPD management strategies. Both OEP and CT were shown to improve in balance, as measured by the BBS, and improve the quality of life, as reflected in the SGRQ scores.

Interestingly, the lack of significant between-group differences suggests that the home-based OEP is just as effective as the hospital-based CT in improving balance. This is particularly important in the context of resource-limited settings or during periods when access to healthcare facilities is restricted, such as the COVID-19 pandemic. The OEP offers a feasible and effective alternative for COPD patients who are unable to attend regular hospital-based rehabilitation sessions.

Khaled et al.'s study investigated the impact of circuit training within pulmonary rehabilitation for older patients with COPD, finding that it significantly improved over all-body balance and reduced falls. (21). Wajdi Mkacher's research evaluated the impact of a circuit training program within pulmonary rehabilitation on balance in COPD patients. The study found that integrating circuit training significantly enhanced balance measurements and exercise capacity. (32) This study also demonstrates how circuit training greater balance improvements were observed in COPD patients.

Another randomized controlled trial examining the effects of balance training in people with COPD at risk of falling found that adding balance training to pulmonary rehabilitation significantly improved balance, lower-extremity strength, and self-reported physical function. The thrice-weekly regimen was found to be practicable and sustainable across mild to severe COPD. (22) The current study, which included patients with moderate to severe COPD, observed remarkable refinement in balance and pulmonary function in both groups that received balance training alongside pulmonary rehabilitation.

The strengths of this study include the randomized controlled design, the use of validated outcome measures, and the inclusion of both men and women with moderate to severe COPD. However, there are several limitations to consider. First, the sample size was relatively small, which may have limited the ability to detect subtle differences between the two interventions. Second, the study was conducted over a relatively short period of time, and the long-term effects of these interventions remain unknown. This study did not properly evaluate intervention fidelity. The home-based Otago Exercise Programme depended on participant self-report and weekly phone conversations, without any direct monitoring of exercise performance, whereas circuit training sessions were overseen by a physiotherapist to guarantee proper execution.

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Although spirometry is the gold standard for evaluating pulmonary function, it could not capture gains in dynamic balance or functional exercise capacity. Our capacity to identify subtle changes and comprehend the mechanics behind balance improvements is restricted by the lack of objective biomechanical measurements, such as posturography or wearable inertial sensors. More sensitive, instrumented outcome measures should be used in future research to supplement clinical evaluations. Future research should also explore the sustainability of balance improvements and the potential impact of these interventions on fall rates over a longer follow-up period in COPD patients.

Conclusion

Balance and quality of life among COPD patients were significantly improved within groups by both circuit training and the Otago Exercise Programme, whereas no significant changes were found across groups. Given the feasibility and accessibility of home-based interventions, the Otago Exercise Program presents an attractive option for COPD patients who are unable to attend hospital-based rehabilitation. Future studies should investigate the long-term impact of these interventions and their potential role in reducing fall rates among COPD patients.

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The primary questions this study sought to address were:

- After eight weeks of either Circuit Training or Otago Training, do persons with COPD have better balance?
- Do these fitness regimens enhance life quality?
- Is one program superior to another?

Who participated?

- 40 individuals, aged 50–70, with moderate to severe COPD.
- Every participant was able to walk on their own and had experienced at least one fall.

What activities did participants take?

As part of their pulmonary rehabilitation, both groups kept up their daily breathing exercises.

- For eight weeks, the Circuit Training Group (CT) performed walking, strength, and balance exercises under supervision in a planned circuit three times a week.
- With weekly phone check-ins, the Otago Exercise Group (OEP) conducted a home-based program centered on leg strengthening and balance.

What was find by the study?

- By using the Berg Balance Scale to test balance and the St. George's Respiratory Questionnaire to measure quality of life, both groups demonstrated improved health.
- The two groups did not differ much, indicating that the effectiveness of the two programs was equal.

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Why is this important?

- Patients with COPD are more likely to stumble because they frequently have balance issues.
- This study demonstrates the benefits of both home-based (OEP) and supervised (CT) programs.
- For those who are unable to attend hospital-based sessions, the home-based Otago program in particular can be a suitable option, increasing convenience to balance-focused therapy.

Research Ethics statement:

The Riphah International University Islamabad Research Ethics Committee gave its approval for this study (Approval No. Riphah/RCRS/REC/00968). Before being enrolled in the study, each subject provided written informed consent. The complete study protocols were carried out in compliance with relevant institutional and Declaration of Helsinki ethical principles for research involving human subjects.

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Author Contributions

Saba Nadeem: Investigation, Writing, Study Design

Muhammad Fawad: Data Curation, Writing and editing

Suman Sheraz: Conceptualization. Supervision

Varda Farooq: Investigation, Data collection.

Saima Malik: Investigation, Results writing

Muhammad Iqbal Tariq: Methodology, Statistical Analysis, Interpretation of Results

Each author agreed to be responsible for all parts of the work, critically examined the document, and approved the final version.

Conflicts in Interest

Regarding the research, its authorship and publishing, the authors state that they have no conflicts of interest.

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AI Use Statement

The authors merely utilized AI sources to help with grammar correction, language editing, and making the paper simpler to read. The authors are solely responsible for the authenticity and

integrity of the paper; they conceived and validated all scientific content, study design, data analysis, interpretation of results, and final conclusions.

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