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Effectiveness of Otago Exercises Versus Manual Perturbation Exercises on Improving Balance and Mobility in Subjects with Stroke

Dr. N. Sharon Lilly (PT)[1], Dr. CH Ashok Chakravarthi (PT)[2], Dr. G. John Wilson (PT)[3]

[1]Assistant Professor, MPT(Neurology), Konaseema Institute of Medical Sciences BPT & MPT, Amalapuram, Andhra Pradesh India, Affliated to the Dr. NTR university of health sciences.
Email: *navundrisharonlilly[at]gmail.com*

[2]Principal, MPT(Orthopaedics), Konaseema Institute of Medical Sciences BPT&MPT, Amalapuram, Andhrapradesh India, Affliated to the DR.NTR University of Health Sciences.
Email: *chennupatiashok1[at]gmail.com*

[3]Post Graduate, MPT(Neurology), Konaseema Institute of Medical Sciences BPT & MPT Amalapuram, Andhra Pradesh India, Affliated to the Dr. NTR University of Health Sciences.
Email: *johnwilsongathala[at]gmail.com*

Abstract: ***Background And Objectives: Stroke can be defined as a rupture or blockage of an artery of the brain, which results in bleeding into the brain parenchyma or in decreased blood supply and ischemic damage to specific brain areas, respectively. In stroke, patients lose functions of the motor, sensory and higher brain cognitive functions to various degrees, which leads to diminished balance, reduced mobility, difficulty performing activities of daily living, and may sustain injuries from falls. The study aims to compare the Effectiveness of Otago exercises versus Manual perturbation exercises on improving Balance and Mobility in subjects with stroke. Methodology: Experimental study design. A total of 70 subjects four participants met with an exclusion criteria, screening is done for total 66 subjects and allocated into 2groups. Each group consists 33 subjects, 3 subjects discontinued from each group. A total of 60 subjects randomly divided in to two groups. 30 members in group A (Otago exercises along with Conventional physiotherapy) and 30 members in group B (Manual perturbation exercises along with Conventional physiotherapy). Both groups performed interventions for 4 weeks. The outcomes are balance and mobility measured by using Berg balance scale and Timed up and go test. Results: To test the statistical significance between pre and post scores, paired t-test is used and to test the significance for the mean differences of two groups, unpaired t-test is used. It is statistically shown that there is some significant impact on the parameters of Balance and Mobility in Stroke. The results showed that, group A had more significant improvement in all parameters than group B. Conclusion: This study concluded that Otago exercises is more effective on improving Balance and Mobility than Manual perturbation exercises.***

Keywords: Stroke, Otago exercises, Manual perturbation exercises, Berg balance scale, Timed up and go test

1. Introduction

According to the World Health Organization, Stroke is defined as 'a clinical syndrome consisting of rapidly developing clinical signs of focal (or global in case of coma) disturbance of cerebral function lasting more than 24 h or leading to death with no apparent cause other than a vascular origin[1]. A stroke can be defined as a rupture or blockage of an artery of the brain, which results in bleeding into the brain parenchyma or in decreased blood supply and ischemic damage to specific brain areas respectively[2].

In 2020 the global incidence of stroke was 11.71 million people and, of all strokes, ischemic stroke was approximately 65% of all cases, Intracerebral Hemorrhage and Subarachnoid Hemorrhage were respectively around 29% and 6% of all cases[3]. A 2020 review in the Journal of Clinical Medicine notes that approximately 10–14% of all strokes occur in individuals younger than 50, and while mortality is generally lower in this group than in older adults, survivors commonly face permanent cognitive and physical disability, psychosocial consequences, epilepsy, and chronic fatigue[4]. The risk factors of stroke are of two types: Modifiable or Non-modifiable. Modifiable risk factors include Hypertension, heart disease, diabetes mellitus, hyperlipidemia, obesity, smoking, alcohol consumption, physical activity, diet and nutrition. Non-modifiable factors include Age, gender, race, heredity[5].

In stroke, patients lose functions of the motor, sensory and higher brain cognitive functions to various degrees, which leads to diminished balance, more postural sway, asymmetric weight distribution, impaired weight bearing on affected side, impaired weight-shifting ability and decreased stability capability seen commonly[6].When walking, stroke patients typically demonstrate impaired balance and compensatory movements in various portions of their bodies, have difficulty performing activities of daily living, and may sustain injuries from falls. Various interventions, such as virtual reality, robotics and mental practice with motor imagery, have been studied to improve balance and mobility of stroke patients[7].

The OEP is an evidence-based fall prevention program that physical therapists created and designed to be used at home. The goal of the Otago Exercise Program is to retrain your muscles and balance[8].The Otago Exercise Program consists of three areas: walking, balance training, and muscle strengthening[9].

Otago exercises enhance walking, upright posture, and automatic balance control. Improved ankle strategy allows the body to move as a unit around the ankle when foot muscles are engaged. As speed and distance increase, the hip strategy is activated to maintain stability[10]. Walking, posture management by correcting movement and muscle activation patterns, and balance control by considering the base of support are all aided by Otago exercises[11]. The use of Otago exercises improves both the hip and ankle strategies[10].

Peturbation is a sudden change in circumstances that causes the body posture to shift out of equilibrium[12,13]. Perturbations were applied by hand. Postural stability relies on both in-place and adaptive support strategies across multiple planes. To maintain balance and keep the trunk within the base of support, coordinated limb movements are required during weight shifts. Anticipatory and multi-joint coordination of leg and trunk muscles play a key role in minimizing instability and restoring balance[14-16].

Traditional therapy and other physiotherapy interventions include exercises for passive range of motion exercises, active exercises, resistive exercises, weight-bearing exercises, weight-shifting exercises.

Aishwarya Satish Valiv, Vrushali Bhore has performed a study on Effectiveness of Otago Exercise versus Task Oriented Progressive Resistance Strength raining on Balance and Functional Performance in Stroke patients their findings concluded that Otago exercises shown prominent results in terms of Balance and Mobility.

Chandan kumar,Nawaj Mehtab pathan has performed a study on Effectiveness of Manual Perturbation Exercises in Improving Balance,Function and Mobility in Stroke Patients their findings concluded that Manual perturbations along with conventional physiotherapy shown prominent results on improving Balance and Mobility/Numerous physiotherapeutic approaches are used to help stroke patients become more mobile and balanced, but there isn't enough proof to support them as the most effective course of treatment.

Hence this is an effort taken to know the Effectiveness of Otago exercises versus manual perturbation exercises on improving balance and mobility in subjects with Stroke.

2. Review of Literature

Aishwarya Satish Valiv, Vrushali Bhore et al 2022 conducted a comparative study to examine the effects of Otago Exercise Programme and task-oriented progressive resistance strength training on balance and functional abilities in individuals with stroke. A total of 30 subjects were randomly assigned into two groups and received interventions over a period of four weeks. Outcome measures included the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test, and data were analyzed using SPSS software. The findings indicated statistically significant improvement in both groups, with identical p-values ($p = 0.001$). However, Group B demonstrated a greater effect size on both outcome measures, suggesting a superior clinical benefit compared to Group A.
International Journal of Health Sciences and Research 2022;12;(6):2249 9571

Sebin Jose, K Sangita et al. 2018 evaluated the effectiveness of the Otago Exercise Programme in improving balance, reducing fall risk, and enhancing quality of life among hemiplegic patients. The study involved 30 participants selected through convenience sampling and divided into two groups, with a four-week intervention duration. Assessment tools used were the Berg Balance Scale, Timed Up and Go test, and SF-36 Quality of Life questionnaire, with statistical analysis performed using SPSS version 20. Results revealed that subjects undergoing the Otago exercise intervention experienced considerable improvement in balance performance and overall quality of life, along with a marked decrease in fear and risk of falls.
International Journal of Science and Research 2018;2319-7064

Logeshwari Selvaraj and Saravana Hari Ganesh et al. 2018 investigated the impact of the Otago Exercise Programme on individuals with hemiplegia. Thirty participants were allocated into two groups using convenience sampling and trained over a 12-week period. Outcome measures included the Tinetti Performance-Oriented Mobility Assessment (POMA), Timed Up and Go test, and Chair Rise Test. Statistical analysis using SPSS 17.0 showed significant improvements in both groups; however, Group A exhibited more notable gains in mobility, balance, and lower limb strength compared to Group B.
International Journal of Pharmacy and Biological Sciences 2018;8;(2):2230-7605

Nimmi KP, Anjupriya D et al. 2024 compared Otago Exercise Programme and gaze stability exercises for their effectiveness in improving balance and reducing fear of falling among older adults. Thirty participants were randomly assigned into two groups and trained for eight weeks. Balance was assessed using the Berg Balance Scale, while fear of falls was measured using the Fall Efficacy Scale-International (FES-I). Analysis with SPSS version 28 demonstrated statistically significant improvements in both groups, though the Otago Exercise Programme produced greater improvement in both balance and fall prevention outcomes compared to gaze stability exercises.
Medicine (2024) 103:23

Pavithralochani V, Rebecca Sandhiya D et al 2020 studied the comparative effects of BOSU ball exercises and the Otago Exercise Programme on balance in elderly individuals with impairment. Thirty participants were divided into two groups and completed a four-week intervention program. Balance outcomes were measured using the Berg Balance Scale, with data analyzed by SPSS version 24. Both exercise methods resulted in significant balance improvements, but participants who followed the BOSU ball training showed better outcomes than those in the Otago group.
Innovare Journal of Medical Science, Vol 8, Issue 6, 2020, 25-28

Chandan Kumar,Nawaj Pathan et al 2016 conducted a randomized controlled trial to determine the effectiveness of

manual perturbation exercises in improving balance, functional ability, and mobility in individuals with stroke. The study consisted of 30 participants who were assigned into two groups using simple random sampling and received treatment over a period of four weeks. Outcome measures included the Berg Balance Scale, Functional Independence Measure, and Timed Up and Go test, with statistical analysis performed using SPSS version 20. The findings revealed that both conventional physiotherapy alone and manual perturbation combined with conventional physiotherapy were effective in enhancing balance, function, and mobility. However, patients who received perturbation training in addition to routine physiotherapy demonstrated greater improvements in balance and walking ability compared to those undergoing conventional treatment alone.
Journal of novel physiotherapies 2016;(2)2165-7025

Tuba MADEN, Hatice YAKUT et al 2021 assessed the effects of perturbation-based training on balance, gait performance, and trunk stability in patients with multiple sclerosis. The study included 10 patients who underwent six weeks of training. Balance and mobility were evaluated using the Sharpened Romberg Test, Single Leg Stance Test, and Timed Up and Go test, with analysis done through SPSS 22.0. The results suggested that non-computerized perturbation training could positively influence balance and walking ability. However, due to the small sample size, conclusions about trunk stabilization outcomes were limited.
Bezmialem Science 2022;10(1):10-16

La Porta F, Caselli S, Susassi S, Cavallini P, Tennant A, et al 2012 assessed the effects of perturbation-based training on balance, gait performance, and trunk stability in patients with multiple sclerosis. The study included 10 patients who underwent six weeks of training. Balance and mobility were evaluated using the Sharpened Romberg Test, Single Leg Stance Test, and Timed Up and Go test, with analysis done through SPSS 22.0. The results suggested that non-dcomputerized perturbation training could positively influence balance and walking ability. However, due to the small sample size, conclusions about trunk stabilization outcomes were limited.
Arch Phys Med Rehabil 93: 1209-1216

Lyders Johansen K, Derby Stistrup R, et al 2016 explored the reliability of functional outcome measures in individuals hospitalized post-stroke. Their study established that both the Timed Up and Go test and the 30-Second Chair Stand Test showed excellent reliability. The minimum change required to identify real improvement was estimated to be 18.7% for the TUG and two repetitions for the Chair Stand Test at the group level, with higher thresholds required when assessing individual patients.
PloS one. 2016 Oct 31;11(10): e0165663

Ekker MS, Verhoeven JI et al 2019 analyzed stroke incidence in young adults according to age, sex, and stroke subtype. The study observed that stroke risk increased significantly after 35 years of age, with a higher prevalence among women aged 18–44. Over a ten-year period, a 23% rise in ischemic stroke was reported, while the occurrence of intracerebral hemorrhage remained stable across both genders.
Neurology. 2019 May 21;92(21): e2444-54.

3. Methodology

Type of study: Experimental study

Sample Method: Participants were recruited using a convenience sampling method

Sample Design: Subjects were randomly allocated into 2 groups

Study setting: The study was conducted at department of physiotherapy at KIMS General hospital, Amalapuram.

Study duration: 4 weeks

Study period: 1 year (June 2024 to July 2025)

Sample size: 70 subjects, Two groups, Group A & B, Each group contain 35 subjects
Group A: Otago exercises + Conventional Physiotherapy
Group B: Manual perturbation exercises+ Conventional Physiotherapy

Sampling: Convenience sampling

Blinding: Single blinded study

Ethical clearance: Ethical clearance was taken from ethical committee of KIM'S college of Physiotherapy and Research foundation, Amalapuram.

Criteria for Selection.

Inclusion Criteria
Age between 45-75 years
Both males and females are included Diagnosed with stroke (first ever stroke)
Ambulatory patients with or without ambulatory aids Occurrence of stroke within 0-3months i.e,sub-acute Able to follow command.
Subjects who are willing to participate

Exclusion Criteria
Patients with sensory, proprioception, cognitive and perceptual disorders. Patient who has contracture.
Orthopedic or any other neurological disorder which impair balance.

Outcome Measures
BERG BALANCE SCALE used to evaluate balance (Annexure 5)

The Berg Balance scale is used to objectively determine a patient's ability (or inability) to safely balance during a series of predetermined tasks. It is a 14- item list with each item consisting of a five-point ordinal scale ranging from 0 to 4, with 0 indicating the lowest level of function and 4 the highest level of function.

TIMED UP AND GO TEST to assess mobility and risk of falls (Annexure 6)

To determine fall risk and measure the progress of balance, sit to stand and walking. Simple screening test that is a sensitive and specific measure of probability for falls.

Procedure

This was an experimental study which included a 4-week protocol. Both male and female participants who had stroke were recruited from KIMS Hospital, Amalapuram. The study was explained individually to the subjects who met the inclusion criteria, and informed consent was obtained from all participants. The subjects were divided into two groups. Pre-test measurements were taken using the Berg Balance Scale and the Timed Up and Go Test. Subjects in Group A received Otago exercises along with conventional physiotherapy, and Group B received manual perturbation exercises along with conventional physiotherapy. After completion of the study duration, post-test measurements were taken using the Berg Balance Scale and the Timed Up and Go Test. Based on the post-test measurements, the results were interpreted

Interventions

Group A: Otago Exercise Program along with Conventional Physiotherapy

The Otago Exercise Program (OEP) is one of the most recent home-based exercise training programs. OEP is composed of three domains, namely muscle strengthening, balance training and walking.

Procedure:

There are 4 levels in Otago exercise program. They have to do warm up and cool down exercise before and after the exercise and walk regularly of their speed and distance of their comfort. Exercises were demonstrated to the subjects and before the start of the session were noted in the Otago exercise program schedule.

The subjects started with level 1 exercise when they complete the first level next level training were given to them. Simultaneously all the levels were taught according to their ability. Levels & Number of Repetitions for the Strengthening & Balance Retraining Exercises. Cool down session includes Calf stretch and Back of thigh stretch - hold for 8 sec[17].

OEP starts with head movement, neck movement, back extension, trunk movement and ankle movement. The muscle strengthening exercises includes front knee strengthening exercise, back knee strengthening exercise, side hip strengthening exercise, calf raises, toe raises. Balance training includes knee bend, backward walking, walk and turn around, sideways walk, heel toe stand, heel toe walk, one leg stand, heel walk, toe walk, heel toe walking backwards, sit to stand and stair walk.

Strengthening Exercises: The weight cuff was placed at the ankle for the three strengthening exercises and repeated ten times. Weight cuffs with weight of 1kg, 1.5kg, 2kg and 2.5kg are used according to the level of exercise.

1) Front knee strengthening: The patient was made to sit with their back supported in the chair, and a weight cuff was placed on the ankle. The subject was made to lift the weighted leg slowly, straighten the knee, and then lower the foot with control. The exercise was repeated ten times on one leg and ten times on the other.
2) Back knee strengthening: The ankle weight cuff was placed on the ankle with the Patient in a standing position and feet hip-width apart, holding support. The patient was asked to lift the weighted leg backwards off the floor towards the buttock and slowly lower the foot, bringing the leg back to the initial position. The exercise was done in the repetition of 10 times alternately.
3) Side hip strengthening (With the ankle weight cuff on and the patient in a standing position with feet) hip-width apart holding support. The patient was made to Lift the leg sideways, slowly away from the other foot and bring it back to the initial position. The exercise was done in the repetition of 10 times and changed legs alternately. (The exercises ended with calf raises and toe raises as a remarkable down period)

4. Balance Exercises

1) Knee bends: A chair or table was used as a support, and the patient's position with Feet hip-width apart, toes facing forwards, holding support; the patient bent the knees as if going for a squat and pushed the bottom backwards as though going to sit down. Making sure the patient doesn't lift the heels. They then brought the body back up to the start position.
2) Tandem standing: using the chair as support, the patient was made to stand straight, Placing one foot directly in front of the other so that the feet form a straight line.Then, look straight ahead and maintain the balance for 10 seconds. After 10 seconds, the patient returned to the initial position, placed the other foot in front, and repeated it for another 10 seconds.
3) One leg stand: the patient in standing position was asked to hold on to the chair with both hands lifting one leg off the ground slowly, balancing on one leg keeping the support knee soft and upright posture position for 10 seconds. They were then repeating it on the other leg.
4) Sit to stand: Sit toward the front edge of the chair without an armrest; the patient was asked to bend their knees and feet flat on the floor. They placed their hands lightly on each side of the seat, back, and neck straight and slowly got up from the chair, stand-pause and sat down slowly with a repetition of 10 times.
5) Toe walking: the patient was in a standing position, feet hip-width apart and lifting the heels off the floor, keeping the weight over the toes and walking 5-10 steps forward on toes repeating it ten times.
6) Tandem walking: the patient begins by placing the heel of one foot in front of the other foot and standing heel-to toe , looking forward and ahead, Walking heel-to-toe in a straight line for at least 5-10 steps forwards without looking down at the feet. As tandem walk improved, the distance was increased.
7) Heel walking: the subject in an upright standing position holding on to the chair as support. Toes point upwards, gently step on the heels, and walk for 5-10 steps with a repetition of 10 times.
8) Sideways walking: patient position; standing tall, looking ahead, holding support; the patient was made for walking sideways and taking a few steps and

walking back sideways to the starting point, with a repetition of 10 times.

9) Backward walking: Stand tall, looking ahead and straight, holding on to the support; the patient was made for walking backwards, taking 5-10 steps with a repetition of 10 times.
10) Tandem walking backwards: the patient is standing, looking straight ahead and placing one foot directly behind the other, touching the toe against the heel and standing heel to toe in a straight line. With that position, the subject continues walking backwards for 5-10 steps with a repetition of 10 times.
11) Walk and turn: in this, a pattern of eight '8' is marked on the floor with 6-8 feet width and 12-16 feet length from north to south. The subject started at the position marked '1' in the picture, continued in the sequence, and followed the '8' pattern at a usual pace[18].

This program is done for 50 mins, 3 times / week for 4 weeks



Figure 1: Back knee strengthening exercise



Figure 2: Front knee strengthening exercise



Figure 3: Side hip strengthening exercise

Group B: Manual Perturbation Exercises along with Conventional Physiotherapy

Manual perturbation exercises, were given to the patients. Before giving manual perturbations to the patients, all possible precautionary measures were taken, to avoid risk of injuries.

Manual Perturbations were given in the sitting, kneeling, standing positions on the mattress, with 10 sec hold, 10 perturbations in each position, 2 sets/6 days/week for 4 weeks. For giving manual perturbations patients were placed into sitting positions over the couch, 5 Minutes manual perturbations were given; along with 10 seconds break in between two successive sets of manual perturbations.

As patient was able to regain balance following manual perturbations, progressed to next position i.e. kneeling & standing respectively

Manual Perturbations were given in both Right and Left sideways, forward and backward directions in Sitting, Kneeling and Standing. Manual Perturbations were given at the shoulder, trunk, and waist region.

Total duration of the session was 45 mins; Manual perturbations for 5 minutes and conventional physiotherapy 40 minutes treatment for six times in a week for 4 weeks[19].



Figure 4: Perturbations at shoulder{forward}



Figure 5: Perturbations at shoulder{backward}



Figure 6: Perturbations at pelvis{forward}

Conventional Physiotherapy

1) Passive range of motion exercises

- Hip and Knee Flexion
- Hip Rotation
- Hip Abduction
- Ankle Rotation
- Toe Flexion and Extension
- Heel-Cord Stretching

2) Active exercises

The subjects were asked to do the following exercises:

- Hip and knee bends
- Leg lifts
- Leg movement, side to side
- Leg rotation, in and out
- Knee rotation, in and out
- Ankle bends
- Ankle rotation
- Toe bends
- Toe spreads

3) Weight bearing and weight shifting exercises

- Weight Shift Side to Side: Repeat 10-15 times.
- Weight Shift Forward and Back: Repeat 10-15 times[20].



Figure 7: Active range of motion exercises

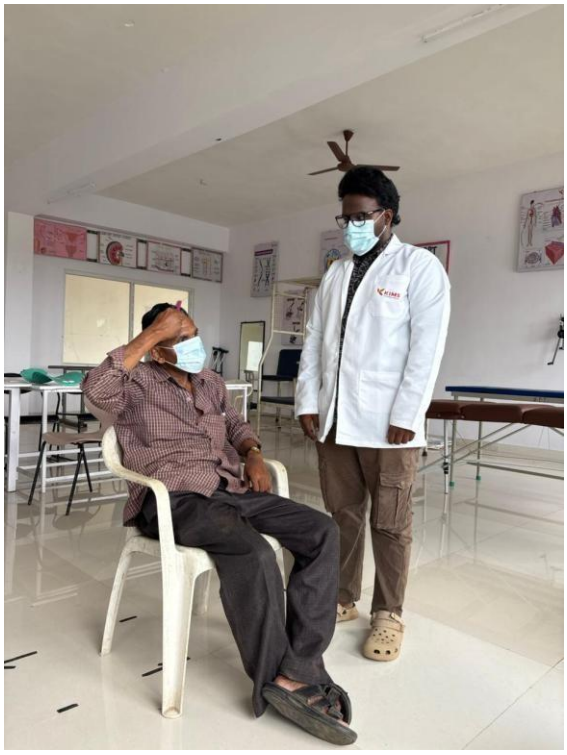


Figure 8: Combing activity



Figure 9: Drinking activity



Figure 10: Assessing Berg balance scale



Figure 11: Assessing Time up and go test

Statistical Analysis

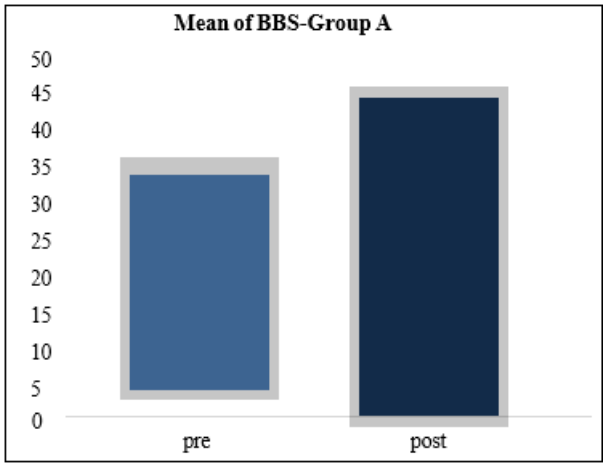
- Statistical analysis was performed by using SPSS version 21.0 Software. Data were entered in Microsoft Office Excel sheets.
- Descriptive data are presented as means, standard deviations and percentages. Data will be tabulated and graphically represented.
- The paired t-test was used to assess the statistical difference within groups for Berg Balance Scale and Timed up and go test for pre and post-test values for stroke subjects.
- Between the groups independent student "t-test was performed to assess the statistical significance difference in mean value between the groups for Berg Balance Scale and Timed up and go test for stroke subjects.
- $P \leq 0.05$ was considered as statistically significant.

5. Results

Table 1: Analysis of pre and post mean value of BBS in Group A

Group-A	Tests	Mean	S.D	T-value	P-value
BBS	Pre	30.667	5.7496	3.75	0
	Post	45.567	3.6548		

The above table shows pre & post values of BBS in group-A with T- value 3.750 & P- value 0.000.

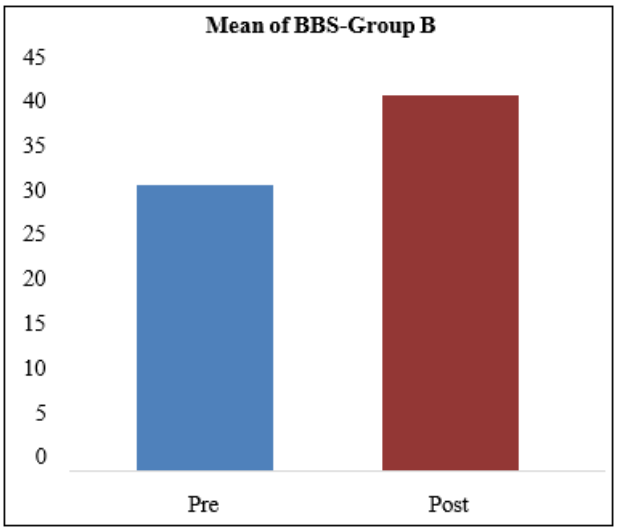


Graph 1: Comparison of pre and post mean values of BBS in Group-A

Table 2: Analysis of pre and post mean values of BBS in Group-B

Group-B	Tests	Mean	S.D	T-value	P-value
BBS	Pre	30.933	6.6537	3.75	0
	Post	40.567	6.3228		

The above table shows pre and post mean values of BBS in Group-B with T-value 3.750 and P-value 0.000.

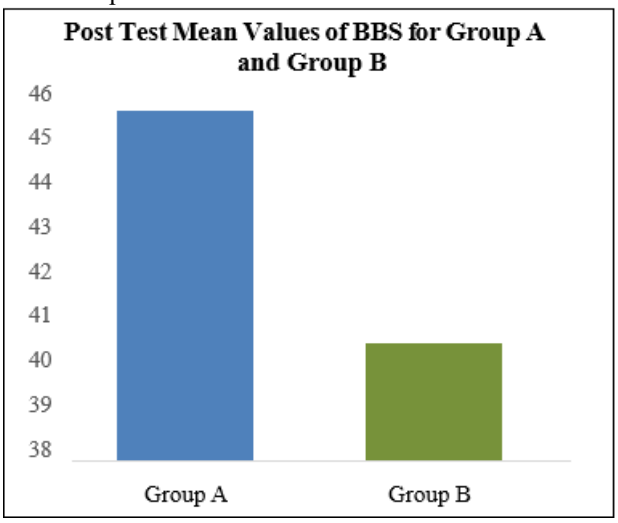


Graph 2: Comparison of pre and post mean values of BBS in Group-B

Table 3: Analysis of post mean of BBS between Group-A and Group-B

Group-A&B	Tests	Mean	S.D	T-value	P-value
BBS	Post test Group-A	45.567	3.6548	3.75	0
	Post test Group-B	40.567	6.3228		

The above table shows the post mean values in both Group-A and Group-B with T-value 3.750 & P-value- 0.000.

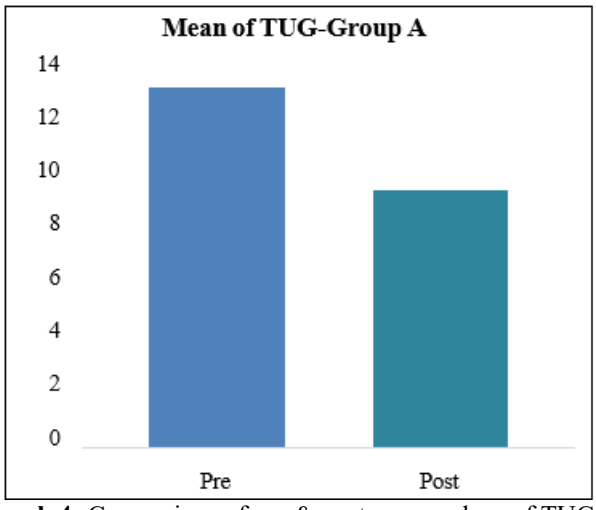


Graph 3: Comparison of post mean values of BBS Group-A and Group B

Table 4: Analysis of pre and post mean values of TUG in Group-A

Group-A	Tests	Mean	S.D	T- Value	P-value
TUG	Pre	13.067	1.0875	6.106	0
	Post	9.333	0.5467		

The above table shows pre & post mean values of TUG in Group-A with T-value 6.106 & P-value – 0.000.

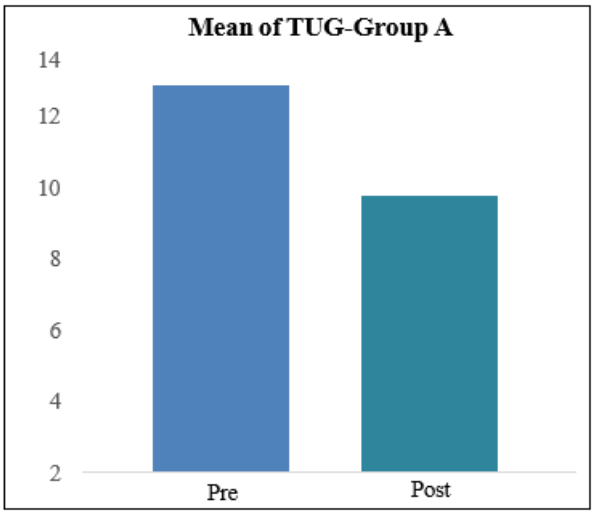


Graph 4: Comparison of pre & post mean values of TUG in Group-A

Table 5: Analysis of pre and post mean values of TUG in Group-B

Group-B	Tests	Mean	S.D	T- Value	P-value
TUG	Pre	13.067	0.7397	6.106	0
	Post	10.333	0.7112		

The above table shows pre & post mean values of TUG in Group-A with T-value 6.106 & P-value – 0.000.

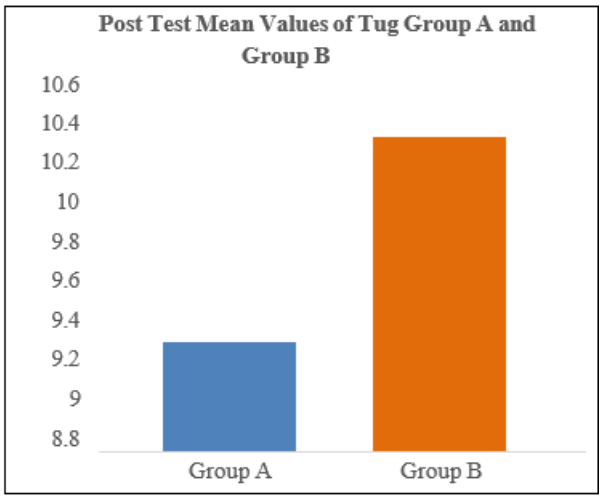


Graph 5: Comparison of pre & post mean values of TUG in Group-A

Table 6: Analysis of post mean of TUG between Group-A and Group-B

Group-A&B	Tests	Mean	S.D	T-value	P-value
TUG	Post test Group- A	9.333	0.5467	6.106	0
	Post test Group-B	10.333	0.7112		

The above table shows the post mean values in both Group-A and Group-B with T-value 6.106 & P-value- 0.000.



Graph 6: Comparison of post mean values of TUG Group-A and Group B

6. Discussion

In this study, out of seventy subjects four subjects doesn't met inclusion criteria, three subjects from the Otago exercises and three subjects from the Manual perturbation exercises are taken. Berg balance scale and Timed up and go test are used to assess Balance and Mobility.

This study is done to compare the Effectiveness of Otago exercises versus Manual perturbation exercises on improving balance and mobility in subjects with Stroke. Limited evidence is available regarding these techniques in individuals diagnosed with Stroke. Some evidence suggests that Otago exercises and Manual perturbation exercises improve balance and mobility, This study will useful in determining the efficacy of the two techniques when they are implemented in conjunction.

Both approaches were used as treatment interventions in the current study to treat patients with stroke having issues with Balance and Mobility. Two groups of 60 patients with Stroke diagnosis were randomly assigned. Group A had Otago exercises in addition to conventional physiotherapy for three sessions per week for four weeks, whereas Group B received the Manual perturbation exercises along with conventional physiotherapy. Before and after the four weeks of treatment, parameters were assessed.

Otago exercise program creates a comprehensive and effective rehabilitation strategy for improving balance and mobility in populations at risk for falls, mainly stroke survivors. This targets multiple systems- muscular, sensory, and neurological- to produce functional improvements in postural control and gait.

A core mechanism by which the Otago program improves function is through lower limb strengthening. Exercises such as knee extension, hip abduction, and calf raises are performed in a progressive manner to improve strength in the quadriceps, gluteal muscles, and ankle dorsiflexors. These muscle groups are essential for postural stability and efficient movement during everyday activities like standing, walking, and changing direction. Strengthening these muscles improves the ability to generate joint torque,

maintain upright posture, and recover from balance. According to Liu-Ambrose et al. (2004), resistance training in the lower limbs significantly contributes to improvements in functional balance and reduces fall risk among older adults[20].

In addition to strength, **balance retraining** is a primary component of the Otago program. Exercises such as single-leg stance, heel-to-toe walking, and turning tasks challenge the center of gravity and promote both static and dynamic balance control. These exercises train the individual to respond effectively to changes in position and environment, improving their anticipatory and reactive postural responses. Sherrington et al. (2011) demonstrated that structured balance training significantly reduces fall incidence and enhances postural stability in older populations. The mechanism here involves better coordination between the visual, vestibular, and somatosensory systems, leading to more efficient motor responses and improved equilibrium[21].

Mobility and gait training also play a significant role in the effectiveness of this combined approach. While the Otago program encourages regular walking to build endurance and coordination, conventional physiotherapy often includes gait retraining, weight-shifting exercises, and functional mobility drills. These techniques improve gait speed, stride length, and rhythm while reinforcing symmetrical limb use—particularly important in stroke rehabilitation. Batchelor et al. (2010) observed that stroke patients who participated in OEP showed significant improvements in Timed Up and Go (TUG) scores, indicating better mobility and functional independence[22].

Finally, OEP along with conventional physiotherapy contributes to increased psychological confidence and reduced fear of falling. Many individuals with impaired balance limit their activity due to fear, which further deteriorates physical function. The Otago program, when supervised and progressively implemented, fosters a safe environment where patients gain confidence in their balance and movement abilities. Campbell et al. (1997) found that participation in the Otago program not only reduced actual falls but also improved participants' confidence in performing daily tasks without losing balance[24].

Manual perturbations play a vital role in enhancing balance and mobility by targeting the neuromuscular and postural control systems of the body. These exercises involve the deliberate and controlled disturbance of a person's posture by a therapist, which forces the patient to activate compensatory strategies to maintain or regain balance. This repeated exposure to postural challenges trains the body to respond more effectively to real-world perturbations, such as slips or changes in surface or direction, thereby improving overall balance stability.

The primary mechanism behind the effectiveness of manual perturbation training lies in **enhancing reactive postural control**. Reactive balance refers to the body's ability to automatically recover from sudden or unexpected external forces. By repetitively triggering these responses in a controlled environment, patients improve their timing, coordination, and strength of compensatory muscle activity. Mansfield et al. (2015) found that balance training involving external perturbations improved reactive stepping ability and reduced fall risk in individual's post-stroke. Such training enhances the activation of postural muscles and promotes quicker and more appropriate motor responses[24].

In conjunction with conventional physiotherapy, which typically includes strength training, gait retraining, and flexibility exercises, manual perturbation exercises help in **improving anticipatory postural adjustments (APA)**. APAs involve the body's ability to prepare for a disturbance before it occurs, such as shifting weight before reaching or stepping. By combining both reactive and anticipatory balance control strategies, the patient's overall stability is enhanced. This dual mechanism is crucial for improving functional mobility, including tasks like walking on uneven terrain, turning, or rising from a chair[25].

The superior outcomes observed in the Otago Exercise Program (OEP) group compared to the manual perturbation group, as measured by the Berg Balance Scale (BBS) and Timed Up and Go (TUG) test, can be attributed to the **multicomponent and task-specific structure** of the Otago protocol, which directly targets both static and dynamic aspects of balance and functional mobility. The OEP includes a well-rounded combination of progressive lower-limb strengthening, dynamic balance training, and gait practice. This combination not only enhances muscular power—particularly in the quadriceps, gluteal muscles, and ankle stabilizers—but also systematically trains the neuromuscular system to adapt to functional demands such as walking, turning, and changing speed. These are the exact activities assessed by TUG and indirectly reflected in BBS scores, which evaluate balance during everyday tasks like standing, transferring, and reaching[21,22].

The mean BBS (Berg Balance Scale) score for Group A increased from **30.667** pre-treatment to **45.567** post-treatment, showing a mean improvement of **14.9 points**. Mobility measured using the Timed up and go test (TUG)showed superior gains in Group A. Group A's mean TUG score reduced from **13.067** pre-treatment to **9.333** post-treatment (a mean improvement of **3.73 points**).

In contrast, manual perturbation training, while valuable for improving **reactive balance** and postural reflexes, primarily focuses on involuntary responses to external challenges and lacks the structured, progressive mobility and strength-building component present in OEP. This limits its ability to produce improvements in **mobility-related tasks** measured by the TUG test. Furthermore, Otago exercises encourage **anticipatory postural adjustments (APA)** through voluntary balance tasks such as tandem walking, heel-to-toe standing, and backward walking. These movements better simulate real-life challenges and enhance proactive balance control, which is crucial for reducing fall risk and improving overall stability in dynamic conditions[21,22]. Moreover, the repetition and progression embedded in the Otago program enhance **motor learning and neuroplasticity**, particularly when paired with conventional physiotherapy. This improves coordinated movement patterns and gait symmetry- key components evaluated in the TUG. This study found that older stroke survivors undergoing the Otago

program showed greater improvements in both TUG and BBS scores compared to other standard interventions. Similarly, this study also emphasized that multi-component exercise programs focusing on strength and balance are more effective than single-domain approaches, such as reactive balance training alone.

In Group B mean BBS score increased from **30.933** pre-treatment to **40.567** post-treatment, showing a greater mean increase of **9.634 points**., whereas Group B reduced from **13.067** to **10.333** (a mean improvement of **2.73 points**). Therefore, the **functional relevance, progression, and comprehensive targeting of both strength and balance mechanisms** in the Otago Exercise Program make it more effective in improving outcomes on BBS and TUG, compared to manual perturbation exercises that are more limited to reactive balance control.

Both therapies yielded statistically significant enhancements in balance and mobility; however, mean scores demonstrate that Group A attained superior enhancements in balance and mobility relative to Group B.

7. Limitations of the Study

Despite the encouraging results, this study has several limitations that should be acknowledged:

Sample Size:
The study was conducted with a relatively small sample size, which may limit the generalizability of the findings to the wider population. Larger, multicenter trials are needed to validate these results.

Short duration of perturbations has given.

8. Conclusion

This study concluded that both Otago exercises and Manual perturbation exercises produced statistically significant an improvements on improving Balance and Mobility in individuals with Stroke. However, Otago exercises along with conventional physiotherapy, demonstrated greater clinical significance, with a improvement in Balance and Mobility outcomes when compared to Manual perturbations along with conventional physiotherapy alone. Hence, Otago exercises are more effective on improving Balance and Mobility compared to Manual perturbation exercises in subjects with Stroke.

9. Summary

Stroke can be defined as a rupture or blockage of an artery of the brain, which results in bleeding into the brain parenchyma or in decreased blood supply and ischemic damage to specific brain areas respectively. When walking, stroke patients typically demonstrate impaired balance and compensatory movements in various portions of their bodies, have difficulty performing activities of daily living, and may sustain injuries from falls Previous studies have suggested that both Otago exercises and Manual perturbation exercises play a vital role in managing Stroke by addressing Balance and Mobility outcomes

The main objective of this study was to compare the effectiveness of Otago exercises versus Manual perturbation exercises on improving Balance and Mobility. Balance and Mobility outcomes were measured using the Berg balance Scale (BBS) and the Timed up and go test (TUG) respectively.

The study was conducted on a total of 60 individuals diagnosed with stroke, aged between 45 to 75 years, who were randomly divided into two groups. Group A 30 subjects received Otago exercises, whereas Group B 30 subjects received Manual perturbation exercises. Both groups underwent the respective interventions for a period of four weeks. Statistical analysis was performed using appropriate paired and unpaired tests for BBS and TUG scores. The results of the study showed that both interventions produced statistically significant improvements; however, Group A demonstrated greater clinical significance, indicating that Otago exercises along with conventional physiotherapy is more effective on improving Balance and Mobility compared to Manual perturbations along with conventional physiotherapy alone.

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