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Effect of Visual Cueing on Dynamic Balance and Fall Risk among Subjects with Sub Acute Stroke: A Quasi Experimental Study

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Abstract

Background: Stroke is a leading cause of long term disability and is frequently associated with impaired dynamic balance, gait disturbances, and an increased risk of falls. Visual cueing has been proposed as an effective rehabilitation strategy to improve mobility and balance in subjects with sub acute stroke.

Objective: To determine the effects of visual cueing on dynamic balance and fall risk among subjects with sub acute stroke.

Methodology: A quasi-experimental study was conducted on 20 subjects with sub acute stroke. Participants were allocated into two groups Group A and Group B. Group A an experimental group (n=10) receiving visual cueing along with conventional physiotherapy and Group B a conventional group (n=10) receiving conventional physiotherapy alone. Dynamic balance and fall risk were assessed using Dynamic Gait Index (DGI) at baseline and after 4 weeks of intervention. Statistical analyses were performed to evaluate within-group and between-group differences.

Result: Both groups demonstrated improvement in Dynamic Gait Index (DGI) scores following the 4-week intervention period. However, the experimental group receiving visual cueing showed significant greater improvement compared to conventional group alone.

Conclusion: Visual Cueing is an effective intervention for improving dynamic balance and reducing fall risk among subjects with sub acute stroke. Incorporating visual cueing into stroke rehabilitation programs may enhance functional mobility and contribute to safer ambulation.

Keywords: Visual Cueing, Sub Acute Stroke, Dynamic Gait Index

Introduction

Stroke is defined as the rapid developing disturbance of cerebral function continues to be the significant global health concern, with disability and mortality rate. [1] The world health organization (WHO) defines stroke as the sudden onset of clinical signs indicating a focal (or global) disturbance in brain function, persisting for over 24 hours or resulting in death , with no clear cause other than a vascular one [2]. Stroke is leading to the second most cause for the death and disability worldwide. A Transient ischemic stroke (TIA) is characterized by a temporary episode of focal neurological impairment that does not result in lasting brain damage and lasts under 24 hours. [3] Stroke is a non-communicable disease with growing socio-economic significance in the aging populations. [4] Stroke is the main cause of adult neurological impairment and the most common cause of death worldwide. [5] Approximately 83% of survivors have impairment of balance, which is the common outcome of stroke. It produces asymmetries between the two sides of the body, reduced supporting time, and walking speed and increased risk of falls.[6] A stroke, or cerebrovascular accident (CVA), results in a sudden and specific neurological dysfunction, which occurs when an artery of the brain is either occluded by a clot or tears. The critical feature of this neurological dysfunction-occurring within seconds, minutes, hours, or a few days-characterizes the disorder as vascular.[7] Patients with transient ischemic attack have short periods of neurological dysfunction. Traditionally, the dysfunction was being defined as less than 24 hours, but it actually persists for only 10 to 30 minutes, and only occasionally for more than 1 hour. [8]

Types of stroke

Ischemic stroke - Infarcts are usually the result of an arterial blockage, which happen when blood flow is insufficient or interrupted to a part of the brain. An Ischemic stroke occurs when the blood supply to one or more areas of the brain is interrupted, is suddenly stopped or interrupted. The majority of ischemic strokes are caused by a blood clot or debris that plugs or blocks a brain artery, such as plaque, which is a mixture of fatty compounds, including cholesterol. The blood vessels that transport blood from the heart to the body and brain are known as arteries**.** [9]

Three diseases can result in blockages that cause ischemic stroke:

1. **Thrombosis: A** clot inside the brain blood artery that is unhealthy and gets big enough to stop blood blow.
2. **Embolism:** A clot that originates in another area of the body, like the heart or a sick artery in the neck or chest, travels to a smaller artery in the brain or neck.
3. **Stenosis:** Narrowing of an artery in the head or neck. The most frequent cause of Stenosis is an atherosclerosis, a disorder in which plaque deposits build up inside the arteries, thickening, hardening, and reducing elasticity of the artery walls.[9]

Hemorrhagic stroke: Artery supplying blood to the brain that ruptures and bleeds during a hemorrhagic stroke. The effect of bleeding from an artery inside the brain means that brain cells and tissues receive little or no oxygen or nourishment. Secondly, there is also pressure build-up in tissues around the affected area due to bleeding. Inflammation-swelling—all of which may add to existing brain damage. The most common reason for intra cerebral hemorrhage is high blood pressure. Bleeding occurs immediately. Undiagnosed hemorrhage may bring on coma or death. Meningeal hematoma is created by bleeding of the brain into the subarachnoid space. Aneurysms and Arteriovenous malformations, or AVMs, are the most typical causes of hemorrhage. These conditions can also be caused by traumatic events. [10]

Hemorrhagic stroke can be classified into several categories based on the location of the bleeding:

1. A subarachnoid hemorrhage occurs when an artery on the brain's surface bursts causing blood flow into area between the brain and the arachnoid layer, a tissue envelope.
2. An intracranial hemorrhage occurs when there is bleeding inside the brain.[11]

TIA: A transient ischemic attack, abbreviated as a TIA, is a temporary loss of blood flow to the brain. It invariably occurs because of a clot and resolves rapidly. The symptoms following a stroke are reversed once the obstruction is cleared. Damage due to TIA-related stroke is usually temporary and invisible during brain scans such as MRI. However, TIA stands out as an important diagnostic signal that a more significant stroke may follow shortly. A transient ischemic attack (TIA), commonly referred to as a "mini stroke often mistakenly termed mini-stroke, begins just like any stroke. The "impairments or symptoms will begin to resolve themselves, disappearing in under 20 minutes" and typically does so in an hour. One form of TIA causes intermittent loss of vision in one eye and is precipitated by carotid artery constriction. On the affected side, individuals "It is commonly described as if a shade descends over the eye. TIA Often, they indicate illness requiring sick individual attention in addition to a significant risk for a more catastrophic stroke. One in three TIA survivors will have a stroke at some point in time in the future, with most occurring in a year after the TIA. Many individuals misunderstand TIAs by disregarding them while they last for a few minutes. Then again, acting can save a life. As soon as symptoms appear to demonstrate, calling 911 may assist in avoiding permanent disability. [12]

Clinical features

Examples of anterior circulation are:

1. Weakness on one side of the body
2. Loss of sensation on one side of the body
3. Sudden loss of vision in one eye
4. Loss of vision in half of the visual field
5. Difficulty in speaking or understanding speech
6. Reduced attention to one side of the body

Posterior circulation symptoms involve:

1. Loss of balance and coordination
2. Double vision and abnormal eye movements
3. Numbness on the one side of face
4. Weakness of facial muscles
5. Difficulty in speaking and swallowing
6. Sensation of spinning or dizziness
7. Reduced ability to hear properly
8. Feeling of nausea and vomiting
9. Slurred or unclear speech due to poor muscle tone
10. Weakness affecting both sides of the body
11. Loss of sensation of the body
12. Loss of half of the field of vision in one or both eyes. [13]

The following are possible additional effects of stroke on the neurological system: [14]

Numbness: Numbness in parts of the body, usually on only one side, often accompanies a stroke.

Sensation: You may feel pain for extended periods or even for the first time for some activities that you may have practiced without any pain. You may feel that your body no longer interprets sensations such as warmth or cold as it should.

Vision: Problems may range from having trouble moving the eyes, difficulty with losing one or more sides of the vision, through to the total loss of eyesight. There may also be vision processing difficulties; this could imply that the eyes are sending incorrect data to the brain.

Foot Drop: Raising the front part of the leg becomes difficult if a person suffers from this very common weakness or paralysis. When a person walks, a Foot Drop can make the feet drag along the ground. To avoid this problem, the person can bend their knees to lift the leg a bit. A brace can also solve this problem.

Seizure: It is also true that having a stroke increases one's vulnerability to seizures. This often depends on the size, location, and severity of the cerebral infarction. In fact, after a hemorrhagic stroke, out of every 5 people, one may suffer from seizures. [14]

Medical management

Medical Management comprises techniques that are:

1. To sustain blood circulation & oxygenation
2. Support blood pressure.
3. ensure adequate cardiac output
4. Replace fluid and electrolyte loss
5. Seizures and infections
6. Control intracranial pressure and herniation [15]

Pharmacology management

1. Ant platelet therapy: Aspirin needs to be given to the patients in the first 48 hrs post acute ischemic stroke. Dose needs to be 300mg given immediately. Then 150mg once a day.
2. Clopidogrel is a strong anti platelet drug as well.
3. Anticoagulants: Anticoagulants like heparin should be administered to the patients, following the presumed ischemic or transient ischemic attack/stroke. Warfrain starts with heparin, the duration of time being 3 months.
4. Hypertensive/Antihypertensive medications: There exist several hypertensive medications that work alone or as mixtures.
5. Thrombolytic: IV Altepase is utilized in case of acute stroke. [16]

Visual cueing is a rehabilitative approach applied to facilitate motor performance and movement control by the provision of external visual stimuli. It supplies the individual with precise visual information about the timing, direction, amplitude, or sequence of movement, thus assisting in motor planning and execution. In neurologically impaired individuals, for instance, following a stroke, visual cueing plays an important compensatory role, supplementing impaired intrinsic feedback mechanisms such as proprioception and sensorimotor integration. By relying on visual input, patients are better able to understand task demands and make appropriate corrections in their movements in real time.

The visual cues were placed in a manner to facilitate the process of heel strike during the initial contact phase and enable the proper loading of the affected lower limb during the stance phase. The patients were instructed to look at their foot placement. This practice helped minimize compensatory movements and enabled a more normalized gait pattern. The repetitive practice of walking by visual guidance was emphasized. [17, 18]

Visual cueing as rehabilitation strategy has shown promising results in improving gait pattern in patients with neurological conditions such as chronic stroke or Parkinson's disease. Previous researches show that visual cueing helps patient to improve initiation, and rhythm. In sub acute stage of stroke person may show deficits in motor control and coordination. Therefore, as previous studies have been explored visual cueing have better results in neurological populations, more specific research on sub acute stroke population could fills gaps in literature.

2. Methodology

Study Design

The study design was quasi experimental in nature. The method of sorting the patient was using convenient sampling technique.

Protocol

The patients meeting the inclusion criteria were recruited for the study and were taken from Out Patient Department of Neurology, DAVIPTR and from its affiliated hospitals. After informing the patients the study's purpose, their written consent was obtained. The patients were distributed into two groups out of which Experimental Group A undergoes visual cueing training for 20 minutes per session, 3 days per week for 4 weeks, along with conventional training for 20 minutes per session, 5 days per week for 4 weeks. Group B (conventional group) undergoes only conventional physiotherapy for 40 minutes per session, 5 days per week for 4 weeks. Dynamic gait index was used as outcome measure, which was assessed at baseline (1st day) and after completion of the 4th week intervention period.

Group 'A' Intervention

Prior to the initiation of the intervention (as the baseline), Scores of Dynamic Gait Index (DGI) were carried out in accordance with standard measures. The eight tasks included in the Dynamic Gait Index had a maximum score of 24. When the patient carried out the eight tasks, his/her performance would then be recorded based on his/her completion of these eight tasks.
Patients assigned to the visual cue training group had their step length quantified with the boric powder technique. The boric powder was spreaded over the floor and the patient was asked to walk along a 10-meter walkway to leave foot prints along the way. Both the step lengths of the sound side and affected side of the patient were measured. The average value of the step lengths of the sound and affected side was obtained, and the summated value of the step lengths was taken as baseline step length for designing different visual cues.

Figure 1: Measurement of Step Length.

For visual Cue Training

For visual cue training, visual cues were made on the floor using the colored stripes. The stripes were 2.5 cm wide and 90 cm long, placed parallel to each other on a 10-meter walkway. The space between the lines will b e set to 110% which is the person's usual step length.

Over the course of 4 weeks, baseline step length will be increased gradually:

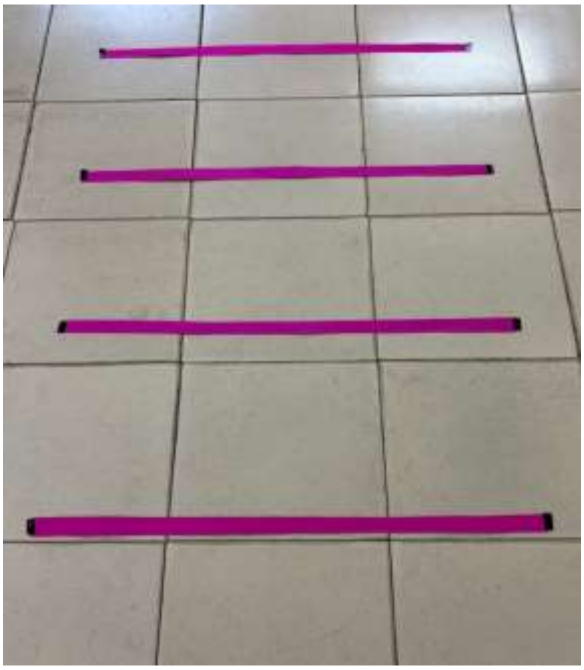
Week 1: 110% of baseline step length

Week 2: 120% of baseline step length

Week 3: 130% of baseline step length

Week 4: 140% of baseline step length

Figure 2: Visual Cues on the floor using colored strips



Training was conducted for 3 times per week and each session last for 20 minutes. The entire session period was for 4 weeks.

Along with visual cue training, patient undergoes conventional physiotherapy also that was for 20 minutes per session, 5 days per week for 4 weeks.

1. Step up – step down
2. Chair rises
3. Marching
4. Toe raises
5. Kicking a ball

After completion of intervention in the 4th week, re-testing of participants in the experimental group was carried out. The Dynamic Gait Index scores have been re-evaluated using similar standardized techniques employed during baseline evaluation. Results obtained during baseline assessment and in the 4th week have been recorded and used for statistical analysis to assess the impact of visual cue training along conventional training on the gait functioning.

Group 'B' Intervention

Prior to the initiation of the intervention (as the baseline), Scores of Dynamic Gait Index (DGI) were carried out in accordance with standard measures. The eight tasks included in the Dynamic Gait Index had a maximum score of 24. When the patient carried out the eight tasks, his/her performance would then be recorded based on his/her completion of these eight tasks.

After baseline measurements, the subjects in the conventional exercise group were only provided with conventional physiotherapy treatment as per the treatment protocol without the use of visual cues.

They received same conventional physiotherapy protocol as group A for 5 days / week for 4 weeks for 40 minutes. Exercises as followed:

1. Step up – step down
2. Chair rises
3. Marching
4. Toe raises
5. Kicking a ball

After completion of intervention in the 4th week, re-testing of participants in the conventional group was carried out. The Dynamic Gait Index scores have been re-evaluated using similar standardized techniques employed during baseline evaluation. Results obtained during baseline assessment and in the 4th week have been recorded and used for statistical analysis to assess the impact of conventional exercises on gait functioning.

3. Results

Data analysis was done by SPSS software version 18. This chapter gives out the explanation of the result of the study changing the raw data into useful information. To determine the effects of visual cueing on dynamic balance and fall risk among subjects with sub acute stroke was aim of investigation.

To test the difference between the groups, a test was applied. A significance of $p<0.05$ was applied. To illustrate the results of the current study, the data were arranged and analyzed as tables and graphs.

Within Group analysis (Paired t-test)

Table 3.1 Comparison of pre and post intervention measures in Experimental Group A

Paired T-Test	**Group A**	
	DGI SCORE	
Table No 3.1	BASELINE	4th week
Mean	12.80	19.20
S.D.	2.394	1.874
Number	10	10
Mean Difference	6.40	
Paired T Test	14.154	
P value	0.0000	
Table Value at 0.05	2.26	
Result	Significant	

This table shows the comparison of Dynamic Gait Index (DGI) scores within Group A between baseline and the 4th week. The mean DGI score increased from 12.80 (SD = 2.394) at baseline to 19.20 (SD =

1.874) at the 4th week. The mean difference was 6.40 with a paired t-value of 14.154 and a p-value of 0.0000. Since the p-value was less than 0.05, the improvement was statistically significant, indicating that visual cueing produced a marked improvement in dynamic balance among subjects in Group A.

Table 3.2 Within group comparison of DGI score in Group B (Paired t-test)

Paired T-Test	**Group B**	
	DGI SCORE	
Table No 3.2	BASELINE	4th week
Mean	12.10	12.90
S.D.	2.424	2.726
Number	10	10
Mean Difference	-0.80	
Paired T Test	3.207	
P value	0.0107	
Table Value at 0.05	2.26	
Result	Significant	

The table presents the comparison of DGI scores in Group B between baseline and the 4th week. The mean score improved slightly from 12.10 (SD = 2.424) to 12.90 (SD = 2.726). The paired t-value was 3.207 with a p-value of 0.0107, showing a statistically significant difference. Although improvement was observed, the magnitude of change was smaller compared to Group A.

Between Group Analyses (unpaired t-test)

Table 3.3 Between groups comparison of DGI score

Unpaired T-Test	**Comparison**			
	DGI SCORE			
	BASELINE		**4th week**	
	Group A	**Group B**	**Group A**	**Group B**
Mean	12.80	12.10	19.20	12.90
S.D.	2.394	2.424	1.874	2.726
Number	10	10	10	10
Mean Difference	0.70		6.30	
Unpaired T- Test	0.650		6.022	
P value	0.5241		0.0000	
Table Value at 0.05	2.10		2.10	
Result	Not-Significant		Significant	

This table compares DGI scores between Group A and Group B at baseline and at the 4th week. At baseline, the difference between groups was not statistically significant ($t = 0.650$, $p = 0.5241$), confirming group equivalence before intervention. However, at the 4th week, the t-value increased to 6.022 with a p-value of 0.0000, indicating a statistically significant difference favouring Group A, suggesting greater effectiveness of visual cueing on dynamic balance.

4. Discussion

Stroke, also known as cerebrovascular accident, is one of the leading causes of the long term disability worldwide. It entails rapid onset of clinical signs and symptoms indicating a loss of brain function due to vascular causes. The part of brain affected and the severity of the condition determine the long-term effects of the stroke. The most common symptoms include the body weakness or paralysis, speech problems, a reduction in physical capabilities and cognitive and perceptual issues. After six months, stroke patient's functional status improves, with the first month showing a rapid recovery. However, residual deficits in gait, balance, and functional mobility often persist, significantly affecting the independence and quality of life of patient.

The quintessential sign of stroke is that if curbs the functional independence of the patient. Impotence in bearing weight on the affected foot due to reduced proprioception and spatial sensation increases the chances of imbalance and fall. Walking disability is one of the most common and debilitating is one the most consequences of stroke, with a majority of stroke survivors demonstrating reduced walking speed, impaired dynamic balance, and an increased risk of falls. Restoration of walking ability is therefore one of the primary goals of stroke rehabilitation. Among the various rehabilitation strategies employed, visual cueing has emerged as an effective technique to improve gait parameters and dynamic balance in stroke. Visual cueing provides external rhythmic or spatial stimuli to help patient regulate their step length, cadence and overall gait pattern, thereby improving functional mobility and reducing fall risk.

The present study was conducted to evaluate the effect of visual cueing on dynamic balance and fall risk among subjects with sub acute stroke using a quasi experimental study design. A total of 20 subjects were equally divided into Group A (experimental group) and Group B (conventional group). The variable of the current study was Dynamic gait index (DGI) score. The Dynamic Gait Index is a well-established clinical tool used to assess the ability of an individual to modify gait in response to changing task demands and it is widely used to evaluate dynamic balance and fall risk in stroke patients. The outcome measure was assessed at baseline and at the end of 4^{th} week of intervention to determine the effect of visual cueing among the sub acute stroke subjects.

The findings of this study have shown significant improvement in dynamic gait index scores at the end of the intervention period of 4 weeks. At the baseline, there were no significant differences in the outcome measures between the experimental group (Group A) and the conventional group (Group B). The mean DGI score of Group A at baseline was 12.80 □ 2.394 and that of Group B was 12.10 □ 2.424, with mean difference of 0.70 and unpaired t-test value of 0.650 (p=0.5241), which was not significant at 0.05 level of significance ., thereby confirming complete group equivalence before the commencement of intervention.

Within the group analysis revealed statistically significant improvements in DGI scores in both groups from the baseline to the 4^{th} week. In experimental Group A, the mean DGI score increased from 12.80 □□2.394 at baseline to 19.20 □ 1.874 at the 4^{th} week, with a mean difference of 6.40 and paired t-test value of 14.154 (p=0.0000), which was highly significance. This substantial improvement in Group A clearly demonstrates that the addition of visual cueing to conventional physiotherapy produced a marked enhancement in dynamic balance and gait performance in sub acute stroke patients.

These findings were consistent with the study conducted by **Upadhyay and Verma (2022)** [19] who reported in a quasi experimental study on 38 chronic stroke patients that visual cue training combined with conventional training showed significantly greater improvements in DGI scores and walking velocity as compared to conventional training alone, with a mean difference of DGI in Group A and B of 1.94 □ 0.002 and 3.26 □ 0.41 respectively ($p<0.001$). Similarly, **Chouhan and Kumar (2012)** [20] conducted a randomized controlled trial comparing rhythmic auditory cueing and visual cueing in 45 patients with acute hemiparetic stroke and reported that both therapies were effective for gross motor , fine motor and gait imbalance in acute hemiparetic stroke, with a statistically significant difference found between groups A, and C and group B and C data ($p<0.05$) , thereby confirming that visual cueing combined with conventional treatment alone improving DGI scores. Furthermore, a meta-analysis by **Spaulding et al (2013)** [21] on cueing and gait improvement reported that visual cueing significantly improved gait parameters in neurological patients, further supporting the role of visual cueing in enhancing gait parameters.

In Group B the mean DGI score increased 12.10 □ 2.424 at baseline to 12.90 □ 2.726 at the 4th week, with a mean difference of 0.80 and paired t-test value of 3.207 ($p=0.0107$), which was also significant. However the magnitude of improvement was considerably higher in Group A as compared to Group B, indicating that visual cueing played crucial role in enhancing dynamic balance beyond what was achieved with conventional physiotherapy alone. This is further supported by between group comparisons at the 4th week, which is revealed a significant difference in DGI scores between Group A and Group B with mean difference of 6.30, unpaired t-test value of 6.022 and p-value of 0.0000, which is highly significant.

5. Future Scope

The findings of this study suggest that visual cueing training may be beneficial in improving dynamic balance and reducing fall risk. Future studies should be conducted with larger sample sizes and longer follow-up periods to confirm the effectiveness and long terms of visual cue interventions. Additionally, the effects of visual cueing on other gait and functional outcomes can be explored in different neurological populations.

6. Conclusion

The results of this study indicate that visual cueing training, when combined with conventional physiotherapy, is effective in improving dynamic balance and fall risk as measured by the Dynamic Gait Index (DGI). Subjects who received visual cueing demonstrated greater improvement in dynamic balance and gait-related functional mobility compared to those receiving conventional physiotherapy alone. Therefore, visual cueing can be considered simple, cost effective and clinically useful intervention for enhancing the gait performance and reducing the fall risk in individuals with neurological impairments.

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