



## Original Research Article

# Comprehensive cognitive retraining with CogSMART in mild traumatic brain injury: An interventional study

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## ABSTRACT

Traumatic brain injury is one of the major causes of Neurological disability in India.<sup>1</sup> Post Concussive Symptoms of mild traumatic brain injury (mTBI) are usually ignored and not given importance, due to natural recovery and return to work. The aim of the present study was to find out the efficacy of Cognitive Retraining using CogSMART (Cognitive symptom management and rehabilitation therapy) for mild traumatic brain injury. The objectives were to measure cognitive impairment and evaluate the efficacy of CogSMART in the improvement of impaired cognitive functions. Sixty six out of ninety mild traumatic brain injury patients who were free from psychiatric problems were divided equally into experimental group, who received CogSMART, and control group who did not receive any intervention. Cognitive assessment was done using PGI battery of brain dysfunctions before the intervention, one and three months after withdrawing the intervention. Experimental group showed significant improvement ( $p < 0.05$ ) in Memory, Verbal Intelligence, Performance Intelligence, Visual acuity and Visuomotor functions than the control group after the cognitive intervention. Cognitive Retraining, using CogSMART has the potential to improve cognitive impairment, which is commonly ignored in mTBI for a better quality of life. Early identification and intervention of cognitive impairment in mTBI can prevent long term persistent neurological dysfunction.

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## 1. Introduction

Traumatic brain injury is one of the most important causes of serious morbidity and mortality worldwide which has become a public health concern in the recent times among men and women of all ages, educational and socioeconomic status.<sup>2</sup> Incidence of traumatic brain injuries are found to increase in India, as we progress in greater urbanization with rapid development in terms of motorization. Epidemiological survey in Bengaluru, India has estimated 150/100,000, 20/100,000 and 10%, of incidence, mortality, and case fatality rates respectively. It is estimated at a national level that two million people will sustain traumatic brain injuries with approximately a million among them requiring rehabilitation services.<sup>3</sup>

Depending upon the level of consciousness and duration of post traumatic amnesia, traumatic brain injury is classified as mild, moderate, and severe.<sup>4</sup> 80-100% of individuals with mTBI complain of symptoms like headache, slowed thinking, impaired attention and memory.<sup>5</sup> 46% of the persons are cognitively impaired at 3 months post mild head injury, 61% at 6 months, 48% at 12 months and 88 % at more than 12 months. 15% of the injured individuals have notable long-term persistent cognitive impairments especially in memory, attention, learning and executive functions, which require intervention.<sup>6-8</sup> 5-10% patients demonstrate abnormalities in CT scan of the brain, though many clinicians believe that no significant findings are observed in neuroimaging in mTBI.<sup>9</sup> This implies a need for a detailed neuropsychological assessment and planned intervention strategies for an extended period in mTBI patients with abnormalities.

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There are no studies from India that have explored the efficacy of cognitive intervention in improving the post concussive cognitive decline in mTBI. The aim of the current experimental study was to investigate the efficacy of a novel comprehensive cognitive rehabilitation technique, CogSMART (Cognitive Symptom Management and Rehabilitation Therapy)<sup>10</sup> in addressing the impaired cognitive functions post mild head injury and whether there is any influence of demographic characteristics in improvement.

## 2. Material and Methods

### 2.1. Study design and participants

The study was conducted in a tertiary care hospital in south India. Ninety patients aged between 20-60 years with first episode of mTBI and Glasgow Coma Scale scores of 13-15 at the first evaluation in the emergency department of Neurosciences willing to participate by providing a written consent were registered. In order to control the differential effects in the results, subjects with a history of psychiatric problems (all participants were screened using Multiphasic Personality Questionnaire (MPQ)),<sup>11</sup> Diabetes Mellitus, Cardiac illness, moderate to severe traumatic brain injury, epilepsy and other neurological disorders were excluded from the study. Demographic data was obtained. All the patients were assessed bedside within 24 hours of admission with a Neuropsychological battery, PGI battery of brain dysfunction. Eleven patients with no cognitive dysfunction, eight with psychiatric problems and five who could not complete the cognitive test were excluded from the study. The remaining sixty six patients were briefed about the study and its purpose, assessment and intervention methods and potential benefits. They were divided into control and experimental groups. Matching was done based on their scores in the test variables. Thirty-three persons were allotted to each group. The length of time between baseline assessment and entry into interventional program was approximately 3 months. Experimental group received CogSMART (Table 1)<sup>10</sup> for a period of two months with one hour session for five days a week, whereas control group was not exposed to any such intervention. They were assessed with PGI battery of brain dysfunctions<sup>12</sup> at three phases; before intervention (Pretest), one month after intervention (Posttest) and three months after intervention (follow-up). This study was approved by the Institutional ethics committee.

### 2.2. Inclusion Criteria

Persons diagnosed as mTBI with a Glasgow coma scale score of 13-15<sup>13</sup> aged between 20-60 years of age with a history of loss of consciousness less than 30 minutes, Dysfunctional Rating Score of 3(severe), or 2(mild) in any of the subtests in PGI Battery of Brain Dysfunctions and

free from psychiatric problems were included in the study.

### 2.3. Exclusion criteria

Persons with a previous history of psychiatric problems, Diabetes Mellitus, Cardiac illness, traumatic brain injury, epilepsy, patients on medications for chronic illnesses and other neurological disorders were excluded from the study.

### 2.4. Clinical evaluation

Socio demographic data was obtained from all participants. Cognitive assessment was done with the following battery of tests:

### 2.5. PGI battery of brain dysfunctions:

This battery of tests is designed to evaluate the extent of decline or loss in cognitive area such as memory, verbal and performance intelligence, visual acuity, visuospatial skills and visuo motor coordination. It requires nearly 90 to 120 minutes for its complete administration. It consists of the following five subtests.

1. PGI Memory Scale: Memory tests assesses 10 different areas of Memory namely Remote memory, Recent memory, Mental Balance, Attention and Concentration, Delayed Recall, Immediate Recall (Sentence Reproduction), Verbal retention of similar pairs, Verbal retention of dissimilar pairs, Visual retention and Recognition.
2. Revised Bhatia's Short Battery of Performance test of Intelligence for adults : This battery consists of two subtests namely Koh's block design test and Alexander's pass along test to assess the performance intelligence of the individuals. It focuses on speed, accuracy and efficiency.
3. Verbal Adult Intelligence Scale: This scale assesses the verbal ability of the person which is determined by the left side of the brain in a right-handed person. It consists of four subtests i.e. Information, Arithmetic, Digit Span and Comprehension. It gives Test Quotient separately for four subtests and a Verbal Quotient that is mean of Test Quotients, separately for male and female of different age and education levels. It stresses on power and capacity.
4. Nahor Benson Test: This test measures perceptuo - motor functioning of the right hemisphere and related to parieto occipital lobe.
5. Bender Visual Motor Gestalt Test: This test evaluates visual motor functioning and organicity in mental functions among head injured individuals. This test consists of nine simple designs which are allowed to copy in the first phase and reproduce from memory in the second phase of test.

## 2.6. Statistical analysis

Data was analysed using the Statistical Package for the Social Sciences (SPSS), version 17. Descriptive data were analyzed in frequencies, mean, and standard deviation. Effect of intervention and differences between groups and within group were analysed using t- test and analysis of variance. Between subject effects of demographic variables in experimental group post intervention was analysed using analysis of variance and Duncan's post hoc test to explore the pairs of means that differ. All statistical tests were two tailed and a significance level was set at 0.05.

## 3. Results

The final clinical sample was composed of 66 patients with mTBI who were divided into control and experimental group based on their cognitive dysfunction scores in test variables with 33 in each group. Sociodemographic data of the sample are shown in Table 2. Both the groups were composed mainly by men (Control group (66.7%); Experimental group (81.8%)) in the age group of 21-30 years (Control group (66.7%); Experimental group (42.4%)), with a professional degree (33.3 % in both groups) working as software engineers (Control group (51.5%); Experimental group (45.5%)). 63.6% had normal CT scan reports in control group and 51.5% had abnormal findings in experimental group.

Comparison of cognitive performance between groups is shown in Table 3. Experimental group showed significant difference in all the memory tests, verbal intelligence and performance intelligence quotient compared to control group in posttest (one month after the intervention) and follow-up phase (three months after the intervention) and experimental group's Pretest scores with  $p < 0.001$  (PIQ,  $p < 0.05$ ) except in remote memory ( $P = 0.163$ ). There was no difference in scores of NBT and BVMT between groups.

Demographic differences in posttest and follow-up scores among experimental group are shown in Table 4. Patients between 30 to 40 years showed better improvement in VIQ (119.71(6.99), 120.00 (6.95),  $p < 0.05$ ) compared to other age groups. Patients, whose CT report were normal showed better improvement in PIQ (114.38(17.44),  $p < 0.05$ ) in the posttest phase than those with abnormal report. No other significant demographic differences were found among experimental group post intervention.

## 4. Discussion

This is the first Indian study to investigate the effect of novel comprehensive cognitive retraining strategy, CogSMART in improving the impaired cognitive functions and demographic differences in intervention following mTBI. CogSMART has been found to be effective in addressing post concussive symptoms in veterans.<sup>14,15</sup> Since individuals with psychiatric problems have increased

risk of impaired cognitive performance, they are screened and excluded from the study.<sup>16,17</sup>

Findings of our study demonstrated significant improvement ( $p < 0.05$ ) in all domains of memory namely recent memory, immediate recall, delayed recall, attention and concentration, verbal retention for similar and dissimilar pairs, visual retention and recognition except remote memory over the three phases of memory testing between control and experimental group. There was a significant improvement among experimental group in the posttest and follow up phase compared to pretest phase after intervention indicating that the participants are able to maintain their levels of psychological well-being over three months even after withdrawal of the intervention.<sup>15</sup> Munivenkatappa et al. have reported natural recovery of post concussive symptoms and cognitive functions in mTBI though there were residual symptoms.<sup>18</sup> However, in our study, control group did not have any natural recovery of memory even after 9 months post mTBI. Memory is important for independent living and maintaining good relationship in all areas of life. Persisting problems beyond 9 months is an indicator of cerebral compromise of mild injuries.<sup>19</sup> Memory and other related domains in mTBI were reported to be impaired due to post-traumatic stress, depression and pain.<sup>20</sup> Direct retraining is reported to restore impaired cognitive functions. Improved attention enhances speed and accuracy on recognition of tasks. Cognitive retraining improves individual's ability to attend selectively and ignore irrelevant stimuli else it may result in encountering life threatening situations. Adequate attention improves encoding and retrieval of stored information which is required in day-to-day life to prevent natural caution and fear of consequences. Integrated cognitive rehabilitation helps to address impairment in cognitive functions during post-mild traumatic brain injury.<sup>21</sup> However, remote memory was not affected in both control and experimental group. Recollection of autobiographical events has been reported to depend on the neocortical areas especially frontal, lateral temporal and occipital lobes and not on the medial temporal lobe alone.<sup>22</sup>

The present study revealed a significant difference in verbal and performance intelligence quotients between control and experimental group after intervention ( $p < 0.05$ ). Scores of VIQ improved from 99.91 to 113.45 and PIQ from 97.7 to 111.3 among experimental group with CogSMART. Control group who were not given cognitive intervention did not show any significant improvement in the scores of VIQ and PIQ in the posttest and follow-up phase. Persistent mental fatigue was found to be associated with reduced cognitive performance disabling persons with mTBI affecting their working capacity and social activities.<sup>23</sup> Depressions in VIQ and PIQ were correlated to post traumatic amnesia.<sup>24</sup> Psychoeducation and relaxation strategies in CogSMART facilitated reduction of post-

**Table 1:** List of targeted domains and CogSMART strategies taught to Experimental group

| Domains Targeted            | Cognitive Symptom Management and Rehabilitation Therapy strategies taught  |
|-----------------------------|--|
| Symptoms of concussion      | Psycho-education, pacing, use of routines, life style modification, Relaxation techniques  |
| Prospective Memory          | Calendar use, to do lists, can't miss reminders  |
| Attention and Concentration | Conversational vigilance skills such as listening carefully, reducing distractions, maintaining eye contact, paraphrasing, asking questions and task vigilance skills such as self-talk and paraphrase instructions  |
| Learning and Memory         | Encoding techniques like writing down things, repeating, association, chunking, using acronyms, visual imagery, strategies for learning name and Retrieval strategies like retracing and recreating context and organizational strategies.   |
| Executive Functioning       | 6-step problem-solving method DBESTE (define problem, brainstorm solutions, evaluate solutions, select solution, try it, evaluate how it worked), strategy verbalization-self talk while solving problem, Testing the hypothesis to see pros and cons, set shifting and maintenance, planning to meet goals. |

**Table 2:** Frequency distribution of the sample

| Demographic Characteristics | Control group (n=33) |      | Experimental group (n=33) |      |
|-----------------------------|----------------------|------|---------------------------|------|
|                             | N                    | %    | N                         | %    |
| <b>Age (in years):</b>      |                      |      |                           |      |
| 21-30                       | 22                   | 66.7 | 14                        | 42.4 |
| 31-40                       | 6                    | 18.2 | 7                         | 21.2 |
| 41-50                       | 4                    | 12.1 | 3                         | 9.1  |
| 51-60                       | 1                    | 3.0  | 9                         | 27.3 |
| <b>Gender:</b>              |                      |      |                           |      |
| Male                        | 22                   | 66.7 | 27                        | 81.8 |
| Female                      | 11                   | 33.3 | 6                         | 18.2 |
| <b>Education:</b>           |                      |      |                           |      |
| <X                          | 3                    | 9.1  | 4                         | 12.1 |
| X                           | 2                    | 6.1  | -                         | -    |
| XII                         | 3                    | 9.1  | 3                         | 9.1  |
| Under Graduate              | 9                    | 27.3 | 10                        | 30.3 |
| Post Graduate               | 5                    | 15.2 | 5                         | 15.2 |
| Professional Degree         | 11                   | 33.3 | 11                        | 33.3 |
| <b>Occupation:</b>          |                      |      |                           |      |
| Software                    | 17                   | 51.5 | 15                        | 45.5 |
| Teaching                    | 3                    | 9.1  | 1                         | 3.0  |
| Clerk                       | 8                    | 24.2 | 15                        | 45.5 |
| Housewife                   | 2                    | 6.1  | 2                         | 6.1  |
| Unemployed                  | 1                    | 3.0  | -                         | -    |
| Student                     | 2                    | 6.1  | -                         | -    |
| <b>CT Findings:</b>         |                      |      |                           |      |
| Normal                      | 21                   | 63.6 | 16                        | 48.5 |
| Abnormal                    | 12                   | 36.4 | 17                        | 51.5 |

concussive symptoms like headache, fatigue, irritability and sleep problems and other strategies in the improvement of attention and concentration, memory and executive functions in day-to-day functions of individuals with mTBI to improve their overall performance and quality of life.

Demographic differences were found to influence cognitive recovery in experimental group (Table 4). Patients who aged between 31 and 40 years showed better improvement in VIQ one month (119.71(6.99)) and three months (120.00(6.95)) after intervention compared to other age groups. Cognitive functioning appears to be associated with age which impacts the type and severity of symptoms

post mild head injury. Older adults reported higher severity of symptoms like headache, nausea, irritability, poor concentration sleep disturbance and taking longer time to think and had delayed recovery rate.<sup>25</sup>

Results of our study also revealed that patients with normal CT findings showed better improvement in PIQ compared to those with abnormal findings among experimental group post intervention. Region specific white matter abnormalities are found to be associated with loss of consciousness and cognitive impairment, which are detrimental to neurocognitive functions.<sup>26</sup> Focal frontal contusions were found to impair neurocognitive functions

**Table 3:** PGI battery of brain dysfunction subtest scores of Control Vs. Experimental groups over three phases of evaluation

| Test           | Pretest       |              | Posttest      |                | Follow-up     |                | P value (ANOVA) |
|----------------|---------------|--------------|---------------|----------------|---------------|----------------|-----------------|
|                | C             | E            | C             | E              | C             | E              |                 |
| <b>Memory</b>  |               |              |               |                |               |                |                 |
| Remote memory  | 5.82(0.63)    | 5.91(0.38)   | 5.84(0.44)    | 6 (0.00)       | 5.87(0.33)    | 6(0.00)        | 0.163           |
| Recent memory  | 4.69(0.63)    | 4.55(0.79)   | 4.75(1.00)    | 5(0.00)        | 4.78(0.41)    | 5(0.00)        | 0.000*          |
| Mental Balance | 8.12(1.31)    | 7.24(1.39)   | 8.18(1.23)    | 8.73(0.45)*    | 8.21(1.34)    | 8.85(0.39)*    | 0.000*          |
| Attn & Conc.   | 9.97(3.04)    | 10.12(2.21)  | 10.06(2.86)   | 12.45(1.12)*   | 10.09(2.78)   | 13.36(1.11)*   | 0.000*          |
| DR             | 8.85(1.41)    | 8.61(1.73)   | 8.93(1.43)    | 10(0.00)*      | 8.96(1.40)    | 10(0.00)*      | 0.000*          |
| IR             | 9.36(2.77)    | 8.67(2.98)   | 9.45(2.65)    | 9.51(2.58)*    | 9.51(2.58)    | 11.52(0.75)*   | 0.000*          |
| VRSP           | 4.94(1.19)    | 4.30(1.32)   | 4.96(1.91)    | 5(0.00)        | 4.96(1.89)    | 5(0.00)        | 0.000*          |
| VRDP           | 10.67(4.03)   | 9.3(4.56)    | 10.78(3.76)   | 12.55(2.72)*   | 10.84(3.69)   | 14.06(1.27)*   | 0.000*          |
| VR             | 9.88(2.40)    | 9.70(3.01)   | 10(2.17)      | 12.33(1.45)*   | 10.06(2.13)   | 12.61(0.93)*   | 0.000*          |
| Recognition    | 9.12(1.16)    | 8.79(1.24)   | 9.18(0.98)    | 9.94(0.24)*    | 9.24(8.30)    | 10(0.00)*      | 0.000*          |
| <b>VIQ</b>     | 105.30(13.45) | 99.91(12.01) | 105.48(13.08) | 113.21(7.39)*  | 105.60(12.84) | 113.45(7.28)*  | 0.000*          |
| <b>PIQ</b>     | 98.52(17.71)  | 97.70(19.31) | 98.93(17.65)  | 109.12(14.45)* | 99.30(17.16)  | 111.30(14.03)* | 0.002*          |

Values-Mean(SD); C-Control group; E-Experimental group; Attn&Conc.-Attention and Concentration; DR-Delayed Recall; IR-Immediate Recall, VRSP-Verbal retention of similar pairs; VRDP-Verbal retention of dissimilar pairs, VR- Visual retention; VIQ- Verbal Intelligence Quotient; PIQ- Performance Intelligence Quotient; P\* < 0.05

**Table 4:** Demographic differences in test scores among experimental group

| Test/category           | N(%)     | Posttest       | Follow-up     |
|-------------------------|----------|----------------|---------------|
| <b>VIQ /Age Group</b>   |          |                |               |
| 21-30 years             | 14(42.4) | 112.14(6.82)   | 112.21(6.71)  |
| 31-40 years             | 7(21.2)  | 119.71(6.99)*  | 120.00(6.95)* |
| 41-50 years             | 3(9.1)   | 106.00(5.92)   | 106.00(5.29)  |
| 51-60 years             | 9(27.3)  | 112.22(6.32)   | 112.78(5.84)  |
| <b>PIQ/ CT Findings</b> |          |                |               |
| Normal                  | 16(48.5) | 114.38(17.44)* | 116.06(16.94) |
| Abnormal                | 17(51.5) | 104.18(8.86)   | 106.82(9.02)  |

VIQ- Verbal Intelligence Quotient; PIQ- Performance Intelligence Quotient; \*P < 0.05

and rehabilitation prognosis.<sup>27,28</sup> Hence, we suggest early imaging in mTBI and intervention though they appear to be non symptomatic. There were no significant differences in cognitive improvement related to educational status, gender or occupation after intervention.

Results on Bender visuomotor gestalt test and Nahor Benson test did not show any significant impairment in both control and experimental group indicating that there was no significant deficit in visual acuity, visuospatial skills and perceptuomotor coordination.

Many studies support the beneficial effect of cognitive rehabilitation at any point post- mild to severe head injury to improve their cognitive functions and overall psychosocial functioning. Significant benefits can be produced by developing insights about the post concussive symptoms and interventions to offset impairments. Providing information on the effects of injury and management strategies can reduce anxiety and lower incidence of long term problems.<sup>29</sup> Evidences on cognitive rehabilitation in specific domains of mTBI are sparse and requires further

work.

The findings of this study open up new avenues for the future research works in the field of neuropsychological assessment and planning specific cognitive intervention modules based on the impairment focusing on key cognitive and psychological factors such as memory, intelligence, executive functions and post concussive symptoms for mild head injury which is mostly neglected to prevent long term persistent neurocognitive degenerative disorders. The key findings of the study that the comprehensive cognitive intervention, CogSMART was effective in specific cognitive domains in mTBI makes it imperative for the Neuropsychologists, Neurologists and in general the health care sectors to come up with intervention strategies that aim at specific target groups that are otherwise tend to be neglected and ignored. Adaptive new problem-solving approaches can enable the injured persons to refocus on the problems at hand and deal with them to reduce stress in their personal, social and occupational life.

This improves the psychological well-being and physical aspects such as maintaining a healthy life style, continuing employment and maintaining sources of income for the family relieving the burden of the family and the society as a whole. Improvements in cognitive functions can facilitate better management of the long-term complications of head injury. Hence, this study highlights the fact that management of neuropsychological issues can improve the overall quality of life among mild traumatic head injury persons. The findings of this study convey a strong message to the society that mild traumatic head injury and its associated symptoms should not be neglected.

The limitations of this study would be worth listing as it will enable the reader to interpret the results in the backdrop of these limitations. A limited sample size and purposive sampling technique due to voluntary participation, matching based on test variables could not facilitate analysis of demographic differences in all cognitive domains. Patients with previous history of neurological/ seizure disorder, psychiatric problems and mTBI more than once were not included in our study. Future studies can focus on the influence of these factors on the results.

To conclude, our study showed significant improvement in impaired memory, verbal and performance intelligence among mTBI patients intervened with CogSMART. Middle aged patients showed better improvement in verbal intelligence and patients with normal CT findings in performance intelligence. However, there was no such improvement found in non intervened patients even after 9 months of injury. Hence, CogSMART is found to be an effective, comprehensive and cost-effective intervention for mTBI.

## 5. Source of Funding

None.

## 6. Conflict of Interest

None.

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