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# A Study to Determine the Efficacy of Cognitive Sensory Motor Training on Bipedal Cartography in Patients with Stroke: A Pilot Study

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**Abstract**

**Background:** Stroke is rapidly developing clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin.

**Materials and Methods**: Study conducted in department of neurology at D.A.V.I.P.T.R for one and half year with a total of 20 patients, aged 45- 60 years in late sub- acute stage and chronic stage divided into 2 groups that is Group A and Group B. Group A as experimental group, received Cognitive Sensory Motor Training and Group B as control group, received conventional physiotherapy treatment, continued for a period of 7 weeks; 4 days per week for a minimum duration of 45-60 minutes for both the groups for 28 sessions. All participants were assessed at baseline and after 7$^{th}$ week for dynamic multiple and postural acquisition on force plate.

**Results:** CSMT group showed statistically significant improvement in plantar area, compared to control group whereas Centre of pressure deviation had statistically non-significant improvement in both CSMT group and control group.

**Conclusion:** This study proves that cognitive sensory motor training has significant impact on improving the plantar area of patients with stroke.

**Keywords:** Bipedal Cartography, Center of Pressure, Cognitive Sensory Motor Training

## INTRODUCTION

A stroke, formerly referred to as a cerebrovascular accident, involves the rapid onset of clinical signs and/or symptoms indicating a loss of brain function that is focal; in some cases, it can be more widespread, as seen in patients who are in deep comas or those suffering from subarachnoid hemorrhage.

These symptoms persist for over 24 hours or result in death, with no clear cause other than a vascular origin [1].

Despite of making major amelioration and amendments in primary management and treatment, low-and middle-income nations continue to face the greatest burden of illnesses, out of which stroke is the second most leading cause of death and disability worldwide. Stroke poses a staggering burden at the levels of body function and structures, activities and participation personal and environment factors. In numbers, 11.6 million incidents were reported just for the ischemic stroke and hemorrhagic stroke accounted for 5.3 million incidents worldwide in 2010[2,3]. India has 89.2% incidence of ischemic stroke and 17.7% of hemorrhagic. There is huge variation of prevalence of stroke in India, i.e 147- 922/100,000 across diverse community – based studies [4].

Treatment is generally focused on improving the proprioception awareness, balance, gait and coordination of individual with the help of different exercises. One of the techniques to improve the proprioception awareness is **cognitive sensory motor training**. Cognitive sensory motor training also known as Perfetti method, as it was first proposed by Professor Carlo Perfetti. According to Perfetti recovery of patient should not only focus on the muscle strengthening but also on the cognitive skills of the patient and retraining of sensory deficits. In neurological conditions like stroke, where coordinated movement is impaired due to brain damage, cognitive sensory motor training therapy (CSMT) is a rehabilitation approach that aims to improve motor function by simultaneously stimulating a patient's cognitive processes and sensory perception. It focuses on actively engaging the patient's awareness of their body position and movement through sensory input while performing motor tasks, effectively retraining the brain to better control movement. This technique can help patient gain the capacity to coordinate variables for the exercise sequence's spatial and temporal intensity, which is necessary for the body's maximal engagement with its surroundings. Particular emphasis of the technique is on recognition of a specific position of the joint. It helps the patient to relearn how to move his or her body by thinking, feeling and imagining it [5].

## MATERIALS AND METHODOLOGY

The study was conducted in Neuro – Out Patient Department of DAV Institute of Physiotherapy and Rehabilitation. A total of 20 subjects were enrolled in the study and were divided into two groups, Group A and Group B. Sampling technique used for the study is convenient sampling. The study was carried out for duration of one and a half year.

Inclusion criteria for patients: Age between 40-65 years, both genders were enrolled, patients with stroke as diagnosed on CT & MRI Scans, either ischemic or hemorrhagic, brunstrom recovery stage of 3,4 and 5 for lower extremity, Grade of 1+,2+ and 3+ of common clinincal rating scale. Patients with spasticity grade 0 and 1 for affected side hip flexors, knee extensors and ankle dorsiflexors. (according to Modified Ashworth Scale). Patients presenting with hypoalgesia, hypoaesthesia in affected lower extremity. (as per International Association for the Study of Pain, IASP) Patients with score greater than 22 of mini mental scale examination. Patient with stroke of either right side or left were enrolled.

Exclusion Criteria: Patients presenting with neurodegenerative disease like Parkinson's, dystonia, Alzheimer's, patient with hemiplegia due to traumatic brain injury, any surgical history following stroke like craniotomy, craniectomy, decompressive and shunting procedures. Patients with abnormal sensations like hyperalgesia, hyperesthesia, allodynia, speech disorders like global aphasia, body scheme and body

image disorders like unilateral neglect. Patients with visual field deficits like homonymous hemianopsia, quadrantanopia.

All the patients who met the inclusion and exclusion criteria were selected for the study. A written informed consent was obtained from each participated subject. A total of 20 patients in late sub- acute stage and chronic stage were enrolled and was divided into 2 groups that is Group A and Group B. Group A was the experimental group and Group B, the control group, each group having 10 subjects respectively. The required assessment of the patients was done on the day of enrollment.

The treatment was given for a period of 7 weeks; 4 days per week for a minimum duration of 45-60 minutes. The total number of sessions were 28 for both the groups. The patients were assessed at baseline and post intervention 7 weeks for parameters of area and center of pressure deviations using dynamic multiple acquisition.

All the exercises for Group A were carried out for 10 repetitions each.

Cognitive Sensory Motor Training exercises included:

1. Proprioception training: The training was performed to improve the joint sense and sense of movement after applying pressure to ankle joint and was given in the initial position and in the final position for position sense.
2. Tactile Stimulation training: It was given using contact tasks that present cognitive problems to distinguish the difference between sense of friction and weight. Subjects used visual and somatosensory technique to differentiate each sense.
3. Pressure Stimulation: Subjects were given a cognitive problem to distinguish the difference in degree of sponge pressure on the trunk in sitting posture and patient were ask to distinguish between the vision and somatosensory senses while conducting a task.
4. Spatial Task: An ellipse was made on the floor depending on the angle of knee with heel in contact with the ground, for spatial cognition a movement was made to retrace the ellipse in front of them.
5. Participants were given conventional rehabilitation interventions:

Stretching of Calf, Hamstring, Tendo Achilles, Active assisted range of Motion exercises for hip, knee, ankle, bridging, lower lumbar rotations. 10 repetitions of each exercise were performed.

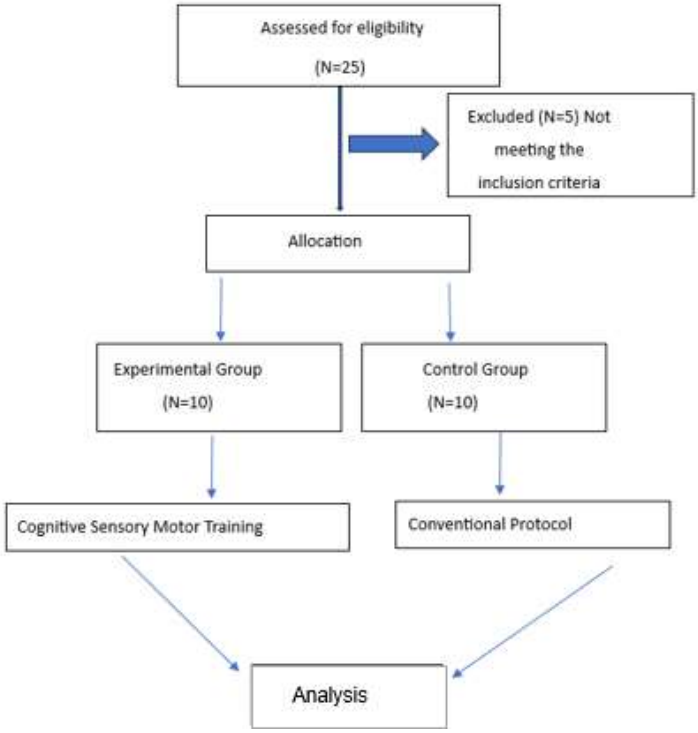
The patients were assessed pre and post intervention for plantar supports using 2 different acquisitions, this Dynamic Multiple on Ortho- King pressure plate SDP610.

For Dynamic Multiple acquisition, following plantar supports were assessed:

a) Area: Surface Area covered by both feet (total support surface), was measured in $cm^2$
b) Centre of Pressure: It is used to visualize the foot shape, center of pressure and the maximum pressure point. It also displayed the Gait Line and the Max Line which were used to measure the deviation of center of pressure.

In Dynamic Multiple acquisition, subjects were instructed to walk from a distance and placed their left foot first on the force plate and then right foot while coming back as instructed by the software used. This intervention was done for 3 times so that we could get 6 images in total, 3 for each foot as required for the software and one mean image was automatically created and all the parameters required for our study of dynamic multiple acquisition was displayed.

**Figure 1: Showing study Flow Chart**




## RESULTS

The mean age for patients in Group A was 57.50 ± 3.308 years and in control group i.e. Group B it was 53.40±7.058 years. There was no statistically significant difference in baseline sociodemographic parameters between CSMT and control group. There were 7 men and 3 women recruited in the CSMT group, compared to the control group in which there were 8 men and 2 women.

There was statistically significant increase in plantar area of the foot in CSMT group. Mean of Group A increased from 103.10±18.071 to 130.80±12.372. P value calculated as 0.0001 which is less than selected p value of 0.05. There was no statistical difference in plantar area of foot of the control group as the mean increased from 114.30 $cm^2$ at baseline to 125.20 $cm^2$ at the 7th week, with standard deviations of 26.920 and 13.290, respectively, the mean difference is 10.90 $cm^2$ and the calculated t-value is 1.756, with a p-value of 0.1129, which is greater than the table value of 2.26 at the level of significance of 0.05.

There was no statistical difference observed in center of pressure deviation of both experimental group and control group as there was no increase in mean and calculated p value was 0.9727 while of control group the calculated p value was 0.2670.

**Table 1: The table presents a paired t-test analysis for the Area ($cm^2$) and Centre of Pressure Deviation for Group A between baseline and the seventh week.**

| **Paired T Test** | **Group A** | | **Group A** | |
|---|---|---|---|---|
| | **Area (cm2)** | | **Centre of Pressure Deviation** | |
| . | Baseline | 7th week | Baseline | 7th week |
| Mean | 103.10 | 130.80 | 0.73 | 0.73 |
| S.D. | 18.071 | 12.372 | 0.209 | 0.180 |
| Number | 10 | 10 | 10 | 10 |

| | | |
|---|---|---|
| Mean Difference | 27.70 | 0.00 |
| Paired T Test | 7.058 | 0.035 |
| P value | 0.0001 | 0.9727 |
| Table Value at 0.05 | 2.26 | 2.26 |
| Result | Significant | Not- Significant |

**Table 2: The table presents a paired t-test analysis for the Area (cm²) and Centre of Pressure Deviation for Group B between baseline and the seventh week.**

| **Paired T Test** | **Group B** | | **Group B** | |
|---|---|---|---|---|
| | **Area (cm2)** | | **Centre of Pressure Deviation** | |
| . | Baseline | 7th week | Baseline | 7th week |
| Mean | 114.30 | 125.20 | 0.76 | 0.61 |
| S.D. | 26.920 | 13.290 | 0.552 | 0.153 |
| Number | 10 | 10 | 10 | 10 |
| Mean Difference | 10.90 | | 0.15 | |
| Paired T Test | 1.756 | | 1.183 | |
| P value | 0.1129 | | 0.2670 | |
| Table Value at 0.05 | 2.26 | | 2.26 | |
| Result | Not-Significant | | Not-Significant | |

**Table 3: The table presents an unpaired t-test analysis comparing the area (cm²) between Group A and Group B at baseline and the seventh week.**

| **Unpaired T Test** | **Comparison** | | | |
|---|---|---|---|---|
| | **Area (cm²)** | | | |
| | **Baseline** | | **7th week** | |
| | **Group A** | **Group B** | **Group A** | **Group B** |
| Mean | 103.10 | 114.30 | 130.80 | 125.20 |
| S.D | 18.071 | 26.920 | 12.372 | 13.290 |
| Number | 10 | 10 | 10 | 10 |
| Mean Difference | 11.20 | | 5.60 | |
| Unpaired T Test | 1.092 | | 0.975 | |
| P value | 0.2891 | | 0.3423 | |
| Table Value at 0.05 | 2.10 | | 2.10 | |
| Result | Not-Significant | | Not-Significant | |

**Table 5.4: The table presents an unpaired t-test analysis comparing Centre of Pressure Deviation between Group A and Group B at baseline and the seventh week**

| Unpaired T Test | Comparison | | | |
|---|---|---|---|---|
| | Centre of Pressure Deviation | | | |
| | Baseline | | 7th week | |
| | Group A | Group B | Group A | Group B |
| Mean | 0.73 | 0.76 | 0.73 | 0.61 |
| S.D | 0.209 | 0.552 | 0.180 | 0.153 |
| Number | 10 | 10 | 10 | 10 |
| Mean Difference | 0.03 | | 0.12 | |
| Unpaired T Test | 0.155 | | 1.1619 | |
| P value | 0.8783 | | 0.1228 | |
| Table Value at 0.05 | 2.10 | | 2.10 | |
| Result | Not-Significant | | Not-Significant | |

## DISCUSSION

This current study was done with the aim of determining the efficacy of cognitive sensory motor training on bipedal cartography and functional independence in patients with stroke. The variables of the current study were Centre of Pressure Deviation, Area measured in $cm^2$. To our best knowledge and extensive literature review this is the first time CSMT has been applied in lower limb for stroke patients in Indian population and first time been applied to look for the efficacy of the technique on COP deviation and plantar area.

In quiet standing, the position of centre of mass varies continuously resulting in changes in the forces exerted by human body on support surface & in corresponding ground reaction forces. This postural sway can be studied using force plate that measure displacement of centre of pressure. Similar study was done by **M. Roerdink, et al, (2006),** [6] they investigated the centre of pressure trajectories in patients recovering from stroke. They concluded that COP trajectories were less regular which interpreted the reduction of cognitive involvement in postural control as recovery from stroke progressed.

Patients with stroke presents with heighten risk of fall because of impaired postural control which directly impairs their mobility. The impairment in postural sway can be assessed through different test such as single leg stance, rhomberg test and many more but to quantify the data and to have a reliable measurement of sway the Centre of pressure deviation can be assessed. To test the reliability of COP measures for balance assessment **David Gasq, et al, (2014),** [7] conducted a study for different COP variables that included COP velocity, confidence ellipse area, mean COP position along the mediolateral axis in hemiplegic patients. They concluded that COP velocity variable should be used in clinical practice for the assessment of postural sway.

In our study we assessed the efficacy of Cognitive sensory motor training on the centre of pressure deviation, the patients which were included were those who have brunstrom stage 4 and more than 4 and because of that reason there was no significant deviation found at the baseline as the mean of the group was 0.73 that is more towards the normal deviation therefore after applying the technique the mean remain

same to 0.73 and p value was much higher than the table value which indicated towards the statistically non- significant result.

The range of normal deviation was also mentioned by **Hagedom, et al,(2013),** [8] in their study where they mentioned that the lower deviation indicated towards the pronated foot and higher deviation indicated towards the supinated foot.

Similar study was conducted by **Ruo Onuma, et al, (2021),** [9] for determining whether the individual measurements of the centre of pressure for the stance and stepping legs can reveal new characteristics of reduced anticipatory postural adjustments during gait initiation in post stroke hemiplegic patients. Latency and magnitude of posterior displacement peak of the paretic and non-paretic leg and between stroke patients and control group was compared. Study was concluded that latency of posterior displacement peak of paretic leg centre of pressure with either the paretic or non- paretic leg leading was significantly longer in stroke patients compared with control and was also longer than non- paretic leg whereas the magnitude of the posterior displacement of peak of the paretic leg centre of pressure was smaller than that of non- paretic leg.

Foot drop, during the swing phase of gait is the most prominent gait deficits in post stroke patients and that is because of limited dorsiflexion at heel contact during stance due to weakness in dorsiflexors of the foot and specifically atrophied tibialis anterior. Study done by **Ramsay et al**,**(2016),** [10] determined that there is 4% difference in atrophy of tibialis anterior in paretic and non-paretic side of lower limb. Similarly, there is deficit in forward propulsion and vertical support walking, this is due to atrophy of gastrocnemius and soleus by 38% and 12% respectively. These muscle weakness leads to decrease in contact area of the foot. In stroke patients, the plantar area is essential for balance, walking, and general mobility, and its function may be impacted by changes associated with a stroke. A decline in plantar sensitivity, pressure distribution, and muscle control may result in challenges with balance, walking and a higher risk of falling. Different rehabilitation protocols are used to improve the plantar area of foot so as to decrease the risk of fall and improve the gait of patients. Until now no studies have focused specifically on the effect of Cognitive sensory motor training in improving the plantar area. This technique applied in our study, significantly showed the increase in the area of foot with mean difference of 27.70. This increase in contact area is because of continuous pressure on ankle while doing proprioceptive exercises such as heel slides, ankle dorsiflexion and plantar flexion and while doing spatial exercise which included dragging the heel along the semicircle made on floor.

Similar results were shown by other studies in which different protocols were used, such as study conducted by **Rusu, et al**, **(2021),** [11] concluded that there was significant increase in the contact area of foot at lateral heel, medial heel, mid foot and at 1$^{st}$ and 5$^{th}$ toe. They continued the protocol for 1 year and measured the parameters thrice with first reading at baseline, second after 6 months of protocol and the last after 1 year of rehabilitation. Patients included in Group A were those who have stroke for less than 3 months and Group B who had stroke strokes for more than 3 months. Former group showed more significant increase in area as compared to the latter one.

## CONCLUSION

The findings indicate that CSMT is statistically effective in ameliorating the plantar area in patients with stroke, highlighting its role in enhancing musculoskeletal alignment and neuromuscular coordination. Participants who underwent CSMT showed significant improvements in contact area of the foot, suggesting better weight distribution and support during standing and walking. However, there was no

significant change in the centre of pressure deviation following intervention. This finding suggests that while CSMT benefits several aspects of postural control and function, its influence on dynamic postural sway and fine balance mechanisms may be limited or require a longer intervention duration. Further research is necessary to explore the factors influencing COP deviation and to determine whether modifications to the CSMT protocol could yield improvements in this parameter.

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