IJPTRS Vol 2(3) Julyl-August-September 2023 pp 26-38 E-ISSN 2583-4304

Effectiveness of Multisensory balance training versus Vision deprived balance training on balance and gait speed in stroke patients – A Comparative study.

URL: https://ijptrs.com/view-issue/104/Fulltext

DOI:https://ijptrs.com/public/images/content/191Rutuja.pdf

Dr. Rutuja Indapure1, Dr. Abhijit Satralkar2, Dr. Sucheta Golhar3.

1.MPT (neurosciences physiotherapy), 2.HOD, MPT neurophysiotherapy, 3. Principal, MPT musculoskeletal Physiotherapy, PES Modern college of physiotherapy, Pune, Maharashtra, India.
Corresponding author: Dr. Rutuja Indapure
Email: rutujaindapure@gmail.com

Submission: 24th August 2023

Revised: 4th September 2023

Publish: 14th September 2023

Table of content

ABSTRACT

Background: India has high Stroke prevalence. Stroke causes motor & sensory loss which contributes to balance & gait impairment. Multisensory exercises & Vision deprived training helps re-train sensory pathway & regain function. Many individual studies have been conducted but there is limited evidence on which training program is more effective. Thus, present study aimed at comparing 2 exercise protocol to find out which is more effective on balance & gait speed. **Material & methodology**: With ethical clearance & written consents,40 (aged 40-60 years), were selected & randomly assigned to 2 groups by chit method: Group A (evens)[multisensory training] & Group B(odds)[vision deprived training]. Pre & post (after 6 weeks) assessment done, for balance = Berg's balance scale & gait speed = 10 Meter walk test.

Group A→ 5 minutes = warm up, 30 minutes = multisensory balance training program

Group B→ 5 minutes = warm up, 30 minutes = vision deprived balance training.

Analysis→ within group = paired t test & between group = unpaired t test. **Result**: Within groups showed significant difference (p=0.00). On comparison, between groups showed no significant difference for balance (p= 0.85) & gait speed (p=0.94). **Discussion**: multisensory training activates the proprioceptive and somatosensory system. Vision deprivation causes compensatory plastic changes in the brain that is in the absence of one sensory system the other systems take charge to help the brain adjust to the changes. **Conclusion**: Both training program are equally effective on balance & gait speed in stroke patients.

Keywords: Balance, Gait speed, Multisensory training**,** Stroke, Vision Deprived Balance Training, Berg's balance scale

Introduction

In low- and middle-income countries like India, Stroke caused an estimated 5·7 million deaths in 2005. The number of global deaths is projected to rise to 6·5 million in 2015 and to 7·8 million in 2030 (Strong et al (2007), p. 182). Stroke is one of the leading cause of death and disability in India. The estimated adjusted prevalence rate of stroke range is 84-262/100,000 in rural and 334-424/ 100,000 in urban areas (Pandian & Sudhan, 2013, p. 128). The World health organization defines stroke as "rapidly developing clinical signs 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 origins"(Truelsen et al(2000), para. 1.1.1).

Stroke is characterized by sudden loss of neurological function caused by an interruption of blood flow to the brain. Changes in level of consciousness, sensory, motor, cognitive and perceptual impairments are seen post stroke. Motor defects are characterized by paralysis (hemiplegia) or weakness (hemiparesis) on the side of the body, opposite to the side of the lesion. Gait is altered post stroke. Balance is disturbed following stroke with impairments in alignment, stability, symmetry (O'Sullivan et al (2014)). Stroke hampers the quality of life of a patient. It is seen that about 40% of physical domain, 55% of psychological domain, 75% of social domain and 50% of environmental domains of health related quality of life was poor following stroke(Shetty et al(2016),p.10). It is seen that in stroke patients balance impairment is associated with lower quality of life (Schmid et al (2015),p.340).

Balance is the condition in which all the forces acting on the body are balanced such that the center of mass is within stability limits, the boundaries of the base of support. Stroke patients usually show uneven weight distribution and increased postural sway in standing(O'Sullivan et al (2014). Postural instability in hemiplegic patient is seen in both directions that is Antero-posterior& Medio-lateral (Corriveau et al, 2004,p.1099). This is due to disruption to the central sensory motor processing that lead to inability to recruit postural strategies and adapt postural movements to changing task and environmental demands (O'Sullivan et al (2014).

Grace Vincent et al (2018,p.3) found that there is 36.8% prevalence of balance impairment following stroke. Balance is a complex process which requires input from the somatosensory systems, visual, vestibular, and general exterosensibility, in order to generate a motor response allowing the transition between dynamic and static activities. Balance training is utilization and integration of these systems. Hence it is postulated that the balance training in stroke may be a useful exercise and may result in better out comes and improved function (Woollacott & Shumway-cook, 2001).

A study done by A. Middleton et al (2017,p.8) concluded that individuals with chronic stroke are already walking "at capacity" in the community and, as a result, are unable to increase their walking speed in response to environmental demands. The inability to increase walking speed on demand may limit these individuals' ability to be functional ambulators in the community. Balance is a significant contributor to the ability to increase walking in individuals with chronic stroke.

Gait is defined as the manner in which a person walks(eg. Cadence, step length, stride length, speed and rhythm (O'Sullivan et al (2014)). The hemiparetic gait shows decreased velocity and cadence and increased double limb support (Von Schroeder et al,1995,p.25).Walking is an incredibly complex task. A majority of the gait cycle is spent in single leg stance and during this phase, the center of mass is traveled outside the margin of stability, thus making this phase inherently unstable, Therefore, balance recovery is critical to having a stable and safe ambulation (Middleton et al,2017,p.6].Kara K Patterson et al (2008,p.304) found that 55.5% community dwelling stroke participants showed statistically significant temporal asymmetry and 33.3% exhibited statistically significant spatial asymmetry.

Multisensory stimulation approach is a therapeutic program that uses sensory stimulation and helps to recover functional sensibility in the affected area and learn adaptive functioning (Misha & Velmurugan,2017,p.369).
Multisensory teaching combines three learning senses, auditory (hearing and speaking), visual (seeing and perceiving), and kinesthetic (touch and movement (Nissee Neelima Raj et al,2016,p.558).
Nicola S et al (2008,p.318) concluded that physical therapy program focusing on balance rehabilitation in patients with chronic hemiplegia should include exercises performed in sensory challenging conditions. In a study conducted by Majeed kutty & Latheef Majida (2013,p.79) showed that multisensory balance training caused significant improvement in gait and balance in diabetic patients.

Conventional physiotherapy balance training exercises with masked vision is vision deprived balance training.
Compared to conventional physical therapy exercises, blindfold balance training, a sensory motor stimulation based on visual deprivation is able to modify gait parameters (Bonni et al ,2018,p.12.The results of the study conducted by Jibi Paul (2014,p.52) show that conventional therapy along with masked vision could bring about significant changes in balance, mobility and function of patients suffering from balance impairment post stroke .A study conducted by Bonan et al (2004) concludes that Vision overuse may be a compensatory strategy for coping with initial imbalance by traditional rehabilitation, hence vision deprived rehabilitation improves balance more effectively than balance with free vision. Masked vision enhances concentration through the somatosensory pathway towards promotion of balance through sensory re-education.
As previously conducted studies prove effect of individual training program on various parameters of balance and gait in stroke patients, this study aims to compare the effects of multisensory balance training and vision deprived balance training on balance and gait speed at the end of 6 weeks of intervention based on the following hypothesis:

- Null hypothesis(H0)- Both multisensory balance training and vision deprived balance training will be equally effective on balance and gait speed in stroke patients.
- Alternate hypothesis (H1) – Multi-sensory balance training is more effective than vision deprived balance

balance training on balance in stroke patients.

- H2- Multisensory balance training is more effective than vision deprived balance training on gait speed in stroke patients.
- H3-Vision deprived balance training is more effective than multisensory balance training on balance in stroke patients.
- H4- Vision deprived balance training is more effective than multisensory balance training on gait speed in stroke patients.

Materials & Method

This experimental study consisted of 2 active groups with total of 20 subjects in each group and was conducted in hospitals and rehabilitation centers, old age homes in and around the city, over a span of 6 weeks. The target population for the study were subjects diagnosed with stroke (>6months) (O'Sullivan et al (2014).
Selection criteria for the study was as follows:
Inclusion criteria:

1. Demographic characteristics = subjects with Age = 40 to 60 years(Tripathi & Vibha,2010), Gender=Both males and females were included.

2. Population= Presence of stroke for more than 6 months(O'Sullivan et al (2014)

3. Clinical characterisrics- Subjects able to walk 10 meters independently with or without assistive device (Flansbjer et al,2005), who had a Mini mental score >24(lee et al,2014) and Bergs

4. balance score < 40(O'Sullivan et al (2014) with intact Sensations were included.

Exclusion criteria:

1. Recent injuries- Patients having musculoskeletal or surgical problems of lower extremity which affect mobility. Eg. Recent (within 6 months) fractures, dislocations (Jibi Paul (2014)), were exluded.

2. Co-morbid conditions- Cardiovascular (uncontrolled high blood pressure, diabetes), respiratory problems like dyspnea (Kutty & Majida, 2013) were excluded.

3. Other neurological conditions- like brain tumor, demyelinating disease (Basheer KB et al, 2018) were excluded.

4. Other disorders: Subjects with auditory and vestibular disorders(Flansbjer et al,2005) were excluded.

Procedure:

The subjects who met the selection criteria were included in the study and were randomly divided in 2 groups using a random chit method, on the basis of patient's arrival. A written consent was obtained from the patient /guardian at the beginning of the study. All the subjects underwent a pre intervention testing for balance and gait speed followed by a 6 weeks training program. Post intervention test results for balance and gait speed in both groups was collected at the end of 6 weeks.

Intervention details:

Indian Journal of Physiotherapy and Rehabilitation Science

Group A consisted of 20 subjects who underwent multisensory balance training [MBT](Kutty & Majida (2013) . The exercise program consisted of:

1. Walking on firm surface (floor) - forward, backward and side walk
2. Walking on soft mattress - forward, backward and side walk
3. Walking on foam mattress - forward, backward and side walk
4. Challenges from obstacle
5. Unipedal stance on firm
6. Unipedal soft surface,
7. Double leg stance on firm surface,
8. Tandem standing on firm surface
9. Tandem walking on firm surface and
10. Rising from the chair without use of hands.

Exercise frequency: 3 times/ week, for 6 weeks (Kutty & Majida (2013).
Exercise duration: 30minutes per day (Grace Vincent et al (2018),

Photograph: Rising from the chair without use of hands

Group B consisted of 20 subjects who underwent Vision deprived balance training [VDBT] (Jibi Paul (2014)). A blindfold was used to mask the vision. The exercise program consisted of balance exercises with masked vision in different positions:

1.Supine position: bilateral bridging, unilateral bridging, side turning exercises

2.Sitting position: manual perturbations and chair sit to stand in sitting position;

3.Standing position: forward, backward and side walking.

Exercise frequency: 3 times/week for 6 weeks (Bonni et al ,2018).

Exercise duration: 30 minutes per day (Von Schroeder et al ,1995)

Progression: The exercises were progressed with additional 5 repetitions after every 2 weeks for 6 weeks (Jibi Paul (2014), as follows- 1-2 week=10 repetition, 2-4 week=10+5(=15) repetition, 4-6 week=15+5(=20) repetition.

Photograph: Bilateral bridging with masked vision

IJPTRS Vol 2(3) Julyl-August-September 2023 pp 26-38 E-ISSN 2583-4304

Outcome measures:

1. Berg's balance scale (berg at al,1992) was used for measuring balance. Administration: Instructions were given verbally, demonstrated and repeated to patients, performance was observed and noted. Interpretation: score below 45 indicates fall risk.
2. 10-meter walk test was used for measuring gait speed (Palmer,2015). Administration: The total marked distance was 14 meters and the subjects were timed over the middle 10 meters. Standing behind the first mark (0 meters), the subjects were instructed to walk to the last mark (14 meters) and were informed that they would be timed for middle part (from 2 meter – 12 meter) of the walkway. The subjects were told to walk at a self-selected comfortable pace ("like walking in the park") (shamay S.M.Ng et al,2012). Interpretation: The minimal detectable change in gait speed (at comfortable pace) is 0.15 meters/second in stroke (Tyson & Connell,2009)The collected data was analyzed using the statistical software IBM SPSS statistics 20.0

Results

In this study, no statistically significant difference was found on comparing the pre-post values of Berg's balance scale(BBS) (Table1) and 10 meter walk test(10MWT) (Table 2) in both groups. The analysis was done using unpaired t test in terms of mean ± SD. Level of significance was fixed at p=0.05 and any value less than or equal to 0.05 was considered to be statistically significant. This indicated that both the training programs had equal effect on balance and gait speed.

Table 1: Comparison of bergs balance scale values in terms of {Mean (SD)} among both groups using unpaired t test.

Group	Pre BBS (Mean± SD)	Post BBS (Mean± SD)	t value	p value	Results
Multisensory	36.25 ± 4.972	40.65 ± 5.8694	1.791	0.081	**Not significant**
Vision deprived	33.10 ± 6.905	37.65 ± 6.869			

(p > 0.05 = Not Significant)

IJPTRS Vol 2(3) Julyl-August-September 2023 pp 26-38 E-ISSN 2583-4304

Table 2: Comparison of 10-meter walk test values in terms of {Mean (SD)} among both groups using unpaired t test

Group	Pre 10MWT (gait speed) (m/sec) (Mean ±SD)	Post 10MWT (gait speed) (m/sec) (Mean ± SD)	t value	p value	Results
Multisensory	0.2530 ± 0.03028	0.2770 ± 0.03097	0.502	0.619	**Not significant**
Vision deprived	0.2585 ± 0.03856	0.2845 ± 0.04045	0.658	0.514	

(p > 0.05 = Not Significant)

However, the study found that within group comparison of individual training program showed statistically significant difference when analyzed using paired t test in terms of mean ± SD. Level of significance was fixed at p=0.05 and any value less than or equal to 0.05 was considered to be statistically significant.

In group A, pre-post values of Berg's balance scale (BBS) and 10 meter walk test(10MWT) show significant difference, indicating improvement in balance and gait speed post 6 weeks training with multisensory balance exercise program (Table 3).

Table 3: Within group comparison of bergs balance scale and 10MWT (pre–post) values in terms of {Mean (SD)} in group A (MBT) using paired t test

Variable	Pre (Mean± SD)	Post (Mean± SD)	t value	p value	Result
Bergs balance scale test	36.25 ± 4.972	42.25 ± 6.414	11.937	**0.000***	**Significant**
10-meter walk test	0.2530 ± 0.03028	0.2770 ± 0.03097	5.022	**0.000***	**Significant**

(p > 0.05 = Not Significant*)

Indian Journal of Physiotherapy and Rehabilitation Science

IJPTRS Vol 2(3) Julyl-August-September 2023 pp 26-38 E-ISSN 2583-4304

In group B pre-post values of Berg's balance scale(BBS) and 10 meter walk test(10MWT) show significant difference, indicating improvement in balance and gait speed post 6 weeks training with vision deprived balance exercise program (Table 4).

Table 4: Within group comparison of bergs balance scale and 10MWT values (pre-post) in terms of {Mean (SD)} in group B (VDBT) using paired t test

Variable	Pre (Mean± SD)	Post (Mean± SD)	t value	p value	Result
Bergs balance scale test	33.10 ± 6.095	37.65 ± 6.869	6.784	**0.000****	**Significant**
10-meter walk test	02585 ± 0.03856	0.2845 ± 0.04045	4.183	**0.00***	**Significant**

(p > 0.05 = Not Significant)

Discussion

The main objective of the study was to compare the effects of two different balance training exercises on balance and gait speed in stroke patients. Sensory information from somatosensory, visual and vestibular systems must be integrated to interpret complex sensory environments. As subjects change the sensory environment, they need to re-weight their relative dependence on each of the senses. (Horak,2006,p.ii9). the multisensory exercises and vision deprived exercise target the patients sensory system, thus making them prone to use the available sensory inputs to integrate a postural control response.

Postural control is a complex skill based on the interaction of dynamic sensorimotor processes. The two main functional goals ofpostural behaviour are postural orientation and postural equilibrium. Postural orientation involves the active alignment of the trunk and head with respect to gravity, support surfaces, the visual surround and internal references. Sensory information from somatosensory, vestibular and visual systems is integrated, and the relative weights placed on each of these inputs are dependent on the goals of the movement task and the environmental context. Postural equilibrium involves the coordination of movement strategies to stabilise the centre of body mass during both self-initiated and externally triggered disturbances of stability(Horak,2006,p.ii7).

In the present study, on comparing the multisensory exercise with vision deprived exercise we found that there was no significant difference seen between both the groups for balance (p =0851) and gait speed (p=0.948). We conclude that both the exercise regimen i.e multisensory balance training and vision deprived balance training were equally effective on balance and gait speed in stroke patients at the end of 6 weeks of intervention. Thus proving the null hypothesis (H0). This is in accordance with the study conducted by Alain. Y et al (2008) who concluded that there were significant differences seen in within group comparison of the balance and walking parameter, but on comparison no evidence was found for superiority of either of the exercises protocol on balance in stroke patients.

The present study was unsuccessful in providing a statistical significant results on comparing both the groups. The possible reason could be a small sample size that created less scope to get a combined effect. However, the present study was able to successfully conclude that the individual training program had a significant effect on balance and gait speed.

Based on the previous study that say, hemiplegic patients are dependent excessively on vision for balance and stability (Bonan et al (2004)), we made the hypothesis that vision deprived balance training can be effective in improving balance and gait speed in stroke patients. A study conducted by Jung-Hee Kim and Eun-Young Park (2013,p.4) states that balance has an effect on the activities of daily living and interventions that use balance training could be the most effective for improving activities of daily living in community-dwelling stroke patients. In this study we found out that within group comparisons of group A (multisensory balance training) and Group B (vision deprived balance training) for balance and gait speed in stroke patients were found to be significant at the end of 6 weeks of intervention.

The improvements in balance seen in the present study can be explained as , deficit of the central integration of sensory inputs (somatosensory, visual and kinesthetic) lead to balance impairment following stroke (Nicola S et al (2008,p.313), during the multisensory training various inputs through tandem standing , one leg stand and tandem walking activate the proprioceptive system and through use of different surfaces for walking (soft, foam and firm)activates the somatosensory system (Kutty & Majida, 2013,p.84). The vision deprived training will allow the individual to make use of the somatosensory and kinesthetic system more than vision to maintain balance. All this provides a challenging environment for the sensory system thus improving the outcome (Nicola S et al (2008,p.318).

Multisensory processes can not only improve learning and memory under 'normal' circumstances but also create opportunities for remediation in cases of sensory loss via their highly plastic and dynamic representational abilities (Murray et al,2016,vol.39,p577).

By training the different sensory systems separately and combined, the subjects learned to rely on the most appropriate sensory information and suppress those which are more undependable. In this manner, proprioceptive adaptation and sensory-motor coupling mechanism were stimulated(Kristinsdottir & Baldursdottir,2013,p.1215-1216)..

The results of the present study are is in accordance with the study conducted by

Indian Journal of Physiotherapy and Rehabilitation Science

IJPTRS Vol 2(3) Julyl-August-September 2023 pp 26-38 E-ISSN 2583-4304

Addie Middleton et al (2018) who proved that balance exercises are effective in improving walking speed in stroke patients. It is also seen that balance is a significant contributor to the ability to increase walking speed in individuals with chronic stroke (Middleton et al,2018). Improvement in balance correlates well with improvement in gait speed as concluded by bonan et al(2004). The results of this study are also in accordance with the study conducted by Kutty & Majida (2013) who proved that multisensory balance training is effective in improving balance.

The present study concludes that vision deprived balance training is effective in improving balance which is in accordance with the results of the study conducted by jibi paul (2014). This can be explained as proprioception and somatosensory pathway has been found to contribute to the vision deprived therapy to a great extent as stroke patients are disabled by the weakness persisting after stroke; deprived visual feedback promotes the use of affected side and prevents the compensatory over use adaptability (Basher K B et al,2018,p.4).

Vision deprivation causes compensatory plastic changes in the brain through cross modal reorganization i.e in the absence of one sensory system the other systems take charge to help the brain adjust to the changes (lazzouni & Lepore,2014).

Sustained severe perturbations of visual experience may induce functional and structural plastic changes. Thus, sensory experience shapes functional and structural brain organization (Noppeney,2007,p.1177) leading to enhanced motor learning.

This is supported by the results of the study conducted by Kim & Moon (2015) who concluded that, treadmill training with eyes close was found to be effective in improving balance and gait than the treadmill training with eyes open in stroke patients. Therefore, treadmill walking with visual deprivation may be useful for the rehabilitation of patients with chronic stroke.

The results of the study conducted by Sung Jun Moon et al (2012,p.411) provide an explanation for the present study by concluding that visual cue deprivation improves gait speed, step length, step time, functional ambulatory performance in stroke patients.

Thus we conclude that 6 weeks of multisensory balance training and vision deprived balance training protocols can be used as an effective tool in improving balance and gait speed and also enhancing motor learning in stroke patients.

Conclusion:

The study findings conclude that on comparison, both the balance training program were equally effective in improving balance and gait speed in stroke patients. However, the individual balance training program showed significant improvement in balance and gait speed in stroke patients. Hence, based on the study findings, it is recommended that systemic stimulation of sensory systems should be included in rehabilitation protocol to improve postural control for overall maintenance of balance and gait in stroke survivors.

Stroke has a lot of impact on activities of daily living and quality of life which in turn affect the balance and gait and overall wellbeing. Taking these factors into consideration in further research with a relatively bigger sample size would be helpful in better formation of an inclusive rehabilitation protocol.

Acknowledgement

I wish to express my sincere gratitude to the Principal, Dr. Sucheta Golhar and the ethical committee, my project guide, Dr. Abhijit Satralkar, for his precious time and guiding me to carry out my thesis successfully. I express my deepest gratitude to all the participants who put a lot of effort in fulfilling the physical demands of the exercise and for their active participation and cooperation and their valuable time. Without them this dissertation would have not been successful. I would like to take this opportunity to thank my parents and my colleagues who were there when needed.

Conflicts of Interest: Authors have no conflict of interest to declare.

References:

1. Berg KO, Maki BE, Williams JI, Holliday PJ, Wood-Dauphinee SL. (1992). Clinical and laboratory measures of postural balance in an elderly population. Archives of physical medicine and rehabilitation, 73(11), 1073–1080.

2. Bonan IV, Colle FM, Guichard JP, Vicaut E, Eisenfisz M, Huy PT, Yelnik, A. P. (2004). Reliance on visual information after stroke. Part I: Balance on dynamic posturography. Archives of physical medicine and rehabilitation, 85(2), 268–273.

3. Bonan IV, Yelnik AP, Colle FM, Michaud C, Normand E, Panigot B, Roth P, Guichard JP, Vicaut E. (2004). Reliance on visual information after stroke. Part II: Effectiveness of a balance

4. Rehabilitation program with visual cue deprivation after stroke: a randomized controlled trial. Archives of physical medicine and rehabilitation, 85(2), 274–278.

5. Bonnì S, Ponzo V, Tramontano M, Cinnera M, Caltagirone C, Koch G, Peppe A. (2018). Neurophysiological and clinical effects of blindfolded balance training (BBT) in Parkinson's disease patients: a preliminary study. European journal of physical and rehabilitation medicine, 55(2), 176–182.

6. Downs S., Marquez, J, & Chiarelli, P. (2013). The Berg Balance Scale has high intra- and inter-rater reliability but absolute reliability varies across the scale: a systematic review. Journal of physiotherapy, 59(2), 93–99.

7. Flansbjer, U. B., Holmbäck, A. M., Downham, D., Patten, C., & Lexell, J. (2005). Reliability of gait performance tests in men and women with hemiparesis after stroke. Journal of rehabilitation medicine, 37(2), 75–82.

8. Horak FB. (2006). Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls?. Age and ageing, 35 Suppl 2, ii7–ii11.

9. Kim, J. H., & Park, E. Y. (2014). Balance self-efficacy in relation to balance and activities of daily living in community residents with stroke. Disability and rehabilitation, 36(4), 295–299.

10.Kim, Y. W., & Moon, S. J. (2015). Effects of treadmill training with the eyes closed on gait and balance ability of chronic stroke patients. Journal of physical therapy science, 27(9), 2935–2938.

IJPTRS Vol 2(3) Julyl-August-September 2023 pp 26-38 E-ISSN 2583-4304

11. Kristinsdottir EK, Baldursdottir B. (2014). Effect of multi-sensory balance training for unsteady elderly people: pilot study of the "Reykjavik model". Disability and rehabilitation, 36(14), 1211–1218.

12. Kutty, N. A., & Majida, N. A. (2013). Effects of Multisensory Training on Balance and Gait in Persons with Type 2 Diabetes: A Randomised Controlled Trial. Disability, CBR & Inclusive Development, 24(2), 79–91.

13. Lazzouni, L., & Lepore, F. (2014). Compensatory plasticity: time matters. Frontiers in human neuroscience, 8, 340.

14. Lee, Y., Her, JG., Choi Y., Kim, H. (2014). Effect of Ankle-foot Orthosis on Lower Limb Muscle Activities and Static Balance of Stroke Patients Authors' Names. Journal of physical therapy science, 26(2), 179–182.

15. Middleton A., Braun C. H., Lewek MD., Fritz, SL. (2017). Balance impairment limits ability to increase walking speed in individuals with chronic stroke. Disability and rehabilitation, 39(5), 497–502.

16. Moon S., Kim Y., Kim, T. (2012). The Effects of Balance Training with Visual Cue Deprivation on Gait Function in Patients with Stroke. Journal of Korean society of physical medicine, 7(4), 411-421.

17. Murray MM., Lewkowicz DJ., Amedi A., Wallace MT. (2016). Multisensory Processes: A Balancing Act across the Lifespan. Trends in neurosciences, 39(8), 567–579.

18. Ng SS, Ng PC, Lee CY, Ng ES, Tong MH. (2012). Walkway lengths for measuring walking speed in stroke rehabilitation. Journal of rehabilitation medicine, 44(1), 43–46.

19. Noppeney U. (2007). The effects of visual deprivation on functional and structural organization of the human brain. Neuroscience and biobehavioral reviews, 31(8), 1169–1180.

20. O'Sullivan SB, Schmitz TJ, Fulk GD. (2014). Physical rehabilitation (6th ed.). F.A. Davis.

21. Palmer E, M atlick D, Council RO. (2015). 10 meter walk test. EBSCO: Cinhal information systems,10-15.

22. Pandian JD, Sudhan P. (2013). Stroke epidemiology and stroke care services in India. Journal of stroke, 15(3), 128–134.

23. Patterson KK, Parafianowicz I, Danells CJ, Closson V, Verrier MC,Staines WR, Black SE, McIlroy WE. (2008). Gait asymmetry in community-ambulating stroke survivors. Archives of physical medicine and rehabilitation, 89(2), 304–310.

24. Paul J, Balakrishnan P, Izham M. (2014). Comparative effect of vision deprived balance training over free vision balance training among stroke subjects. International Journal of Physiotherapy, 1(2), 46–53.

25. PM Misha, Velmurugan G. (2017). Effects of multisensory exercises on improving physical function and reducing number of falls in subjects with diabetic

neuropathy. International Journal Medical and Exercise Science, 03(03), 367–378.

26. Raj Y, Neelima N, Vadivelan K, Sivakumar VP. (2016). Comparison of Multisensory Versus Strengthening exercises on Functional Mobility and Balance in Elders. International Journal of Physiotherapy, 3(5), 507-511.

27. Riyas Basheer K B, Sukumar S, Deepu S Chandran, Purusotham chippala. (2015). Effects of unstable surface task oriented training and visual deprived balance training in hemiparetic individuals: A comparative study. Kerala, India.

28. Schmid AA., Van Puymbroeck M, Altenburger PA, Miller KK, Combs SA, Page SJ. (2013). Balance is associated with quality of life in chronic stroke. Topics in stroke rehabilitation, 20(4), 340–346.

29. Shetty S, Kundapur R. (2016). Quality Of Life in Stroke Patients - A Qualitative Study. Journal of Health and Allied Sciences, 06(04), 10–13.

30. Smania N, Picelli , Gandolfi M, Fiaschi A, Tinazzi M. (2008). Rehabilitation of sensorimotor integration deficits in balance impairment of patients with stroke hemiparesis: a before/after pilot study. Neurological sciences, 29(5), 313–319.

31. Strong K, Mathers C, Bonita R. (2007). Preventing stroke: saving lives around the world. The Lancet. Neurology, 6(2), 182–187.

32. Tripathi M., Vibha D. (2011). Stroke in young in India. Stroke research and treatment, 2011.

33. Truelsen T, Begg S, Mathers C. (2000). The Global Burden of Cerebrovascular Disease. World Health Organization.

34. Tyson S, Connell L. (2009). The psychometric properties and clinical utility of measures of walking and mobility in neurological conditions: a systematic review. Clinical rehabilitation, 23(11), 1018–1033.

35. Vincent-Onabajo G, Musa HY, Joseph E. (2018). Prevalence of Balance Impairment Among Stroke Survivors Undergoing Neurorehabilitation in Nigeria. Journal of stroke and Cerebrovascular diseases, 27(12), 3487–3492.

36. Von Schroeder HP, Coutts RD, Lyden PD, Billings E, Nickel VL. (1995). Gait parameters following stroke: a practical assessment. Journal of rehabilitation research and development,32, 25–31.

37. Woollacott M, Shumway-Cook A. (2002). Attention and the control of posture and gait: a review of an emerging area of research. Gait & posture, 16(1), 1–14.

38. Yelnik AP, Le Breton F, Colle FM, Bonan IV, Hugeron C, Egal V, Lebomin E, Regnaux JP, Pérennou D, Vicaut E. (2008). Rehabilitation of balance after stroke with multisensorial training: a single-blind randomized controlled study. Neurorehabilitation and neural repair, 22(5), 468–476.