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Original Research Article

Effect of Visual Feedback Training Vs Conventional Therapy on Sitting Balance and Upper Limb Reaching Ability in Patients with Stroke: A Randomized Controlled Trial

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ABSTRACT

Introduction: In stroke balance impairment in sitting which is important early predictor of motor and functional outcome. Visual feedback training (VFT) has largely been used as a rehabilitation method and proven an effective therapy in enhancing balance control in patients with stroke. Very few literatures available on dynamic sitting balance with VFT and upper limb reaching activity.
Material and Methods: Experimental study (RCT) was conducted on 40 participants with stroke of age 25-65 years were included and equally distributed in both the experimental and control group (20 in each group). The demographic variables and stroke related parameters (mFRT and TIS Score) in both groups were comparable. The experimental group received conventional therapy (CT) plus VFT and control group received conventional therapy alone (CT) for 4 weeks (5 days/week).
Data analysis and Results: Statistical software, STATA, version 10.1 2011wasused. Anthropometric parameters, Mean centre of foot pressure (COFP), mFRT and TIS Score were compared between Experimental and Control group by performing independent t-test (paired t-test). Mean COFP, mFRT and TIS Score were compared between pre and post test by performing paired t-test. Changes (effects) in COFP, mFRT and TIS score after post test intervention between experimental and control group were compared by performing independent t-test. Chi-square test was used to compare categorical variables. P<0.05 was considered as statistical significance.
Conclusion: The VFT is an effective tool for improving dynamic sitting balance, weight loading response on paretic side as well as improves the trunk control in 4 weeks of intervention in patients.

Key words: Stroke, Sitting Balance, Visual Feedback, Centre of Foot Pressure, Trunk Impairment Scale (TIS), Modified Functional Reach Test (mFRT).

INTRODUCTION

WHO defined stroke, as rapidly developing clinical sign of focal (or global) disturbance of cerebral function, symptoms lasting 24 hours or more leading to death with no apparent cause other than vascular origin. [1-3] Impact of stroke is considerable worldwide.[2] In (2008) Daniel found that annual incidence rate of stroke in India was 123.57 per 1, 00,000 persons[2] whereas WHO reported that 4.5 million deaths occur per year in which survivor rate was 9 million among stroke. [3] Pandian JD (2013) found that average incidence rate is 119-145 in 1, 00,000 of stroke whereas prevalence rate of stroke range from 84-262/ 1, 00, 000 in rural and 334-424/1, 00,000 in urban, Indian population.[4] It was found that incidence is more common between the age of 40 to 70 years in both genders. [2]

Stroke compromises major cause of adult disability.[5] Most frequent neurological deficit after stroke is hemiparesis which includes weakness of one side of the body (upper limb, lower limb and trunk). [6] Stroke often leads to balance impairment in sitting[7] which may leads to increased risk of falls, limits functional mobility makes patient dependent, socially inactive and falls are major leading cause of serious injuries in stroke.[8,9] It was found that muscle weakness, loss of dexterity, sensory-motor deficit and loss of tendency to adopt compensatory strategies for avoiding the risk of falls, affects the sitting balance.[8,10] Decreased sitting balance also challenges standing balance, reduces transfer and walking abilities, limits activities of daily living such as (toileting, showering, eating dressing, reaching for an object etc). [6,7,9,11,12] Sitting balance and ability to perform selective trunk movement i.e. trunk control have been identified as an important early predictor of motor and functional outcome after stroke.[7,13,14] Due to trunk muscle weakness in patients with stroke sitting balance is compromised which results in poor trunk control during voluntary trunk and limb movement.[10] Ability to maintain the body in upright posture both in static and dynamic sitting requires postural control which reduces postural sway and maintain the centre of pressure within the base of support.[9,15] Studies using an isokinetic dynamometer have concluded that stroke patients have weakness of trunk flexors, extensors and bilateral rotators.[16,17] Therefore restoration of sitting balance and trunk control is an important goal of rehabilitation.[7,14,18]

Reaching for a variety of object requires coordinated movement of trunk and upper limb along with active participation of lower limbs. [19,20] It is one of the activities which are affected in stroke survivors. [21,22] Most persons with stroke have difficulty in shifting their weight toward the affected side compared with non affected side.[23] Nichols DS (1996) and colleagues were first to use a force plates on sitting balance and concluded that the balance system (force plates) are appropriate measure to asses dynamic balance on sitting in patients with stroke.[9] Study done by Dean CM et al concluded that while seated reaching activity the lower limb plays an active role in maintaining sitting balance they also found that there was increase in load taken through the affected limb while performing reaching activity.[7]

Various studies concluded that conventional therapy such as verbal, visual (activity with mirror feedback)and tactile cue, proprioception, vestibular and auditory input, reach task activity, physio ball exercise have always been effective in regaining a good sitting balance in stroke survivors. [15,24-27] among the various therapeutic methods, visual feedback training has largely been used as a rehabilitation method and proven an effective therapy in enhancing balance control in patients with stroke.[10,28-30] Study done by Lee et al showed that training with visual Feedback results in improvement of static and dynamic sitting balance in patients with stroke. [31] Visual feedback training (VFT) increase patient's motivation and individualizes exercise difficulty according to patient's current status.[32] Different forms of VFT have been investigated in recent studies such as VFT(visual feedback training) using force platform, Wii Fit from Nintendo for balance control, gait training with visual signals, gait and balance training using 3d VF, spinal stabilization using VF. [29-31]Studies done by Pellegrino L et al (2017), [10] in one time intervention protocol concluded that visual feedback therapy alone cannot be used as an effective way of improving sitting balance whereas Young KJ (2015) gave 3 weeks intervention with VFT and reported that visual feedback along with conventional therapy enhances the standing balance and mobility among stroke patients. [32]

There are various methods of evaluating dynamic sitting balance in patients with stroke such as Modified

Functional Reach Test, Postural Assessment Scale, Rivermaid Motor Assessment Scale, Trunk Impairment Scale Mini-Balance Evaluation System Test, Motor Assessment Scale, Trunk Control Test, Brunel Balance Assessment and Foot Pressure of lower limbs with visual feedback in standing and sitting. [15,22, 33-37] Modified functional reach test establishes the good reliability and validity (ICC= 0.92 -0.96) when compared in patients with stroke.[22] Study was first performed by Lunch S et al and demonstrated excellent test-retest reliability in forward maximum reach on sitting in patients with spinal cord injury.[38] Trunk impairment scale is one of the important valid tool to evaluate the dynamic balance in patients with stroke.[39] Verheyden G (2008) established the high test re-test reliability (ICC=0.93-0.96) and high concurrent validity (r=0.83 when compared with trunk control test) and concluded that this test can be used as a objective clinical measure for assessing trunk performance in stroke patients.[39]

It evaluates the selective movement of lateral flexion and rotation of trunk initiated from upper and lower parts of the body.[40] Verheyden (2006) concluded that this scale can be used as an early predictor of functional outcome and activities of daily living in among sub-acute stroke patients.[33] Foot pressure have always been a reliable measure for evaluating weight distribution of lower limbs done on standing and sitting and used as clinical outcome measure in most of the studies.[9-11,22,30,37] Shumway-cook et al found that maintaining centre of pressure while standing reduces the asymmetry of the body and increases the weight loading on the affected side.[24] Leurer MK et al used a force platform (Balance Master) which consisted of four force transducers that measure the vertical pressures they assessed the weight shift and symmetry in percentage on sitting balance a significant moderate correlation was found between MFRT and Balance Master.[22]

Most of the activities of daily living are performed by upper limb function also mostly upper limb rehabilitation focuses on unilateral training (i.e. the training of the affected limb only).[41] Mudie and colleague (1996) proposed the theory of involving bilateral upper limb training (i.e. both the affected and unaffected hands) it is the form of training where both upper limb performs identical movement simultaneously.[42] Another study reported that upper limb bilateral activity training promote body symmetry reduces abnormal tone and improves voluntary movement of upper limb and also the activity of daily living in patients with stroke.[41,43] Cauraugh et al (2005) concluded that bilateral upper limb training facilitates the additional pathways such as ipsilateral uncrossed corticospinal pathways and spared indirect corticospinal pathways which receive input from bilateral reticulospinal and rubrospinal pathway.[44] In (2008) concluded that simultaneous activation of both the hemisphere facilitates the action of affected hemisphere and recommended the use of bilateral training in patients with stroke.[45] Kerr HM (2002) used force platform in seated forward bilateral reaching activity and found that centre of pressure is increased by 70 percent with foot support on a force plate.[46] Many studies have been done on standing balance using visual feedback and foot pressure but very few literatures available on dynamic sitting balance with VFT and upper limb reaching activity.[10,11,31] Furthermore some studies have found employing bilateral upper limb training and its effects on weight loading on the affected lower limb along with VFT, very few studies had long term intervention period, some of them were one time study, as well as the equipments or system used such as visual signals, Wii Fit Nintendo and 3D visual display unit used for VFT were very costly and can be only used in well structured personalized setup for balance training in stroke patients.[20,29,31,32] The purpose of the study is to find out the 4 week intervention of visual feedback training along with conventional therapy on sitting balance and upper limb reaching ability (unilateral Vs bilateral) compared to conventional therapy in patients with stroke.

MATERIAL AND METHOD

Permission from the head of Institution and approval from institutional ethical committee was taken. An institutional based experimental (randomized controlled trial) was undertaken on 40 participants known case of stroke who meets the inclusion criteria were briefed about the study and written consent was taken. Demographic data such as (name, age, gender, height, weight, BMI, dominance, time since stroke, paretic side, lesion type,) was documented. Participant diagnosed with first episode of stroke with hemiplegia/hemiparesis and confirmed by neurologist/Computed Tomography/ Magnetic resonance Imaging [14,27,40] individuals willing to participate, able to understand and follow simple instructions in the study. (MMSE>24) [7,11,25,31], age (25-65 years) both male and female[27,32], subjects diagnosed with first episode of stroke with hemiplegia [7,14,15], sub-acute or chronic stroke (> 3 months) [26,29], subjects able to sit independently for 20 minutes[7], subjects with trunk impairment score >7[10] were included for study whereas any history of second episode of stroke[14],Individuals with cognitive dysfunction and communication disorder[28,42], Individuals with other neurological disorder and perceptual disorder[10,14,22], No orthopedic problem that would interfere with the ability to perform seated reaching activity[7,14] were excluded form study. Any participant who cannot tolerate the treatment sessions or who are not completing the four weeks sessions (loss to follow up) were withdrawal from study.

Participant was randomly allocated in 2 groups: randomization proposed was chit method randomization (two Groups group A-experimental group, group-B control group). Allocation concealment proposed was block randomization. Blinding proposed was single blinded i.e. (Participants were unaware about the group allocation but only examiner was aware about allocation). Group A experimental group visual feedback training along with conventional therapy & Group B (conventional therapy group with mirror feedback). Pre intervention outcome measures trunk impairment scale, modified functional (forward) reach test (Figure 1 and 2) and bilateral reach (Figure 3 and 4) and foot pressure was assessed on force platform (Figure 5 and 6) and was documented for both the groups. Participant in both the groups had followed regular institutional rehabilitation protocol. Conventional therapy protocol included strengthening, stretching, coordination (upper limb and lower limb), postural training, lower limb exercises, and gait training lower limb weight bearing exercises for 30 minutes. Participants from the experimental group received 20 minutes of extra training with visual feedback 5 times per week for 4 weeks; in total 7 hours of additional training was given.

Procedure

Group A (Experimental Visual Feedback Training)

Individuals had participated in visual feedback training program, with machine which was kept on the wooden table in front of the subjects at the xiphi-sternum level. Upper limb reach task was done on unsupported sitting with height adjustable stool. The protocol was performed in accordance with the regular conventional therapy session in which the individuals were already participated. Visual feedback training was given with the help of NEUROBICS ARM/LEG REACH TASK EXERCISER [47] (Figure 7 and 8) In this group, participants reached the specific target given by the machine, (machine targeted reaching activity) which glowed as light when patient attempted to correct the given reach task. As soon as the participant had achieved the reach task on given machine, the light turned off, as it had light sensors and the beep sound indicated the completion of task. Targets appeared on programmed set mode machine plate (exercise-1 Random Manual, exercise 2- Random Automatic, exercise-3 Sequential Mode). These three exerciser modes were used for the intervention. Total 15 attempts were there in each mode. 6 sets of 15 attempts were given per day for 4 weeks to the participant for unilateral and bilateral upper limb reach activity. (3 set for unilateral upper limb reach and 3 set for bilateral upper limb reach). Speed of the machine reach target (i.e. timing between the two bulb glows) varied from slow, medium and fast i.e. (Slow-18 seconds, Medium- 12seconds, Fast- 6 seconds) respectively. To complete the given reach task in slow mode the participant required 270 sec i.e. 4.5 minute, in medium mode time required was180 sec i.e. 3 minutes and in fast mode time required was 90 seconds i.e. 1.5 minute. In case the participant was not able to attempt the machine targeted reach in machine set time, then the timing went on increasing and it depended on participant's ability and the speed of reaching task activity was set. Participants were encouraged to attempt the entire targets in given mode depending on the participant reaching activity level. Initially the speed of the machine was set in slow mode for adaptation purpose of the patients. On the day 1, initially subjects were sensitized with the visual feedback machine for 1 set in manual mode. Gradually the speed was increased once the subject adapts the speed in the given mode the speed was gradually increased to medium then to fast. This was dependent on participant ability to complete the machine targeted reach. Subjects were encouraged to bear weight on the affected side while upper limb reaching activity both in unilateral and bilateral. Similarly, the subject had attended the entire light glowing targeted training in a given mode. Unilateral hand activity was performed with the subject unaffected hand, whereas bilateral hand activity was performed by asking subject to clasp both the hands firmly and then perform the reach activity. Visual feedback training was performed with unilateral hand for 10 minutes then with bilateral hand for 10 minutes in between 2 minutes of rest was given to the subjects to reduce fatigue level. Total exercise duration was of 20 minutes i.e. 10 minute dominant (single) hand activities and 10 minute bilateral hand activities. It was performed for 5 times per week for total duration of 4 weeks.

Group B (Conventional Therapy)

Figure 1: Starting Position of Modified Functional Reach Test
Figure 2: End Position of Modified Functional Reach Test

Individuals were participated in regular conventional therapy protocol which was strengthening, stretching, coordination exercises (upper limb and lower limb), postural training, lower limb exercises, gait training and lower limb weight bearing exercises. In addition to this protocol sitting balance training such as symmetrical weight distribution was encouraged through verbal and tactile cues (exercises in front of the mirror), therapist guided reaching task activity involving upper limb and exercises requiring trunk rotations, physio ball exercise and training of functional activities. Exercise duration was of 20 minutes in a day and it was performed for 5 times per week for total duration of 4 weeks.

After completing the therapy period of 1 month (4 weeks), upper limb reaching ability and weight bearing ability on the affected limb of all participant was examined by using the outcome measures (modified functional reach test, trunk impairment scale, foot pressure).

Figure 3: Start Position of Bilateral Reach

Figure 4: End Position of Bilateral Reach

Figure 5: Start Position of Bilateral Reach

Figure 6: End Position of Bilateral Reach

Figure 7: Reaching Task with Unilateral Modified Functional Upper Reach Training using NEUROBICS ARM/LEG REACH TASK EXERCISER [47]

Figure 8: Reaching Task with Bilateral Modified Functional Upper Reach Training using NEUROBICS ARM/LEG REACH TASK EXERCISER [47]

The post intervention data thus collected was analyzed statistically and comparison of both the groups (Group A and Group B) was done.

Data Analysis

Data was coded and entered in Microsoft Excel Worksheet. Statistical software STATA version 14.0 was used for data analysis. Data collected was entered into Microsoft Excel spreadsheet. Continuous variables were presented as Mean±SD. Categorical variables are expressed in frequency and percentages. Anthropometric parameters were compared between Experimental and Control group by performing independent t-test (paired t-test). Mean centre of foot pressure, MFRT and TIS Score were compared between pre and post test by performing paired t-test. Changes (effects) in centre of foot pressure, MFRT and TIS score after post test intervention between experimental and control group were compared by performing independent t-test. Chi-square test was used to compare categorical variables. P<0.05 was considered as statistical significance.

RESULT

The purpose of study was to include total 40 stroke participants of age 25-65years. Total 20 participants were in each, experimental and control group. Number of young age adults in experimental and control groups were 9 out of 40 stroke participants (i.e. 22.5%), whereas middle age adults were 18 out of 40 (i.e. 45%) and old age adults were 13 out of 40 (i.e. 32.5%).

Table 1: Distribution of study stroke participants according to age in years

Age in years	Experimental Group	Control Group
25 – 39 (young age adults)	5	4
40 -59 (middle age adults)	11	7
60-65 (old age adults)	4	9
Total (n=40)	**20**	**20**

Table 2: Distribution of Demographic Characteristics and duration of stroke of Both Experimental And Control Group

Parameter		Experimental Group		Control Group		t-value	*p*-value
		Mean	± SD	Mean	± SD		
Age (years)		49.30	11.55	53.50	12.12	1.12	0.2692,NS
Weight (Kgs)		63.50	5.49	67.30	5.74	2.13	0.0389, S
Height (cm)		171.95	7.90	171.70	9.30	0.09	0.9245,NS
BMI (Kg/m^2)		21.51	1.76	22.86	1.86	2.39	0.0216, S
Duration of Stroke-(in months)	Sub-acute(*n*=16, 8 in each group)	3.87	1.83	4.00	1.69	0.163	0.8727 NS
	Chronic(*n*=24, 12 in each group)	16.91	9.82	14.83	11.18	0.484	0.6325 NS

BMI- Body Mass Index, *n*= number of stroke participants in each group, NS- Non-significant (*p*-value >0.05), S- Significant (*p*-value <0.05)

Table 3: Distribution of participants according to dominance, paretic side and type of lesion in both experimental and control group

Category	Side / Type	Experimental group	Control group	*Chi* square value	*p* value
Dominance	Right	19	19		
	Left	01	01	0.00	1.000,NS
Paretic side	Right	8	8	0.00	1.000, NS
	Left	12	12		
Type of lesion	Hemorrhagic	6	5	0.125	0.723, NS
	Ischemic	14	15		

NS- Non-significant (*p*-value >0.05)

From table 2, the mean and standard deviation of the baseline demographic characteristics such as age, height weight, BMI and duration of stroke (i.e. 40 % stroke participants were sub-acute stroke whereas 60 % were chronic stroke participants) were present. It was observed that there was significant difference in both experimental group and control group for weight and BMI whereas for age, height and duration of stroke does not showed any significant difference between experimental and control group in both category of sub-acute and chronic stroke, which indicated that both the groups were comparable on the basis of duration of stroke.

From table 3, it was found that there was an equal distribution of dominance and paretic side in both experimental and control group. Total 60% of stroke participants were right side paretic and 40% were left side paretic in both the groups. Out of 40 stroke participants, number of hemorrhage participants were 11 which was (27.5%) whereas ischemic stroke participants were 29 i.e. 72.5%.

The mean COFP (%) post exercise in experimental and control group at rest (paretic left & right side) at unilateral and bilateral reach showed significant difference when compared to mean COFP pre exercise in experimental group at rest (paretic left & right side) at unilateral and bilateral reach. Percentage of weight bearing in paretic lower limb is (i.e. COFP %) increases in both control and experimental group of right and left stroke participants after 4 weeks of intervention compared to pre baseline parameters but experimental group showed slightly better improvement in unilateral and bilateral COFP when compared with control group.

Table 4: Comparison of Mean difference of Centre of foot pressure (in %) between pre and post exercise in both experimental & Control group as per paretic side (25 to 65 years).

Group	Paretic Side(*n*)	Position of foot	COFP Pre-test (%) ± SD	COFP Post-test (%) ± SD	t-value	p-value
Experimental (*n*=20)	Left (*n*=12)	At Rest	32.83 ±4.38	37.3 ± 5.05	8.23	<0.0001,HS
		At Unilateral Reach	33.95 ±4.30	38.24±4.96	8.13	<0.0001,HS
		At Bilateral Reach	34.84 ± 4.26	39.2 ± 4.97	7.38	<0.0001,HS
	Right (*n*=8)	At Rest	37.53 ± 3.36	42.1 ± 3.90	8.86	0.0002,HS
		At Unilateral Reach	38.55 ± 3.52	43.06±4.21	8.20	0.0001,HS
		At Bilateral Reach	39.33 ±4.59	44.13±4.34	7.66	0.0001,HS
Control (*n*=20)	Left (*n*=12)	At Rest	34.55 ± 4.38	37.92±4.74	9.93	<0.0001,HS
		At Unilateral Reach	35.65 ± 4.44	38.55±4.81	10.83	<0.0001,HS
		At Bilateral Reach	36.3 ± 4.54	39.28±4.93	7.35	<0.0001,HS
	Right (*n*=8)	At Rest	35.42 ± 6.22	40.17±5.58	4.80	0.0020,HS
		At Unilateral Reach	37.53 ± 5.70	41.48±5.63	4.24	0.0038,HS
		At Bilateral Reach	38.43 ± 5.44	43.23±6.07	4.24	0.0038,HS

COFP-centre of foot pressure, *n*= number of participants, HS- Highly significant (p <0.001)

Table 5: Comparison of difference between the mean values of COFP (in %) between experimental (VFT plus CT) and control group (only CT) in both left and right paretic side

Paretic Side		Experimental Group	Control Group	t-value	*p*-value
Left	At rest	4.46 ± 1.87	3.36 ± 1.17	1.72	0.0994,NS
	Unilateral	4.28 ± 1.82	3.00 ± 0.96	2.14	0.0436,S
	Bilateral	4.36 ± 2.04	2.98 ± 1.40	1.92	0.0667,NS
Right	At rest	4.57 ± 1.88	4.75 ± 2.79	0.14	0.8854,NS
	Unilateral	4.51 ± 1.55	3.95 ± 2.63	0.52	0.6111,NS
	Bilateral	4.8 ± 1.77	4.8 ± 3.19	0.00	1.0000,NS

VFT- Visual Feedback Training, CT- Conventional Training, NS- Non-significant (*p*-value >0.05), S- Significant (*p*-value <0.05)

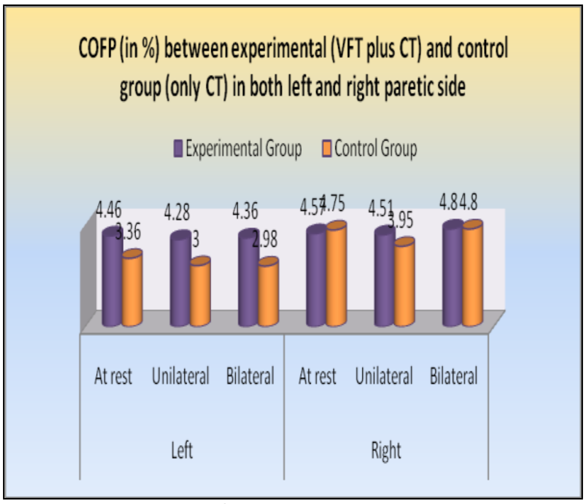

Figure 9: The Center of Foot Pressure-COFP (in %) between experimental (VFT plus CT) and control group (only CT) in both left and right paretic side

From table 5 and figure 9, the difference between the mean values of centre of foot pressure (in %) in both experimental & control group has improved significantly within the groups but not between the groups. The experimental group showed slightly greater values than control group at rest, at unilateral reach and at bilateral reach end positions. There was slight increment in percentage of COFP observed in unilateral as well as bilateral reach after 4 weeks of intervention in experimental group.

Table 6: Comparison of mean between unilateral and bilateral mFRT in pre exercise and post exercise scores in experimental and control group

Reach	Group	Pre test values (cm)	Post Test values (cm)	t-value	*p*-value
At Unilateral Reach	Experimental	27.23 ± 4.67	34.09 ± 3.83	14.64	0.0001,HS
	Control	26.82 ± 4.72	30.33 ± 4.47	15.19	0.0001,HS
At Bilateral Reach	Experimental	22.05 ± 5.46	27.92 ± 4.74	12.13	0.0001,HS
	Control	21.64 ± 4.88	25.24 ± 4.89	8.71	0.0001,HS

mFRT- Modified Functional Reach Test, HS - Highly Significant (p <0.001)

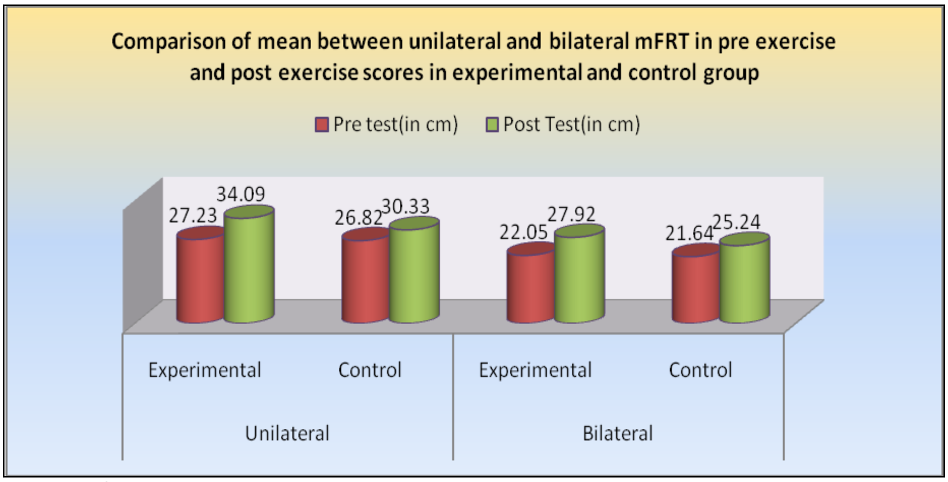

Figure 10: Comparison of mean between unilateral and bilateral mFRT in pre exercise and post exercise scores in experimental and control group

From table 6 and figure 10, it was observed that when compared unilateral and bilateral mFRT post-test values with pre-test values, there was highly significant increase observed in mean values of mFRT in both unilateral and bilateral reach in experimental and control group after 4 weeks of intervention.

From table 7 and figure 11, it was found that when compared with pre and post 4 weeks of intervention the mean difference between unilateral and bilateral reach showed highly significant difference in experimental and control group.

Table 7: Mean Difference of mFRT (in cm) between experimental and control group compared to pre and post test values.

Reach	Experimental group	Control group	t-value	*p*-value
At Unilateral Reach(cm)	6.85 ± 2.09	3.51 ± 1.03	6.40	<0.0001,HS
At Bilateral Reach(cm)	5.87 ± 2.16	3.60 ± 1.85	3.55	0.001,HS

HS:- Highly Significant (*p*-<0.0001), cm- centimeter

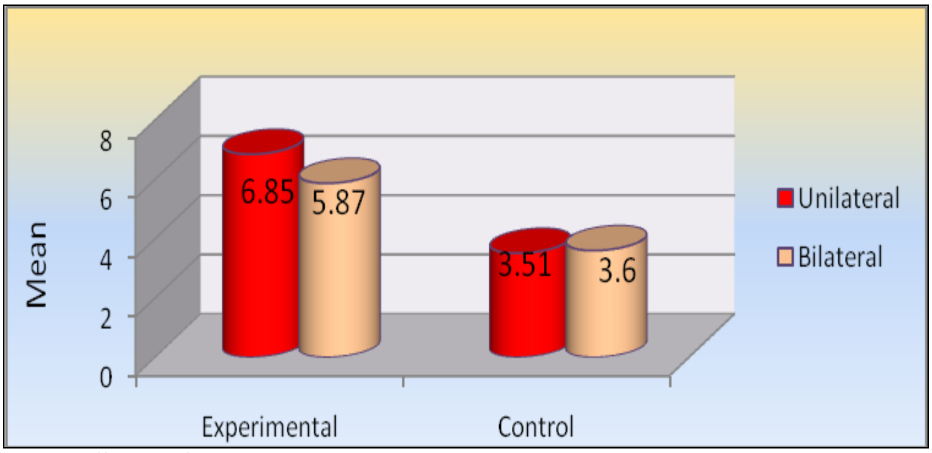

Figure 11: Mean Difference of mFRT (cm) between experimental and control group compared to pre and post test values

Table 8: The mean difference of TIS Score (out of 23) between pre and post exercise in experimental and control group

	Group	Pre test (Score) ± SD	Post test (Score) ± SD	t-value	p-value
TIS Score	Experimental	14.65 ± 2.36	16.35 ± 2.66	6.24	<0.0001,HS
	Control	14.25 ± 2.42	15.8 ± 2.66	5.61	<0.0001,HS

TIS-Trunk Impairment Scale, HS- Highly Significant (*p*-<0.0001)

From table 8 and figure 12, Mean difference of TIS score (i.e. pre test and post test difference values) in experimental and control group showed highly significant difference. The TIS scale score consist of 3 components static- 7, dynamic-10 whereas coordination score- 6 thus total scale score is 23.

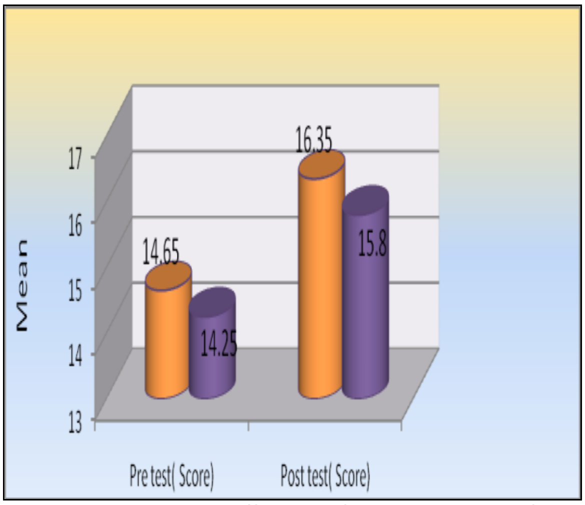

Figure 12: The mean difference of TIS Score (out of 23) between pre and post exercise in experimental and control group

Table 9: Comparison of effect of VFT plus CT on TIS Score between experimental and Control group

TIS score	Experimental Group		Control Group		t-value	p-value
	Mean	±SD	Mean	±SD		
	1.70	1.21	1.55	1.23	0.386	0.7011,NS

TIS- Trunk Impairment Scale, NS - Not Significant (*p*->0.05)

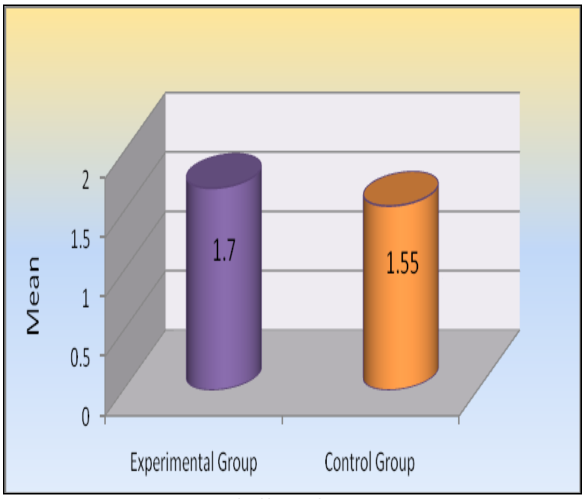

Figure 13: Comparison of effect of VFT plus CT on TIS Score between experimental and Control group

From table 9 and figure 13, there was no significant difference found between Experimental & Control group after 4 weeks of intervention in both left & right paretic side which indicated that both group showed improved trunk control after 4 weeks of intervention.

DISCUSSION

The present study was conducted to find out the effect of visual feedback training on dynamic sitting balance and upper limb reaching ability in patients with stroke of age between 25-65 age years. Total 40 stroke participants (20 in each group) were included in the study, and were equally distributed in both the experimental and control group. The demographic variables and stroke related parameters in both groups were comparable. (Table 1, 2 and 3) The experimental group received conventional therapy (CT) along with visual feedback training (VFT) and control group received conventional therapy alone (CT) for 4 weeks.

In present study assessment of mFRT (unilateral and bilateral), COFP and TIS were performed before and after 4 weeks of intervention. It was observed that all the three outcome measures showed improvement after 4 weeks of training within the experimental and control group whereas COFP and TIS had not shown statistical significant difference between the experimental and control group hence it can be concluded that both VFT along with CT and only CT are equally effective. In present study mFRT was used to assess dynamic sitting balance before and after 4 weeks of training with VFT in experimental group and without VFT in control group. The unilateral mFRT values were lesser in both the groups before intervention. The result showed that unilateral reach, in experimental group, had the increment of average 6.86 cm whereas in control group the average was 3.51 cm (table 7), thus it has observed that unilateral mFRT has increased two times the values of control group and showed highly significant difference in experimental group when compared with control group whereas previous clinical research[31] found that there was average increment of 2.76 cm in experimental group and 0.29 cm average increment observed in control group after 4 weeks of VFT. The values of mFRT in present study were supported by Priyanka Singh et al (2013)[48], who investigated the normative values of mFRT in younger and middle age individuals in Indian population, they reported the score of forward reach i.e.

unilateral reach as 38.05 ± 9.03 cm in 20-39 year of age and 25.18 ± 5.71cm in 40- 59 years of age. In present study mean modified forward reach distance values range within the normal limits for younger and middle age stroke participants in both experimental & control group after 4 weeks of intervention which is also in accordance to the study by Priyanka et al.[48]

Bilateral mFRT values are not available for particular age group of 25-65 years so there is no comparable data available. When compared with the pre-intervention values bilateral mFRT also showed highly significant difference in experimental group as well as in control group. In present study bilateral mFRT values had improved in experimental group with an average of 5.87 cm whereas in control group with average of 3.6 cm (table no. 7), which showed highly significant difference between the groups. Therefore from above findings it can be concluded that both unilateral and bilateral mFRT has showed significant improvement in within and between the experimental group and control group.[22] Better improvement in experimental group when compared with control group might be because of repetitive practice of, task-oriented training which results in motor relearning by enhancing skill in meaningful functional activities and is associated presumably with adaptive neuroplastic changes in the cerebral cortex, brainstem, cerebellum, and spinal cord.[49] Training must be specific to the functional task that an individual needs to perform in daily living furthermore vision has been a dominant form of external feedback and used as augmented form of motor learning in patients with senori-motor impairment.[48-52]

When the two upper limbs are performing identical actions there is activation in both hemispheres.[53] During bilateral isokinematic action when the pattern of one limb is disturbed the other limb tends to `recouple’ to the other’s disturbed pattern of action.[49] Study conducted by Mudie MH and Matyas TA[53] found that long-term stimulation of damaged part of brain involves simultaneous activation of a number of nerve fibers. When an axon of one cell is repeatedly or persistently involved in the firing of another cell some growth process or metabolic change takes place in one or both cells so that the efficacy of the axon firing on the other cell is increased. However this can be a reason for using bilateral reach in present study as it activates the cortico-motor neuron pool. [53]

In present study, the average percentage (%) of Centre of Foot Pressure (COFP) of left paretic side, at rest, at unilateral reach and at bilateral reach had improvement rate of 13.58%, 12.60% and 12.51% in experimental group whereas in control group it showed improvement rate of 9.72%. 8.41%, 8.20% respectively the COFP of right paretic side showed the improvement rate of 12.17 % at rest, 11.69% at unilateral modified functional reach and 12.20% at bilateral modified functional reach in experimental group whereas the control group showed the improvement of 13.41% at rest, 10.54% at unilateral reach and 12.49% at bilateral mFRT reach (table 5). Thus the present study findings suggest that there was significant improvement observed in experimental when compared with control group of left paretic side whereas equal improvements is seen in right paretic side in both experimental and control group.

On paretic lower limb, the percentage of COFP at pre test positions was maximal during bilateral mFR followed by unilateral mFR and least at rest in sitting position. Furthermore after 4 weeks of intervention, the difference in increment of percentage in COFP, at rest was maximum when compared to unilateral as well as bilateral mFR, however when person reaches forward with bilateral upper extremity in sitting showed greater difference in increase of percentage in COFP compared to unilateral mFR. This sequence of finding is followed in both experimental and control group in left as well as right paretic lower limb. In addition to the above findings it is observed that (table 4 and 5) reaching forward with bilateral mFR using VFT, significantly increases (12.51%) the weight loading percentage on paretic lower limb in (both right and left) experimental group. Reaching forward for objects in sitting position requires coordination between upper limb movements and active participation of lower limb and trunk to maintain dynamic sitting balance.[7,54] Peak vertical ground reaction force through the feet occurs normally around the end of the reach[7] thus in early phase of rehabilitation improvement in loading of paretic side while seated reaching task also improves functional activity through increase in force production of paretic lower limb.[7] In the present study it was observed that when bilateral reach values increases, the weight bearing ability of paretic lower limb also increases. It was supported by a study done on 12 healthy older adults using COFP and reaching forward with bilateral hand found that weight loading increases on lower limb when compared to resting position of foot in sitting and also stated that COFP is effective mean for assessing the dynamic sitting balance in patients with neurological deficit.[46]

However, several studies showed the improvement on increase in weight loading ability through visual feedback and auditory cueing interventions[28-32]in stroke patients but the disadvantage was that they have used an expensive software and exerciser games to assess functional outcome measures as well training was given on force platform to observe its effect, whereas in the present study force platform was only used to observe the effect of VFT training before and after the 4 weeks of intervention furthermore the machine used for VFT training (i.e. NEUROBICS ARM REACH TASK EXERCISER)[47] was easy to understand, easy to use, cost-effective, feasible and can be used in any of the neuro-rehabilitation setup. During study as a investigator it was observed that initially stroke participants were slow in reaching given target (delayed reaction time) also more attempts were required to complete the task, but it was also observed that after 2 or 3 sessions of VFT with (NEUROBICS ARM REACH TASK EXERCISER)[47] nearly all stroke participants showed faster response to reach and able to complete all targets within standard time. Trunk Impairment Scale score when evaluated showed significant mean difference in within the group i.e. experimental and control group.

The total TIS score was 23 (static-7, dynamic-10, and coordination-6)33 The dynamic and coordination components of TIS scale was evaluated before after 4 weeks of intervention, the static component of scale was already achieved by the stroke participants and was included in inclusion criteria. The pre and post mean difference of TIS score out of 23 in experimental group was 14.65±2.36 and 16.35±2.66 i.e. the mean difference of 1.70 was seen when compared to control group i.e. 14.25±2.42 to 15.8±2.66 which was 1.55, so the mean difference within the group showed significant improvement in experimental group than control group. However there was 0.15 mean difference found between the experimental and control group which was not statistically significant. The dynamic component of TIS evaluates the selective lateral flexion of upper and lower part of the trunk, stability during selective trunk movements, appropriate shortening and lengthening of the trunk and eventual compensations while performing given task whereas the coordination evaluates the mobility over stability task which requires counter rotation between upper and lower trunk[33,39,40]furthermore the better weight shift ability towards the paretic side is essential for coordination of trunk specially lower trunk.[15]

Stroke patients tend to avoid shifting their centre of pressure towards the hemiplegic side in sitting and standing. [10] Awareness of trunk position could improve weight symmetry in sitting after early phase of stroke.[15] The components involved in assessing TIS was not included in the seated reaching task thus in the present study this could be the probable reason for the improvement seen in within the group but not between the experimental and control group also 4 weeks of training might be not sufficient enough to show the changes in both experimental and control group for TIS. The result of the present study was in support with the previous study conducted by Lee SW (2015)[31] done on visual feedback on sitting balance their outcome measures were mFRT, postural sway and visual perception which showed significant improvement in all outcome measures after 4 weeks of visual feedback training, thus it can be said that 4 weeks of VFT training can show improvement in dynamic sitting balance, unilateral and bilateral reach in sitting and weight loading on paretic side and can be used as an adjuvant to conventional therapy.

Implications for Research and Clinical Practice

Bilateral modified functional reach (BmFRT) values were not available in literature, in order to compare the data of present age group of 25-65 years hence BmFRT values can be established in normal healthy individual to establish reference values in similar age group. Stroke participants who have impaired static and dynamic balance and reduced weight loading on paretic lower limb and impaired trunk control can have benefits from using NEUROBICS ARM REACH TASK EXERCISER [47] using visual feedback training; also it can be used as an adjuvant to conventional therapy in neuro-rehabilitation setup for various other conditions like traumatic brain injury and other brain impairment patients causing paralysis.

CONCLUSION

The VFT with the help of (NEUROBICS ARM REACH TASK EXERCISER)[47] is an effective tool for improving dynamic sitting balance, weight loading response on paretic side as well as improves the trunk control in 4 weeks of intervention in patients with stroke of age 25-65 years. It is a cost effective, easy to understand, easy to use and feasible method to use VFT in patient with neurological disorders.

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APPENDICES

1. **MODIFIED FUNCTIONAL REACH TEST (Forward)**[11,18, 21,22,38]

Technique:

Dynamic balance in the sitting position was measured using a modified version of functional reach test; this has excellent test-retest reliability in stroke population.[21]

A. **Unilateral Reach (with dominant hand):**[22, 38]

I. Participants were seated unsupported, the distance (measuring scale) was set at patients' acromion height and fixed on the adjustable height frame; patients were seated comfortably on a stool. The thigh was fully supported by the stool. Hip and feet were shoulder width apart.

II. The Participants hip joints and knee joints were flexed at 90°, the chair and popliteal area was 5 cm apart, and both the foot was in contact with the ground.

III. For forward direction, the shoulder joint was flexed at 90° with the elbow joint in maximum extension, so that the arm in line with the hand.

IV. The participants were asked to move his/her upper extremity and trunk forward as much as possible, and the distance from the starting position to the end position making a fist was measured. The third metacarpal was taken as a reference point on the standard scale.

V. Participants were not allowed to rotate their trunk, lift up their buttock and feet, and lean against the wall or hold onto surrounding objects for weight bearing. There were 3 testing trails.

VI. The difference between the starting position and maximally reached distance in centimeters was recorded. The average of three testing trails was documented for data analysis.

B. **Bilateral Reach:**

I. Participant were sitting unsupported, the distance (measuring scale) was set at patients' acromion height and fixed on the adjustable height frame; patients had to sit comfortably on a stool. The thigh was fully supported by the stool. Hip and feet were shoulder width apart.

II. The participant's hip joints and knee joints were flexed at 90°, the chair and popliteal area was 5 cm apart, and both the foot was in contact with the ground.

III. For forward direction, both the shoulder joint were flexed at 90° with the elbow joint in maximum extension, so that both the arm is in line with the hand.

IV. Participants were instructed to clasp both the hands together firmly, and instructed to move his/her upper extremity and trunk forward as much as possible without losing balance and the distance from the starting position to the ending position making a clasp hand. The third knuckle was used as a reference point on a standard scale.

V. Participants were not allowed to rotate their trunk, lift up their buttock and feet, lean against the wall or hold onto surrounding objects for weight bearing. There were 3 testing trails.

VI. The difference between the starting position and maximally reached distance in centimeter was recorded. The average of three testing trails was documented for data analysis.

2. **CENTRE OF FOOT PRESSURE** [8,10,28,29,30,31]

Technique

A. Foot pressure using force platform have proven a reliable measure in sitting activities.[9,18, 22]
B. A force platform was used to detect the foot pressure of participant in sitting position with barefoot.
C. This system is attached with a visual display which gives information regarding to weight distribution of lower limbs of foot in percentage in sitting at rest position and after forward reaching activity in participant with stroke.
D. This display encodes the performance of the participant.

A. At Rest:-

I. The starting sitting position was such that the thigh was in full contact with the adjustable height stool, feet and hip were width apart and placed flat on the force platform making a 90-90 hip and knee angle.
II. The hands were placed at the side of the body. Both feet were on same level to check the equal foot contact on the force plat form.
III. Head and body were in midline. Erect posture was asked to maintain.
IV. Eye level was fixed to an imaginary point in front on wall.
V. Readings were recorded on the visual display (monitor) in this static sitting position.

B. Forward Unilateral (dominant hand, centre of foot pressure) upper limb reach:-

I. Participants were instructed to sit erect and take the dominant hand forward maintaining a 90 degree of shoulder flexion asking to reach in forward direction as much as he/she can without losing the balance and maintaining the contact of the feet on the force plate.
II. Both the lower limbs were maintained at the same level while reaching forward with the dominant hand.
III. Readings were recorded on the visual display (monitor) in unilateral (dominant) forward reach in sitting position.

C. Forward bilateral (clasping both hands together, centre of foot pressure) upper limb reach:-

I. Participants were instructed to clasp the both the hands together firmly, asked to reach in forward direction as much as he/she can without losing balance and maintaining the contact of the feet from the force plate. Maintain the shoulder in 90 degree of flexion.
II. Also maintain both the lower extremity at the same level. Readings were recorded.
III. Readings were recorded on the visual display (monitor) in bilateral (clasping both hands) forward reach in sitting position.

3. **TRUNK IMPAIRMENT SCALE** [14, 33, 39, 40]

Technique

I. It is an objective clinical measurement tool for testing the quality of trunk performance in stroke patients. It has high test-retest reliability and constructs validity.
II. Test was done on sitting unsupported at the edge of treatment table.
III. Starting position: - Thigh was in full contact with the table; feet and hip were width apart and placed flat on the floor, Arm rest on legs, Head and trunk in midline position.
IV. This test has 3 components static, dynamic, trunk coordination. Out of which dynamic and trunk

coordination was assessed as static components were already achieved by the participants as given in the above mentioned inclusion criteria which scores (0-7) in trunk impairment scale score.

V. Dynamic component has 10 items and trunk coordination has 4 items, with total score of 7-16.
VI. The starting position for the each item was same as described above.
VII. Each item of the test was performed three times.
VIII. Higher score showed better trunk performance.
IX. No practice session was allowed for the participants.
X. The subjects were corrected between the attempts.
XI. The tests were verbally explained to the patient and were demonstrated if needed.
XII. Trunk impairment score was documented pre and post for data collection.

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