Original Article

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Comparative Study to Evaluate the Effectiveness of Vestibular Rehabilitation Therapy versus Dual Task Training on Balance and Gait in Posterior Cerebral Artery (PCA) Stroke

Physiotherapy Section

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ABSTRACT

Introduction: Vestibular Rehabilitation Therapy (VRT) and Dual Task (DT) training are rehabilitation approaches increasingly used in the care of stroke patients to improve balance and gait, although no comparative evidence has been provided for their efficacy.

Aim: The study was aimed to compare the effectiveness of vestibular rehabilitation therapy versus dual task training on balance and gait in posterior cerebral artery stroke.

Materials and Methods: A total of 30 subjects i.e., subacute Posterior Cerebral Arterystroke individuals were randomly assigned into 2 groups, group A Vestibular Rehabilitation with Conventional Therapy (n=15) and group B DT training (n=15). Each group received treatment for 45 minutes in a day, 3 times in a week for 4 weeks. Both the groups A and B were also given Conventional Physiotherapy treatment comprising of stretching, strengthening and stability exercises, over the period for 5 days for 4 weeks. Participants were assisted with Wisconsin Gait Scale (WGS) to assess the performance of gait and Mini-BEST test to assess the balance.

Mean change score were calculated as the difference between post and pre-test scores and an independent t-test was used to test the difference in the changed scores between two groups. Paired t-test was used to analyse within group differences. A level of significance was set at $p \leq 0.05$.

Results: The comparison of post intervention scores of Mini-BESTest between Group A and Group B showed significant difference (t-value=2.577, p-value=0.018). The comparison of post intervention scores of WGS between Group A and Group B showed significant difference (t-value= -2.356, p-value=0.028). So, result showed that Group A (Vestibular Rehabilitation) was more significant as compared to Group B (DT training) in both Mini-BESTest and WGS.

Conclusion: The result of this study is encouraging to use VRT as a part of rehabilitation protocol by alleviating their gait disturbances, improving balance and gaining confidence of walking with PCA stroke patients as compared with DT Training.

Keywords: Cerebrovascular accident, Vertigo, Walking impairments

INTRODUCTION

Stroke is one of the leading causes of long-term disability associated with severe neurological deficits including sudden weakness or numbness of the face, arm or leg, most often on one side of the body [1]. The other factors includes confusion, severe headache with unknown faintness, confusion, difficulty in speaking and walking, loss of coordination and balance, all these hamper the recovery of these patients [2]. More than 60% of the patients diagnosed with stroke suffer from at least one episode of dizziness [3]. Approximately, 20% of the strokes involve the posterior cerebral circulation. The most common stroke affecting the cerebellum is an infarction of the area supplied by the Posterior Inferior Cerebellar Artery (PICA) [4]. Individuals with Posterior Cerebellar Artery (PCA) stroke generally have long-term sequelae of visual and sensory deficits. They suffer from symptoms of dizziness, nausea, headache and vomiting, nystagmus, dysarthria, vertigo, impaired balance, gait disturbances and limb ataxia. Chronic disability is less in PCA stroke individual compared to anterior cerebral, middle cerebral or basilar artery infarction [5]. Ng YS et al., in their retrospective study on PCA stroke found that visual, motor and cognitive impairments are the squeal of PCA stroke, and functions are achievable after extensive rehabilitation [6].

After a stroke, the recovery of balance is considered of crucial importance which can be affected by various and mixed components like loss of strength or joint motion limitation or modification of tone, motor coordination and sensory organisation components [7].

An important role is also played by the reflex mechanism related to vestibular function in postural control [8]. According to Ala'S A and Lamontagne A, individuals after stroke have been described to exhibit abnormal coordination of axial segments and pelvic rotations during head rotations, which can contribute to changes in balance during gait. The decrease instability of the head and trunk after stroke causes an impaired balance due to lack of quality in visual information [9].

Vestibular rehabilitation is receiving increased interest for the treatment of patients with vestibular or without vestibular disorders and has become one of the main treatments [10]. It is an exercise-based program primarily intended to lessen vertigo and dizziness, gaze instability, and/or imbalance and falls, influencing the amount of recovery that can be extended through compensation [11]. Previous studies have shown that the Vestibulo-Ocular Reflex (VOR) function is significantly related to gait performance and VOR evaluation may be useful for people at risk of falling [12]. The principle of VOR training is based on the sensory conflict that might lead to neurological rearrangements known as vestibular compensations, consist of gaze stabilisation exercises and balance exercises [13]. Mitsutake T et al., showed that patients with subacute stroke also showed significant improvements in the Balance and Gait after vestibular rehabilitation [8].

DT Training allows the practice of multitasking coordination under the various sets of instructions. The efficacy of these different tasks training strategy is for the acquisition, retention, and transfer of tasks coordination skills in Stroke [14]. DT enable the participants to accomplish several tasks concurrently used to explore the effects of cognitive task on postural control and vice versa. Research has emphasised the role of recognition and concentration during dual task performance for balance and gait control as a prototype of motor learning [15]. An HJ et al., showed that patients in DT training improve cognitive and walking abilities of patients with stroke [16]. Bowen A et al., concluded that performing a verbal cognitive task while walking improved the balance and gait of stroke patients [17].

Prolonged neural plasticity follows stroke, so active neuro-rehabilitation of patients is essential. Acute intervention helps in increasing the probability of the individuals achieving maximal independence in Activities of Daily Living (ADL) [6].

The purpose of the present study is to determine the effect of Vestibular Training and DT Training on Balance and Gait on subacute PCA stroke. It has been found that these techniques have shown a significant improvement on improving balance and gait in patients suffering from the stroke but till date, there is no study which has evaluated the comparative effect of the same. So, the aim of this study is to compare the effectiveness of VRT versus DT Training on Balance and Gait and hence enhance the quality of life of individuals with PCA stroke.

MATERIALS AND METHODS

The study was Comparative Intervention study and it was approved by the Institutional Ethical Committee (IEC) number SGTU/FOP/2018/37. Samples were recruited from Sir Ganga Ram Hospital, New Delhi and the duration of the study was 1 month in the May 2018. The Sample size of total 30 subjects (Posterior Cerebral Artery Stroke (PCA) patients sub-acute >3 months [18]) were randomly assigned into 2 groups by simple randomised selection method using chit method. Each group consists of 15 subjects named as Group A- Vestibular Rehabilitation Therapy and Group B- DT Training. All patients were diagnosed with subacute PCA Stroke by physicians, computed tomography, and/or MRI scan of the brain.

Inclusion criteria: 1) Subacute (less than 3 months) cases of subacute PCA Stroke [18]; 2) Verified presence of impaired balance (positive Romberg test); 3) Ability to walk at least 10 m alone with or without an assistive device (10-meter walk test); 4) Ability to perform gaze stabilisation test [19]; 5) Mini Mental State Examination score should not be less than 18 [20]; 6) Minimum score of WGS at least-13.35 [21]; 7) Minimum MINI BEST test score should be- 19/28 [22]; 8) Spasticity grades less than 3 (Modified Ashworth scale) [23].

Exclusion criteria: 1) Subjects with any unstable medical conditions, any comorbidity or disability other than stroke that could affect the gait speed of the participant in the protocol; 2) Any neurological psychological disorders like Parkinson's disease, Spinal-Cord Injury, Multiple Sclerosis; 3) Subjects with severe spasticity (grade >2) as measured by Modified Ashworth scale affected limb) [23]; 4) The ability to perform the proposed exercises is compromised by severe osteo-articular disease like Osteoarthritis, Rheumatoid Arthritis; 5) They had previous experience with Vestibular Rehabilitation exercises conditions including vestibular disorders, ENT disorders, Benign paroxysmal positional vertigo; 6) Subjects having an uncorrected hearing or visual impairments; 7) Any psychiatric or psychological illness.

After checking for eligibility criteria, a sample of 30 subjects i.e., subacute PCA Stroke patients were randomly assigned into 2 groups. Each group consists of 15 subjects each. Group A (N=15) and Group B (N=15). Both followed the protocol of 45 minutes per day, 3 times in a week for 4 weeks.

Both the groups A and B also received Conventional Physiotherapy treatment comprising of limb stretching, strengthening and stability exercises, passive mobilisation of joints, supportive ambulation over that period for 45 minutes in a day for 5 days in 4 weeks [24].

Group A: VRT with Conventional Physiotherapy

Group B: DT Training with Conventional Physiotherapy.

A duly designed informed consent was obtained from the subjects who were willing to participate. All subjects were given a detailed explanation of the procedure. Post-test measures were taken after 4 weeks of intervention. Participants had a baseline assessment with WGS and MINIBEST scale. Furthermore, demographic and clinical information were collected by consulting the previous clinical records (when available), including the date of the stroke, location, gait ability, number of falls after stroke, and their present therapies. After 4 weeks participants of both the groups were submitted to post assessment for Minibest test and WGS to check the difference.

Group A

Vestibular Rehabilitation Therapy intervention consists of 45 minutes per day, 3 times a week for 4 weeks [25-28].

It includes two types of following exercises:

A. Adaptation exercises

Adaptation exercises further divided into two types of exercise i.e.,

1. **Vestibulo-ocular reflex (VOR) stimulating exercise:** it includes Gaze stabilisation exercises.
   a) **Head and eye in same directions:** For head movements with a target (X1 viewing), the patient holds a target at arm's length with eyes focused on the target, move the head from side to side. Repeat the entire cycle 20-30 times. Increasing speed with each progression and also from standing on a firm surface to compliant surface.
   b) **Head and eye in opposite directions:** For head movement "out of phase" with target (X2 viewing), the patient holds target at arm's length with eyes focused on the target and moves the head to the right and the target to the left and vice versa, while keeping the eyes focused on the target. Repeat the entire cycle 20-30 times. The patient gradually increases the speed with each progression and also from standing on a firm surface to standing on a compliant surface.
2. **Ocular motor exercises:** it includes
   a) **Smooth pursuit (visual tracking):** The patient holds a target at arm's length, then moves the target left and right across the visual field, tracking with eye movement and keeping the head still. Repeat the entire cycle 20-30 times.
   b) **Saccade latency (target in both hands):** The patient can hold the target in each hand approximately 15 inches apart at arm's length. Keep the head still, the eyes are moved back and forth from target to target with 1 second per target. The full cycle is repeated 20-30 times.

B. Balance and gait exercises

1. **Balance exercises**
   a) Stand with feet shoulder-width apart, arms across the chest. The difficulty level is raised as the patient progresses from to bring the feet closer together, closed eyes and with standing on cushion sofa or foam.
   b) Practice ankle sways, medial-lateral and anterior-posterior later on with circle sways with closed eyes.
   c) Attempt to walk with the heel touching toe on firm surface and progression made on the carpet.

d) Practice walking five steps and turning 180 (left and right). The difficulty level is raised by making smaller turns with closed eyes.

e) Walk and move the head side to side, up and down,

f) Ball diagonal: Take a ball in hand, lift it up, transfer to other hand, follow arch visually,

g) Circle with ball: The eyes emphasise on the ball and then the patient moves it in a circular fashion in both directions with accelerating speed, the head and body also moves with the ball. The difficulty level is raised by progress from sitting to standing to a narrower stance.

2. **Gait exercises**

a) Walking on the straight line, the patient begins by walking next to a wall with the hand out for support. The patient gradually decreasing the support and increasing the number of steps.

b) Walking with head in motion, the patient walks with the head in motion going right to left with increasing speed.

c) Sitting to standing, then return to sitting: the patient walks from one chair to another chair position 10 feet away. Difficulty level is raised by adding head movements, increase walking speeds, and decrease the width of gait.

d) Gait with wide and sharp turns to the left and right.

Group B

DT training intervention consists of 45 minutes per day, 3 times a week for four weeks [29].

It consists of two sets of exercises i.e., balance tasks and secondary tasks performing simultaneously. Balance tasks are the postural stability task while secondary task is the tasks performing the auditory and visual discrimination tasks as well as cognitive task. They were directed to maintain the same amount of attention on both the tasks at all time.

Balance tasks-secondary tasks

1. **Stance activities include:**

a) Semi tandem, eyes open, arm alterations-Spell words forward,

b) Semi tandem, eyes open, arm alterations-Spell words backward,

c) Draw letter with the right foot-Name any word starts with A-K,

d) Perturbed standing holding the ball-Remember prices.

2. **Gait activities include:**

e) Walk narrow base of support- Count forward by 3,

f) Walk narrow base of support step sideways backwards avoiding obstacles- Remember words.

g) Walk and kick a ball to hit the cans- Tell the opposite direction of the ball.

Conventional Therapy Program [24]

Both the groups A and B were receiving a conventional therapy program 45 minutes a day, 5 days in a week for 4 weeks, comprising of limb stretching, strengthening and stability exercises, passive mobilisation of joints, walking between parallel bars, manual dexterity (grasp release, stacking cones), stretching and weight bearing exercises. During the exercise, the therapist provides necessary assistance to help the patients in executing the exercises.

Outcome Measurements

Xi L et al., found that WGS is reliable and valid protocols to measure the gait of a post-stroke patients. Its Reliability r=0.96 and Interrater reliabilities (ICC=0.73) were both good [21] [Annexure-1].

Mini-BESTest was used to assess the balance. It is a highly reliable balance scale and unidimensional test consist of 14-items which takes around 15 minutes to administer and scoring from 0 (unable to perform or requiring help) to 2 (normal performance) having maximum score of 28. The Mini-BESTest had excellent internal consistency (Cronbach Alpha=0.89-0.94), intrarater reliability (intraclass correlation coefficient=0.97), and interrater reliability (intraclass correlation coefficient=0.96) [21] [Annexure-2].

STATISTICAL ANALYSIS

Data were analysed using SPSS version 23.0 for windows (SPSS Inc., Chicago, Illinois's). The sample size was determined through power calculation from previous studies for balance impairment in patients with stroke with an estimated effect size of 0.80 an overall sample of 28 participants (14 in each group) at 0.05 level of significance was calculated. Thirty subjects were recruited to allow 10% dropout.

Mean change score were calculated as the difference between post and pre-test scores and an independent t-test was used to test the difference in the changed scores between two groups. Paired t-test was used to analyse within group differences. A level of significance was set at $p \leq 0.05$.

RESULTS

Both the Group A and Group B were matched in terms of age p-value=0.94), height (p-value=0.46), weight (p-value=0.18), and MMSE score (p-value=0.21) as shown in [Table/Fig-1].

Variables	Group A Mean (S.D) N=15	Group B Mean (S.D) N=15	t-value	p-value
Age	57.23 (7.39)	57 (8.259)	0.071	0.944^{NS}
Height	73.84 (5.32)	172.40 (3.30)	0.753	0.463^{NS}
Weight	71.30 (9.23)	66.90 (6.04)	1.30	0.183^{NS}
MMSE	25.46 (1.45)	26.30 (1.70)	-1.275	0.216^{NS}

[Table/Fig-1]: Descriptive statistics of subjects participated in the study.
N: Number of subjects; Group A: Vestibular rehabilitation; Group B: Dual task training; SD: Standard deviation; t: Value obtained after analysis with independent t-test; p: Significant at ≤0.05; MMSE: Mini mental state examination; NS: Non-significant

The comparison of pre-intervention scores of WGS between Group A and Group B (showed no significant difference (p-value=0.34) and also in Mini-BESTest between Group A and Group B showed no significant difference (p-value=0.10) indicating that both the groups were matched in terms of WGS scores prior to intervention as shown in [Table/Fig-2].

Variables	Group A Mean (S.D) N=15	Group B Mean (S.D) N=15	t-value	p-value
Mini-BESTest	9.69 (1.18)	10.6 (1.34)	-1.717	0.101^{NS}
WGS	27.01 (2.13)	26.10 (2.32)	0.975	0.341^{NS}

[Table/Fig-2]: Comparison of Pre- intervention scores of Group A and Group B.
N: Number of subjects; Group A: Vestibular rehabilitation; Group B: Dual task training; SD: Standard deviation; t: Value obtained after analysis with independent t-test; p: Significant at ≤0.05; MMSE: Mini mental state examination; NS: Non-significant

The comparison of pre-intervention and post intervention scores of Mini-BESTest (p-value=0.001) and WGS (p-value=0.001) within Group A showed significant difference as shown in [Table/Fig-3].

Variables	Pre-test Mean (SD)	Post-test Mean (SD)	t-value	p-value
Mini-BESTest	9.69 (1.18)	16.15 (1.28)	-18.403	0.001^{S}
WGS	27.01 (2.13)	20.0 (1.62)	22.529	0.001^{S}

[Table/Fig-3]: Comparison of pre-intervention and post-intervention scores of Group A.
N: Number of subjects; Group A: Vestibular rehabilitation; Group B: Dual task training; SD: Standard deviation; t: Value obtained after analysis with independent t-test; p: Significant at ≤0.05; MMSE: Mini mental state examination; S: Significant

The comparison of pre-intervention and post intervention scores of Mini-BESTest (p-value=0.001). and WGS (p-value=0.001) within Group B showed significant difference as shown in [Table/Fig-4].

Variables	Pre-test Mean (SD)	Post-test Mean (SD)	t-value	p-value
Mini-BESTest	10.6 (1.34)	14.7 (1.41)	-17.192	0.001[S]
WGS	26.10 (2.32)	22.01 (2.47)	17.192	0.001[S]

[Table/Fig-4]: Pre-intervention and post-intervention scores of Group B.
N: Number of subjects; Group A: Vestibular rehabilitation; Group B: Dual task training; SD: Standard deviation; t: Value obtained after analysis with independent t-test; p: Significant at ≤0.05; MMSE: Mini mental state examination; S: Significant

The comparison of post intervention scores of Mini-BESTest between Group A and Group B showed significant difference (t-value=2.577, p-value=0.018). The comparison of post intervention scores of WGS between Group A and Group B showed significant difference (t-value= -2.356, p-value=0.028), showed that Group A was more significant as compared to Group B in both Mini-BESTest and WGS as shown in [Table/Fig-5].

Variables	Group A Mean (SD)		Group B Mean (SD)		Mean change scores		t value	p-value
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre	Post		
Mini-BES Test	9.69 (1.18)	16.15 (1.28)	10.6 (1.34)	14.7 (1.41)	-0.90	1.45	2.577	0.018[S]
WGS	27.01 (2.13)	20.0 (1.62)	26.10 (2.32)	22.01 (2.47)	0.91	-2.01	-2.356	0.028[S]

[Table/Fig-5]: Pre-intervention and post-intervention scores of Group A and Group B.
N: number of subjects; Group A: Vestibular rehabilitation; Group B: Dual task training; SD: Standard Deviation; t: value obtained after analysis with independent t-test; p: significant at ≤0.05; MMSE: Mini Mental State Examination; S: Significant

DISCUSSION

The present study investigated the effects of a VRT versus DT training specifically tailored to challenge balance and gait performance in PCA stroke individuals. Both types of training elicited improvements in balance and gait performance, confirming the efficacy of well-designed exercises for stroke patients. In rehabilitation, specific forms of DT training with motor interference and multitasking and VRT with adaptation, balance and gait exercises have been demonstrated to benefit both gait and balance performance in patients with PCA stroke. The result of this study is in accordance with Ng YS et al., who concluded visual, motor and cognitive impairments are common in PCA stroke, and good functional gains are achievable after comprehensive rehabilitation [6]. Many of the findings from this study were similar to those reported in the subacute PCA stroke literature (Deluca C et al., in 2007 and in 2011, Morton SM in 2010) [30-32]. Both the groups demonstrated effective improvement in all the parameters of gait and balance. The present findings of this study indicate that VRT group showed a significant improvement on balance and gait as compared to DT training in patients with PCA stroke.

Whitney S et al., suggested that VRT is important to coordinate learning strategies in order to maximise adaptation, motor learning and avoid over stimulation. Therefore, it is essential for the clinician to pay more attention to not only common vestibular symptoms but also gait stabilisation to avoid fall and to improve further balance [33]. Eye and head movements exercises were performed for the improvement of the gaze stability, whereas exercises performed during sitting, standing on the firm to cushion surface or on narrow base to improve postural stability. Exercises containing stepping over obstacles with forward and backward walking further increase stride length, heel strike and foot clearance [34]. The primary mechanisms for the recovery of posture are increased due to increase independency on visual and somatosensory cues for improving the vestibular responses.

The goals for VRT for postural stability are- firstly to use the remaining vestibular function, further, to use stable visual references and surface somatosensory information and lastly to identify effective and efficient alternative postural movement strategies [26]. Post stroke individuals tend to show an elevation in postural perturbation because of under stimulations in one of the sensory strategies (Bonan IV et al., 2016) [35]. According to Bonan IV et al., hemiplegic patients cannot adequately utilise vestibular information and instead rely largely on visual input for stabilising their postures [36].

The significant result in VRT group is in accordance with Marioni G et al., that Vestibular rehabilitation fosters the sensory reweight to coordinate vestibular input, and as a result, the patients showed improved walking performance after the VRT intervention program [37].

VRT provides the necessary task-specific stimuli for neural reorganisation, fostering central sensory integration and resulting in improved balance and gait. Ocular motor exercises play a key role in neuromuscular reorganisation because visual feedback plays an important role in coordinated limb movements. So, it is possible that eye movement exercises included in the vestibular rehabilitation program contributed to the improved balance and gait [38]. Ricci NA et al., explained in their systematic review that VRT helps in obtaining the vestibular compensation through central mechanisms of neuroplasticity. Therefore, VRT has been considered a safe option with no side effects and also cost-effective and efficient. The improvement is thought to be brought by the exercises that are supposed to stimulate repetitive movements of eye, head, and trunk [39]. According to Horak FB et al., the control of head and trunk orientation in space place an important role in relation to the gravitational force for improving postural instability, as vestibular sensorial references are important for maintaining stability when high frequencies and velocities of body movement takes place [40].

Various researches done on vestibular rehabilitation has already shown significant improvement in balance and gait by vestibular exercises (Balci BD et al., 2013) [41].

So, the results of this study indicates the improvement in the patients with PCA stroke with balance and gait abnormalities after Vestibular Rehabilitation. So, this study extended previous findings and indicated that vestibular rehabilitation has a promising effect on balance gait performance in PCA stroke patients.

Vestibular rehabilitation therapy is found to be very effective and beneficial in gaining confidence of walking by improving balance and alleviating their gait disturbances with stroke patients. It is safe to perform, low cost and without any side effects which can be easily used during the rehabilitation. It can be prescribed as an additional tool during the stroke rehabilitation of these population and also be used for the balance impaired patients of various neurological disorders. It can also be given to the patients for home program to improve balance and gait performance.

LIMITATION

The small sample size, the non-performance of follow-up of participants during the post treatment period, to verify if the VRT effects are maintained in long term. No measurement was performed to ascertain maintenance of effects after exercise cessation.

CONCLUSION

The result of this study are encouraging to use VRT as a part of rehabilitation protocol by alleviating their gait disturbances, improving balance and gaining confidence of walking with PCA stroke patients as compared with DT Training. Based on the results of this study, vestibular rehabilitation is much effective on Balance and Gait impaired patients with PCA stroke. Future studies might compare individuals who are subjected to a protocol with greater frequency of weekly sessions, aiming at establishing an ideal and sufficient number of treatment sessions.

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ANNEXURE 1

Wisconsin Gait Scale (WGS)

Overview: The Wisconsin Gait Scale (WGS) can be used to evaluate the gait problems experienced by a patient with hemiplegia following stroke. This can be used to monitor the effectiveness of rehabilitation training. The authors are from the University of Wisconin.

Observations of the subject:

1. walking towards the observer
2. walking away from the observer
3. from theside

Measures (14 submeasures):

1. stance phase of the affected leg (5 submeasures)
2. toe off of the affected leg (2 submeasures)
3. swing phase of the affected leg (6 submeasures)
4. heel strike of the affected leg (1 submeasure)

Stance phase submeasures:

1. use of hand held gaitaid
2. stance time on impaired side
3. step length of the unaffected side
4. weight shift to the affected side with or without a gaitaid
5. stance width (measure distance between feet prior to toe off of affected foot) Toe off submeasures:
6. guardedness (pause prior to advancing affected leg)
7. hipextension of affected side (observe glutealcreases from behind the subject) Swing phase submeasures:
8. external rotation during intial swing
9. circumduction at mid swing (observe path of affected heel)
10. hip hiking at midswing
11. knee flexion from toe off to midswing
12. toe clearance
13. pelvisrotation

Heel strike affected leg submeasure:

14. initial foot contact

total score=SUM(points for 2 to 10 12 to 14)+(3/5* (points for 1))+(3/4* (points for 11)) Interpretation:

- minimum score: 13.35
- maximum score: 42
- The higher the score the more seriously affected thegait.

Submeasure	Finding	Points
Use of hand held gait aid	No gait aid	1
	Minimal gait aid use	2
	Minimal gait aid use wide base	3
	Marked use	4
	Marked use wide base	5
Stance time on impaired side	Equal (time spent on affected side same as time spent on unaffected side during single leg stance)	1
	Unequal	2
	Ver brief	3
Step length of unaffected side	Step through (heel of unaffected foot clearly advances beyond the toe of the affected foot)	1
	Foot does not clear	2
	Step to (unaffected foot placed behind or up to affected foot but not beyond)	3
Weight shift to the affected side (with or without gait aid)	Full shift (head and trunk shift laterally over the affected foot during the single stance)	1
	Decreased shift	2
	Very limited shift	3
Stance width	Normal (up to 1 shoe width between feet)	1
	Moderate (up to 2 shoe widths)	2
	Wide (more than 2 shoe widths)	3
Guardedness	None (good forward movement with no hesitancy noted)	1
	Slight	2
	Marked hesitation	3
Hip extension of affected side	Equal extension (hips equally extend during push off; maintains erect posture during toe off)	1
	Slight flexion	2
	Marked extension	3
External rotation during intial swing	Same as unimpaired leg	1
	Increased rotation	2
	Marked	3
Circumduction at mid swing	None (affected foot adducts no more than unaffected foot during swing)	1
	Moderate	2
	Marked	3
Hip hiking at mid swing	None (pelvis slightly dips during swing)	1
	Elevation	2
	Vaults	3
Knee flexion from toe off to mid swing	Normal (affected knee flexes equally to unaffected side)	1
	Some	2
	Minimal	3
	None	4

Toe clearance	Normal (toe clears floor throughout swing)	1
	Slight drag	2
	Marked	3
Pelvic rotation at terminal swing	Forward (pelvis rotated forward to prepare for heel strike)	1
	Neutral	2
	Retracted	3
Initial foot contact	Heel strike (heel makes the initial contact with the floor)	1
	Foot flat	2
	No contact of heel	3

ANNEXURE 2

Mini-BESTest:

Balance Evaluation Systems Test

1. SIT TO STAND

Instruction: "Cross your arms across your chest. Try not to use your hands unless you must. Do not let your legs lean against the back of the chair when you stand. Please stand up now."

(2) Normal: Comes to stand without use of hands and stabilises independently.

(1) Moderate: Comes to stand WITH use of hands on first attempt.

(0) Severe: Unable to stand up from chair without assistance, OR needs several attempts with use of hands.

2. RISE TO TOES

Instruction: "Place your feet shoulder width apart. Place your hands on your hips. Try to rise as high as you can onto your toes. I will count out loud to 3 seconds. Try to hold this pose for at least 3 seconds. Look straight ahead. Rise now."

(2) Normal: Stable for 3 s with maximum height.

(1) Moderate: Heels up, but not full range (smaller than when holding hands), OR noticeable instability for 3 s.

(0) Severe: <3 s.

3. STAND ON ONE LEG

Instruction: "Look straight ahead. Keep your hands on your hips. Lift your leg off of the ground behind you without touching or resting your raised leg upon your other standing leg. Stay standing on one leg as long as you can. Look straight ahead. Lift now."

Left: Time in Seconds Trial 1:_____Trial 2:_____

(2) Normal: 20 s.

(1) Moderate: < 20 s.

(0) Severe: Unable.

Right: Time in Seconds Trial 1:_____Trial 2:_____

(2) Normal: 20 s.

(1) Moderate: <20 s.

(0) Severe: Unable

To score each side separately use the trial with the longest time.

To calculate the sub-score and total score use the side [left or right] with the lowest numerical score [i.e. the worse side].

4. COMPENSATORY STEPPING CORRECTION- FORWARD

Instruction: "Stand with your feet shoulder width apart, arms at your sides. Lean forward against my hands beyond your forward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall."

(2) Normal: Recovers independently with a single, large step (second realignment step is allowed).

(1) Moderate: More than one step used to recover equilibrium.

(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

5. COMPENSATORY STEPPING CORRECTION- BACKWARD

Instruction: "Stand with your feet shoulder width apart, arms at your sides. Lean backward against my hands beyond your backward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall."

(2) Normal: Recovers independently with a single, large step.

(1) Moderate: More than one step used to recover equilibrium.

(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

6. COMPENSATORY STEPPING CORRECTION- LATERAL

Instruction: "Stand with your feet together, arms down at your sides. Lean into my hand beyond your sideways limit. When I let go, do whatever is necessary, including taking a step, to avoid a fall."

Left

(2) Normal: Recovers independently with 1 step

(crossover or lateral OK).

(1) Moderate: Several steps to recover equilibrium.

(0) Severe: Falls, or cannot step.

Right

(2) Normal: Recovers independently with 1 step

(crossover or lateral OK).

(1) Moderate: Several steps to recover equilibrium.

(0) Severe: Falls, or cannot step.

Use the side with the lowest score to calculate sub-score and total score.

7. STANCE (FEET TOGETHER); EYES OPEN, FIRM SURFACE

Instruction: "Place your hands on your hips. Place your feet together until almost touching. Look straight ahead. Be as stable

and still as possible, until I say stop."

Time in seconds:_____

(2) Normal: 30 s.

(1) Moderate: <30 s.

(0) Severe: Unable.

REACTIVE POSTURAL CONTROL

ANTICIPATORY

SENSORY ORIENTATION

SUB SCORE: /6

SUB SCORE: /6

SUB SCORE: /6

8. STANCE (FEET TOGETHER); EYES CLOSED, FOAM SURFACE

Instruction: "Step onto the foam. Place your hands on your hips. Place your feet together until almost touching. Be as stable and still as possible, until I say stop. I will start timing when you close your eyes."

Time in seconds:_____

(2) Normal: 30 s.

(1) Moderate: < 30 s.

(0) Severe: Unable.

9. INCLINE- EYES CLOSED

Instruction: "Step onto the incline ramp. Please stand on the incline ramp with your toes toward the top. Place your feet shoulder width apart and have your arms down at your sides. I will start timing when you close your eyes."

Time in seconds:_____

(2) Normal: Stands independently 30 s and aligns with gravity.

(1) Moderate: Stands independently <30 s OR aligns with surface.

(0) Severe: Unable.

10. CHANGE IN GAIT SPEED

Instruction: "Begin walking at your normal speed, when I tell you 'fast', walk as fast as you can. When I say 'slow', walk very slowly."

(2) Normal: Significantly changes walking speed without imbalance.

(1) Moderate: Unable to change walking speed or signs of imbalance.

(0) Severe: Unable to achieve significant change in walking speed AND signs of imbalance.

11. WALK WITH HEAD TURNS– HORIZONTAL

Instruction: "Begin walking at your normal speed, when I say "right", turn your head and look to the right. When I say "left" turn your head and look to the left. Try to keep yourself walking in a straight line."

(2) Normal: performs head turns with no change in gait speed and good balance.

(1) Moderate: performs head turns with reduction in gait speed.

(0) Severe: performs head turns with imbalance.

12. WALK WITH PIVOT TURNS

Instruction: "Begin walking at your normal speed. When I tell you to 'turn and stop', turn as quickly as you can, face the opposite direction, and stop. After the turn, your feet should be close together."

(2) Normal: Turns with feet close FAST (<3 steps) with good balance.

(1) Moderate: Turns with feet close SLOW (>4 steps) with good balance.

(0) Severe: Cannot turn with feet close at any speed without imbalance.

13. STEP OVER OBSTACLES

Instruction: "Begin walking at your normal speed. When you get to the box, step over it, not around it and keep walking."

(2) Normal: Able to step over box with minimal change of gait speed and with good balance.

(1) Moderate: Steps over box but touches box OR displays cautious behavior by slowing gait.

(0) Severe: Unable to step over box OR steps around box.

14. TIMED UP & GO WITH DUAL TASK [3 METER WALK]

Instruction TUG: "When I say 'Go', stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair."

Instruction TUG with Dual Task: "Count backwards by threes starting at ___. When I say 'Go', stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair. Continue counting backwards the entire time."

TUG: _____seconds; Dual Task TUG: _____seconds

(2) Normal: No noticeable change in sitting, standing or walking while backward counting when compared to TUG without Dual Task.

(1) Moderate: Dual Task affects either counting OR walking (>10%) when compared to the TUG without Dual Task.

(0) Severe: Stops counting while walking OR stops walking while counting.

When scoring item 14, if subject's gait speed slows more than 10% between the TUG without and with a Dual Task the score should be decreased by a point.

TOTAL SCORE: _____

DYNAMIC GAIT/28

SUB SCORE: /10