Effectiveness of Sit to Stand Exercise with Foot positions combined with Mirror Feedback In patients with Stroke

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ABSTRACT

Background : Stroke, the number one cause of neurological disability worldwide, is characterized by both cognitive and motor impairments, as well as balance impairment, which may lead to functional dependence and reduced quality of life. The sit-to-stand activity is one of the most commonly performed functional activity. Patients with stroke frequently exhibit severe asymmetry of weight distribution while rising to stand, with markedly higher weight bearing on the unaffected side There are insufficient trials that offered sit-to-stand training with visual feedback and different foot placements.

Objective: The aim of this study is to evaluate the benefits of Sit-to-Stand training with various foot positions paired with and without Visual feedback on Balance, Gait, STS Performance, and Quality of life in chronic stroke patients.

Methods: An experimental study design including 4 stroke patients was conducted. This study was conducted at NIEPMD(D), Chennai, India.4 stroke patients fulfilling the selection criteria were randomly assigned in two groups, Group A- Sit to Stand training with asymmetrical foot position (SVAF) and Visual feedback and Group B – Sit to Stand training with symmetrical foot positions

(SSF). Outcomes measured included Berg Balance scale (BBS),Timed Up and Go test(TUG) , Sit to stand performances(STS) and Stroke Specific Quality of Life Scale(SS-QOL).

Paired sample t test was used to examine the changes in outcome variables prior to and after interventions in each group. An Independent sample t test was used to analyze scores between two groups at the end of intervention after 4 weeks.

Result: Follow up assessment at the end of 4 weeks demonstrated a significant improvement in all four outcome measures in Group A than Group B.

Conclusion: These findings suggest that Chronic stroke patients would benefit from the rehabilitation program that includes Sit to Stand training with various foot positions paired with Visual feedback in improving Balance, Gait, STS performance and Quality of Life.

Key words: Stroke, Balance, Gait, Quality of life, Sit to stand performance

INTRODUCTION

Stroke is a rapidly developing clinical sign of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than of vascular origin – According to the World Health Organization (WHO).[1]

Stroke, the number one cause of neurological disability worldwide, is characterized by both cognitive and motor impairments, as well as balance impairment, which may lead to functional dependence and reduced quality of life. The severity of stroke depends on the location and extent of the region involved. The most typical symptom is hemiparesis of the body contralateral to the brain lesion, which causes muscle weakness in the upper and lower limbs and limited walking and balance. [2]

Lower extremity muscular weakness caused by neurological impairment following a stroke, as well as impaired balance, stiffness, and spasticity, make regular walking difficult.[3] Stroke patients also have issues with static equilibrium in sitting and standing postures. Furthermore, there may be an issue with dynamic balance, which is observed during activities such as shifting postures, resulting in diminished postural stability during static and dynamic standing, as well as impaired motor

capacity due to decreased functional activity. [4]

The inability to rise and stand freely after a stroke can impair independent function during activities of daily life. Patients with hemiplegia frequently exhibit severe asymmetry of weight distribution while rising to stand, with markedly higher weight bearing on the unaffected side [4]. Sit-to-stand (STS) and gait characteristics were substantially linked with rising speed and maximal vertical force of both legs during rising[5].Investigation on dynamic postural control in stroke patients discovered that these individuals tended to fall easily and that the chance of falling toward the paretic side was significant. [6] Standing balance is also critical in functional mobility following stroke. [7]

The sit-to-stand activity is one of the most commonly performed functional activities. Stand- up motion belongs to motions that support the weight as a fixed segment in the lower extremities, and an effective ability to stand up is essential for erect bipedalism. In particular, stroke patients show erratic movements, are slow in controlling their postures, and have weak muscles, which lead to a tendency to fall while standing up[8]. In other words, an asymmetrical exercise pattern appears because of the predominant use of the non-affected side and compensation, which compensates for the limited movements and weakening of the muscles of the affected lower limb by moving the central point of the body to the non-affected side [9]. Such compensatory movement in stroke patients leads to greater difficulties in motor control because of the inefficient joint motions during posture control. Therefore, it is essential to reduce the use of the non-affected side during movement for effective weight bearing.

A number of studies on effective intervention programs to treat the non-use of the affected side caused by the predominant use of the non-affected side in stroke patients have been conducted. Inducing movement of the affected side during sitting and standing by changing the position of the non-affected foot is a method that is used mainly by stroke patients to increase the weight support of the affected side [10]. [11] Standing up with the affected foot behind the non-affected foot reduced the asymmetry of weight bearing on thighs and feet of both sides, while standing up with the non-affected foot on the back of the affected foot increased asymmetry. [11]

Such intervention of sitting and standing by changing the position of the affected foot in stroke patients has been studied in various ways. Camargos et al. assessed the effects of changing the foot position in chronic stroke patients through sit-to-stand

activity on muscle activity and performance time[12] and Farqalit and Shahnawaz examined the effects of changing the foot position through sit-to-stand activity on the balance and upright mobility in chronic stroke patients. [13]

In clinical settings, Visual feedback is employed in a variety of methods to enhance the mobility of the afflicted side. Stroke patients are more dependent on visual feedback than other patients because they often place their feet in their visual field and move them in response to the movement of their surroundings [14]. By providing bilateral workouts through reflections in a mirror, visual feedback aids in the recovery of brain function in stroke patients [15]. In order to monitor the functional recovery of the upper limb following a four- week exercise therapy, [16] a mirror was used to provide visual feedback, and [17] reported positive results after continuously providing visual feedback during sitting balance training in stroke patients. [16,17] Cheng et al. examined the effects of visual feedback on weight transfer in stroke patients. [18] Mirror feedback in sit-to-stand exercise helps in building confidence of the Patients, know the movement of his own body parts, maintain and improve mobility and independence and can develop a strong stabilization of trunk and posture

METHODS

Study Design

This pretest-posttest experimental study design was conducted at National Institute for Empowerment of Person with Multiple Disabilities in Chennai, India between June 2022 and August 2022. The period of Intervention and the data collection was 4 weeks for both the groups.

Subjects:

Patients diagnosed with Stroke and came to NIEPMD for treatment were enrolled in this study. A total of six patients were assessed for eligibility. The Inclusion Criteria were Chronic stroke >6 months, Brunnstrom stage IV-V ,able to walk 10 m independently and without aid, able to rise from a chair without the use of the hands, Modified Ashworth Scale (MAS) score of below grade 2 and a Mini Mental State Examination (MMSE) score of 24 or higher. The Exclusion Criteria were those having neurological disorders, severe aphasia, apraxia or visuospatial disorder,

moderate to severe spasticity, musculoskeletal disorder to lower limb, unstable medical condition such as severe hypertension and convulsion, limb fracture, whose heels do not touch the floor when sitting on the affected side

Two patients did not satisfy the inclusion criteria. Hence, a total of 4 patients with chronic stroke took part in the study and they signed a con sent form approved by the Institutional review boardof College of Physiotherapy, NIEPMD(D) ,Chennai, India.

All participating subjects underwent a routine history and physical examination to rule out red flags to participate in this study.

Outcomes:

Balance Ability:

The Berg balance scale (BBS) is used widely to measure the balance ability of stroke patients. The scale consists of 14 items with a total score of 56 points on sitting in an upright position without leaning on the back of a chair, sitting in a standing position, and standing without support with both eyes closed. The items are scored from 0 to 4, with a score of 0 representing an inability to complete the task and a score of 4 representing independent item completion. Scores of 0-20 represent balance impairment, 21-40 represent acceptable balance, and 41-56 represent good balance. The BBS measures both static and dynamic aspects of balance. [19]

Gait:

TUG was used to measure the walking ability.

Time Up and Go (TUG) is a test that can measure functional mobility, mobility, and balance in a short time. After sitting in a chair with an armrest height of 46cm, it measured the time from standing up with the experimenter's starting signal, walking a distance of 3m, returning,and sitting back on the chair.

Sit to Stand Performance:

Sit-to-stand (STS) performance is often used as a measure of lower-limb strength and those weakness. However, the findings of recent studies suggest that performance in this test is also influenced by factors associated with balance and mobility.[20] In the STS test, participants stood up and sat down on a chair as many times as possible in 3minutes and the number of repetitions was recorded.

Quality of Life:

The Stroke Specific Quality Of Life Scale (SS-QOL), which is a disease-specific quality of life measure, consists of 49 items encompassing 12 domains, which include the social role (five questions), mobility (six questions), energy (three questions), language (five questions), self-care (five questions), mood (five questions), personality (three questions), thinking (three questions), upper extremity function (five questions), family role (three questions), vision (three questions), and work/productivity (three questions). Each item is ranked on a five-point Likert scale in which level one means completely agreed while level five means completely disagree. The summary score of this scale is an un-weighted average of the 12 domains. The total score ranges from 49 to 245, with higher scores indicating a better quality of life. [21]

Randomization

All the patients who met the inclusion criteria has been selected and randomly assigned to two groups 2 to group A and 2 to group B to undergo sit to stand training after a baseline evaluation.

Interventions

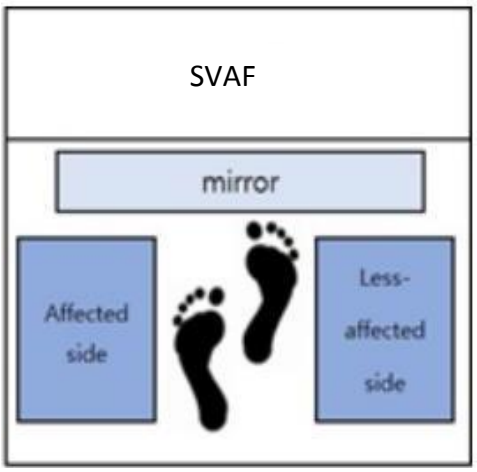
All the interventions were given by same therapist to ensure consistency between groups. Both groups received a supervised exercise program including stretching

exercise, strengthening of lowerextremity and upper extremity, balance training, and gait training, 5 days a week for 4 weeks.

In stretching exercises for tight musculature, each stretch was performed for three repetitions with a 30-second hold. Individual then participated in gait training for a maximum of 20 minutes on a motorized treadmill without elevation at a comfortable self-selected walking speed, 3 days a week for 4 weeks. Patients also participated in a strengthening program for upper extremity, lower extremity, and balance training. Strengthening exercises of upper extremity and lower extremity muscles were completed for three sets of 10 repetitions each following the Delorme regimen of progressive resistive exercise.[24] The rest period between repetitions and sets was 30 seconds and 60 seconds, respectively, and 5 minutes between exercises. Increases of 10% resistance were made gradually every week. [24] Balance training consisted of task-oriented training on a physio ball. While sitting on the physio ball, each participant reached forward, to the left and to the right, while trying to touch the therapist's hand. For forward reach, both hands were extended. For the left and right-side reach, reaching from one side to the other was counted as one repetition. Each task was performed in sets of five, consisting of 10 repetitions, with one minute rest between each set.

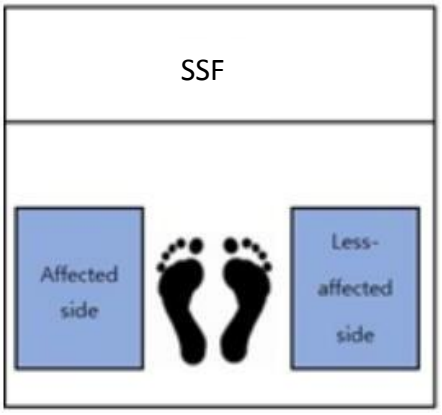
Group A: Sit-to-stand training with visual feedback and asymmetrical foot position(SVAF)

The participants in this group underwent Sit to stand training with affected foot dorsiflexed to 15 ° and placed backward at a distance corresponding to 50% of the subject's foot length from the foot on the non-affected side, and sit-to-stand training was performed in front of a full-length of mirror. The subjects stood up at a comfortable pace [22, 23]



Group B: Sit-to-stand training with symmetrical foot position (SSF)

In SSF, the chair height was adjusted to the knee height of the subject (distance between the greater trochanter and the lateral knee joint line) such that approximately half of the thighs were in contact with the chair. In a sitting position, affected foot was dorsiflexed at 15° and placed alongside the normal foot (symmetrical foot position). At this time, the subjects were asked to gaze at the front. The patient stood up at a comfortable pace with both feet 15-20 cm apart.



DATA ANALYSIS:

Statistical analysis:

Statistics were performed using the SPSS software 26 version. An independent sample t test was used to analyze the mean difference of STS performance, TUG, BBS and SS-QOL scores between the two groups at the end of intervention. Paired sample t test was used to examine the changes in outcome variables prior to and after the intervention in each group. The level ofsignificance was fixed at $p < 0.05$.

RESULT: The results of Paired sample t test and independent sample t test are described in the following table.

Table 1

Outcome measurements

Outcome	Group A (n=2)			Group B (n=2)			Between-group comparison	
	Pre-test	Post-test	Mean difference	Pre-test	Post-test	Mean difference	t	p
STS performance (repetitions)	99 (12.7)	127.5 (10.6)	28.5 (-2.1)	57 (4.2)	59 (1.4)	2 (-2.8)	9.053	0.012
TUG (s)	121 (4.2)	110.5 (0.7)	11 (2.09)	28.5 (9.19)	23(7.0)	-5 (-2.19)	4.890	0.039
BBS	41 (1.41)	52 (3.5)	11 (4.2)	30.5 (7.7)	36.5 (2.1)	6 (-5.6)	5.488	0.032
SS-QOL	184 (8.4)	230.5(0.7)	46.5 (-7.7)	109(15.5)	170 (14.14)	61 (-1.36)	6.042	0.026

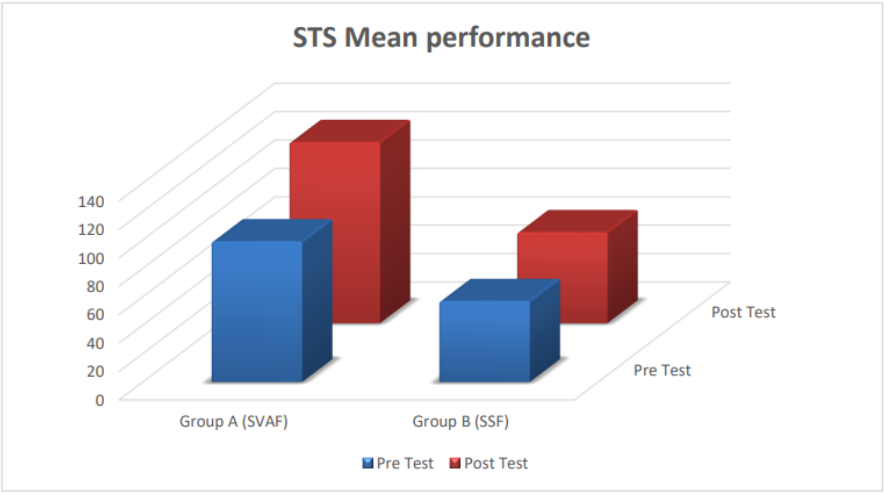
Data are presented as mean (standard deviation).

*Significant at $p < 0.05$ (independent t test).

BBS: Berg Balance Scale; STS: sit-to-stand; TUG: timed up-and-go test; SS-QOL: Stroke Specific Quality of Life.

Sit to stand performance:

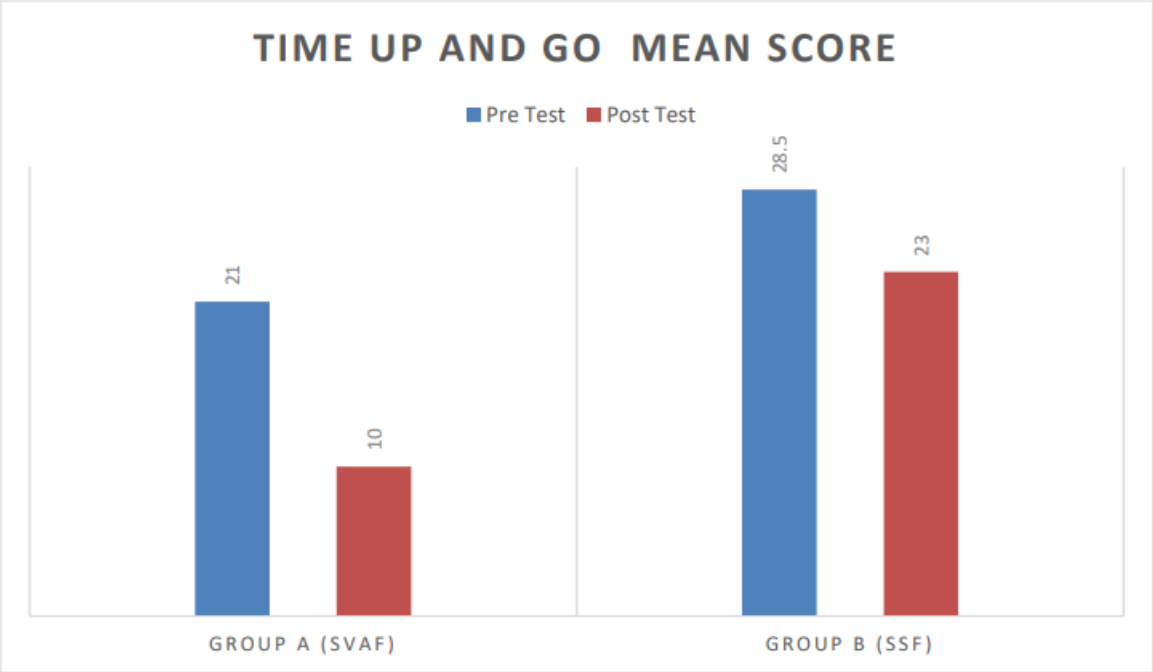
On comparing the STS performance between pre-test and post-test, a significant improvement was noted in both groups (p =0.012). The mean improvement in Groups A and B was 28.5 and 2 repetitions respectively. Between two group comparisons revealed that the mean improvement of STS performance was significantly more in Group A.



(SVAF: Sit-to-stand training with visual feedback and asymmetrical foot position, SSF: Sit-to-stand training with symmetrical foot position)

TUG Test:

Within-group comparison showed a significant improvement in TUG performance in both groups (p =0.039). The mean improvement in Group A was 11 seconds whereas that in Group B was reduced 5 seconds. Between-group comparison showed that the amount ofimprovement in TUG in Group A was significantly greater than that in Group B (p =0.039; Table 1)



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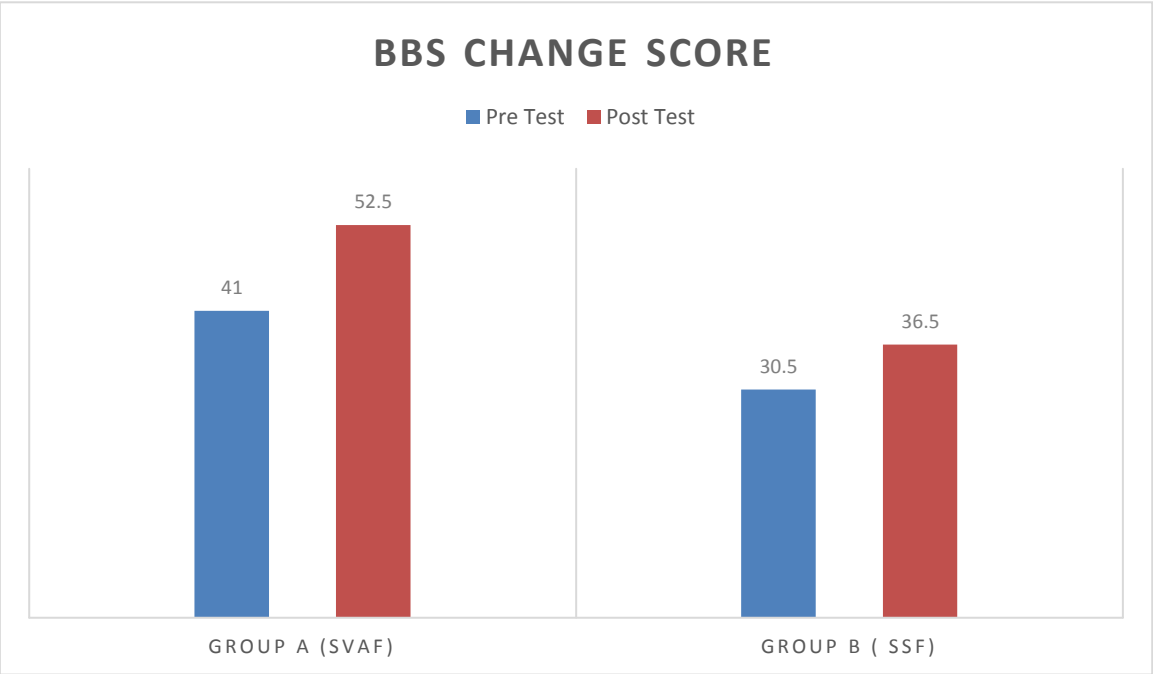
Berg Balance Scale:

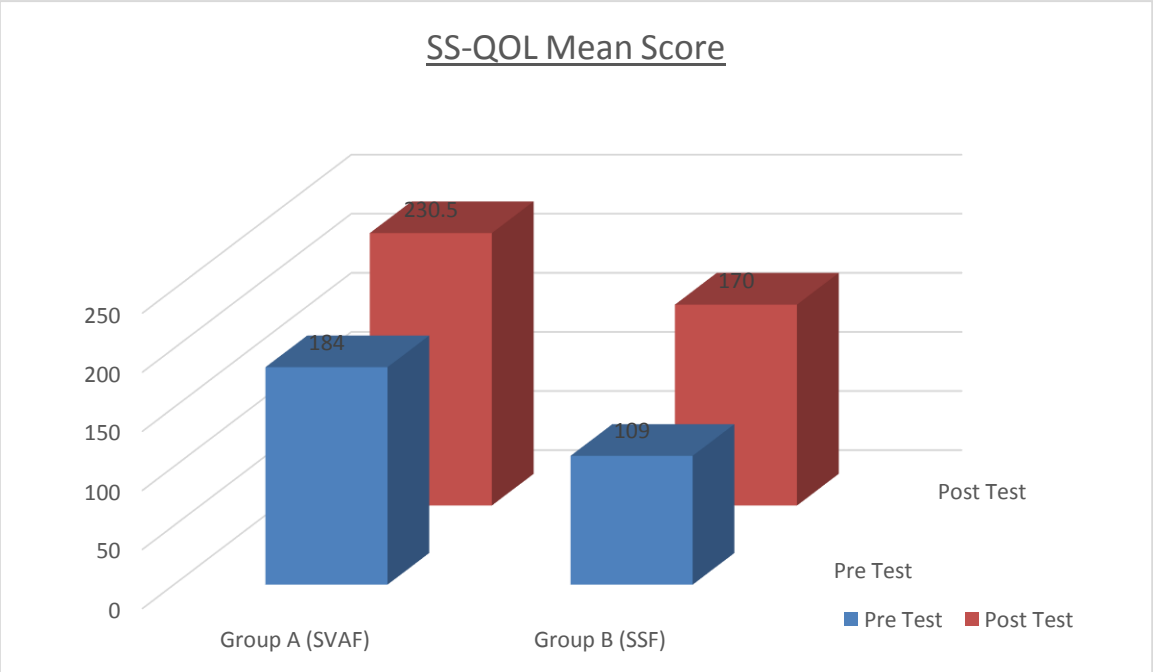
Significant improvement in BBS was noted in both groups after the intervention period ($p=0.032$). The mean improvement in BBS was 11 and 6 in Groups A and B, respectively. The mean improvement of BBS score in Group A was found to be significantly more than Group B.



(SVAF: Sit-to-stand training with visual feedback and asymmetrical foot position, SSF: Sit-to-stand training with symmetrical foot position)

Stroke Specific Quality of Life Scale:

The change in quality of life after training was compared between groups using covariance analysis to see whether there were any differences. The findings revealed variations in SS- QOL that were statistically significant. These findings show that the training programme in this study was successful since Group A's quality of life improved statistically significantly more than Group-Bs achieved (p=0.026).



(SVAF: Sit-to-stand training with visual feedback and asymmetrical foot position, SSF: Sit-to-stand training with symmetrical foot position)

DISCUSSION:

The goal of this study was to determine how the foot position during STS training affected individuals with chronic strokes' upright mobility and balance. Regardless of group assignment, the findings demonstrated that 4 weeks of STS training resulted in a considerable improvement in balance and upright mobility. This research alternate hypothesis was confirmed when, in comparison to the group with symmetrical foot placement, there was a substantially greater improvement in the group with asymmetrical foot position with mirror feedback (Group A) on all four end measures (STS performance, BBS, TUG, and SS-QOL).

The results of our investigation are in line with other studies that suggested that varied foot placements might influence STS performance. Prior to the initiation of the STS movement, Shepherd and Koh examined the influence of foot position (posterior, preferred, and anterior locations), and they found that a more posterior foot position resulted in a shorter movement time. [25] Hip flexion and hip flexion speed decreased with posterior foot location, but the pre-extension phase increased with anterior foot placement.[26] Kawagoe et al have also shown the importance of

posterior foot location. [27] Positioning the feet more posteriorly allowed for lower maximum mean extension moments at the hip (148.8 Nm vs. 32.7 Nm) to be employed for the STS movement.

Hughes et al identified repositioning of the feet as a movement method to reduce moments utilized in the STS movement, which they labelled a "stabilization strategy." [28] Furthermore, Lecourse et al and Duclos et al[30] observed that when the affected foot was positioned behind the unaffected foot, asymmetries of trunk position and mediolateral displacement of the center of pressure were significantly decreased. [29,30] Canning et al [31] showed that increasing the weight burden on the afflicted side's lower extremity is useful for function recovery, as asymmetrical weight bearing when standing is the major cause of falls in stroke patients. [31] Roy et al and Lecourse et al discovered that shifting the foot location and moving the paretic foot behind decreased weight-bearing asymmetry considerably. [32]

According to Ehrsson et al. utilizing a mirror to provide visual feedback is a cognitive strategy that can improve stroke patients' motor performance. [33] In particular, mirror-based therapies that give visual feedback as though the unaffected limb's movement reflected in the mirror is the affected limb's movement and support function are successful in stroke rehabilitation. [34] In the current study, employing a mirror to provide visual feedback during sit- to-stand training dramatically reduced asymmetry at all phases of standing.

CONCLUSION:

This study examined the effects of sit to stand exercise with foot positions combined with mirror feedback in patient with stroke on STS performance, balance, gait and quality of life of stroke patient. four stroke patients were assigned to two different groups, and the pre and post intervention results were compared and analyzed. The collected data suggested that on comparing the SVAF group to the SSF group, the SVAF group had overall improved function than SFF group. Therefore, when creating intervention program for stroke patients in the future, training regimens that include visual sensory inputs will be required for effective rehabilitation.

Limitations and Recommendations of study:

One significant weakness of the study is that the long-term impact of the STS training program was not evaluated. Another disadvantage of the study is the

absence of assessment of training intensity. This training may not be applicable to training of more seriously disabled persons who require additional manual support when completing STS. To establish the long- term impacts, additional study should include a longer training time with proper follow-up examinations. The current study did not control foot location since the space between feet was not maintained within and across individuals throughout time. The findings cannot be applied to acute stroke victims, whether acute stroke patients respond similarly to the two forms of STS training.

On the other hand, the number of subjects included in this study was small, which limits the generalization of the results to all patients with brain lesions. Therefore, systematic studies with more subjects and longer repetition of therapy will be necessary.

REFERENCES

1.Hatano S. Experience from a multicentre stroke register: a preliminary report. Bulletin ofthe World Health Organisation

2.Pathophysiology and Treatment of Stroke: Present Status and Future Perspectives

3.Pang M.Y., Eng J.J., Dawson A.S., McKay H.A., Harris J.E. A community-based fitness and mobility exercise program for older adults with chronic stroke: A randomized controlled trial. J. Am. Geriatr. Soc. 2005

4.Body weight-bearing while rising and sitting down in patients with stroke by M. Engardt and E. Olsen Scand J Rehabil Med, 24 (1992), pp. 66-74

5.Postural control during sit to stand and gait in stroke patients S.W. Chou,+4 , T.H. LinAm J Phys Med Rehab, 82 (2003), pp. 42-47

6.The sit-to-stand movement in stroke patients and its correlation with falling https://www.sciencedirect.com/science/article/abs/pii/S000399939890168X

7.Recovery of standing balance and functional mobility after strokehttps://www.sciencedirect.com/science/article/abs/pii/S0003999303008864

8.Carr JH, Shepherd RB. neurological Rehabilitation 2 edition, 2010.

9.Thielman G, Kaminski T, Gentile AM. Rehabilitation of reaching after stroke: Comparing 2 training protocols utilizing trunk restraint. Neurorehabil Neural Repair. 2008;22(6):697-705.

10.Gray CK, Culham E. Sit-to-Stand in People with Stroke: Effect of Lower Limb

Constraint-Induced Movement. Strategies Stroke Res Treat. 2014;681-3.

11.Roy G, nadeau S, Gravel D, et al. Side difference in the hip and knee joint moments during sit-to-stand and stand-to-sit tasks in individuals with hemiparesis. Clin Biomech (Bristol,Avon). 2007;22(7):795-804.

12.Camargos A, Rodrigues F, Teixeira F. The effects of foot position on the performance of the sit-to-stand movement with chronic stroke subjects. Arch Phys Med Rehabil. 2009;90(2):314-9

13.Farqalit R, Shahnawaz A. Effect of foot position during sit-to-stand training on balanceand upright mobility in patients with chronic stroke. Hong Kong Physiother J. 2013;31(2):75- 80.

14.Shin JB, Lee JS. The Effect of Visual Feedback on Postural Control During Sit-to-Stand Movements of BrainDamaged Patients Under Different Support Conditions. Phys Ther Korea, 2012;19(3):40-50.

15.Yavuzer G, Selles R, Sezer N, et al. Mirror therapy improves hand function in subacute stroke: a randomized controlled trial. Arch Phys Med Rehabil. 2008;89(3): 393-8.

16.Stevens JA, Stoykov ME. Using motor imagery in the rehabilitation of hemiparesis. Arch Phys Med Rehabil. 2003;84(7):1090-2

17.Pellegrino L, Giannoni P, Marinelli L, et al. Effects of continuous visual feedback during sitting balance training in chronic stroke survivors. J Neuroeng Rehabil. 2017; 1(1)4:107

18.Cheng PT, Chen CL, Wang CM, et al. Leg Muscle Activation Patterns of Sit-to-Stand Movement in Stroke Patients. Am J Phys Med Rehabil. 2004;83(1):10-6.

19.Berg K, Wood-Dauphinee S, Williams JI. The balance scale: Reliability assessment with elderly residents and patients with an acute stroke. Scand J Rehabil Med. 1995;27(1):27-36

20.The timed up & go test: its reliability and association with lower-limb impairments and locomotor capacities in people with chronic stroke S.S. Ng and C.W. Hui-Chan Arch Phys Med Rehabil, 86 (2005), pp. 1641-1647

21.Measuring balance in the elderly: validation of an instrument K.O. Berg, B. MakiCan J Public Health, 83 (Suppl. 2) (1992), pp. S7-11

22.Gray CK, Culham E. Sit-to-Stand in People with Stroke: Effect of Lower Limb Constraint-Induced Movement. Strategies Stroke Res Treat. 2014;681-3.

23.Ji S, Nam G, Kim M, et al. The Effect of Visual Feedback Training Using a Mirror

on the Balance in Hemiplegic Patients. J Korean Soc Phys Med. 2011;6(2):153-63.

24. Optimal resistance training: comparison of DeLorme with Oxford techniques D.E. Fis, B.J.DeLateur Am J Phys Med Rehabil, 92 (2003), pp. 903-90

25. http://refhub.elsevier.com/S1013-7025(13)00066-3/sref20

26.The effect of foot placement on sit to stand in healthy young subjects and patients withhemiplegiahttps://www.sciencedirect.com/science/article/pii/S000399930200002

27.Biomechanical analysis of effects of foot placement with varying chair height on the motionofstandinguphttps://www.sciencedirect.com/science/article/pii/S0949265815335156

28. M.A. Hughes,S.A. Studenski Clin Biomech, 9 (1994), pp. 187-192 http://refhub.elsevier.com/S1013-7025(13)00066-3/sref23

29.J. Lecours, L.F. Teixera-Salmela J Rehabil Med, 40 (2008), pp. 200-207 https://doi.org/10.2340/16501977-0155

30.https://journals.sagepub.com/doi/10.1177/1545968308316000C. Duclos, S. Nadeau and J. Lecours Neurorehabil Neural Repair, 22 (2008), pp. 715-722

31.Canning CG, Shepherd RB, Carr JH, et al. A randomized controlled trial of the effects of intensive sit-to-stand training after recent traumatic brain injury on sit-to-stand performance. Clin Rehabil. 2003;17(4):355-62.

32.https://www.sciencedirect.com/science/article/pii/S0268003306000283

33.Ehrsson HH, Spence C, Passingham RE. That's my hand! Activity in premotor cortex reflects feeling of ownership of a limb. Science. 2004;305(5685):875-7

34.Pellegrino L, Giannoni P, Marinelli L, et al. Effects of continuous visual feedback duringsitting balance training in chronic stroke survivors. J Neuroeng Rehabil. 2017; 1(1) 4:107.

35.Ju S, Yoo WG, Oh JS, et al. Effects of visual cue and cognitive motor tasks on standing postural control following a chronic stroke. J Phys Ther Sci. 2018;30(4): 601-4

36. O'Sullivan SB, Schmitz TJ. Stroke. In: Physical rehabilitation assessment and treatment.5th ed. Philadelphia: FA Davis;2007.