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EFFECT OF CALORIC VESTIBULAR STIMULATION ON MEMORY

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ABSTRACT

This study was undertaken to provide an authoritative database for beneficial effects of vestibular stimulation and to suggest vestibular stimulation as a therapy for enhancement of cognition. Vestibular stimulation is performed by caloric vestibular stimulation. Scopolamine is used to induce partial amnesia. T-maze task is used to record acquisition and retention of the memory score before and after vestibular stimulation. Memory scores were significantly different between scopolamine induced amnesia control and hot water vestibular stimulation groups ($p<0.05$). Memory scores between scopolamine induced amnesia cold and hot vestibular stimulation groups were highly significant. (p value <0.05). This study categorically confirms that caloric vestibular stimulation with hot water enhances cognition. Hence this study certainly merits further studies with higher sample size to confirm whether caloric vestibular stimulation can be recommended for enhancement of cognition.

KEYWORDS: Acquisition, Caloric vestibular stimulation, Cognition, Memory, Retention, Amnesia.

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INTRODUCTION

The vestibular apparatus is a membranous structure consisting of three semicircular canals connected at their base to the utricle, saccule and endolymphatic sac. The need of vestibular stimulation can be observed throughout the life[1]. Vestibular system is having extensive connections with hippocampus, raphe nucleus, locus ceruleus, thalamus, amygdala, insular cortex, anterior cingulated cortex, prefrontal cortex, cerebellum, occipital cortex, putamen, parietal lobe and other areas of brain which plays key role in cognitive processes[2]. Vestibular stimulation not only contributes for regulation of posture and equilibrium but also relieves stress, cancer pain, promotes sleep, improves immunity, improves cognition and also treats endocrine disorders[3,4,5]. Memory is the acquisition, storage and retrieval of sensory information[6]. The most common mazes used to study learning and memory are T-maze and R-maze[7].Severe memory problems are observed in brain disorders like Alzheimer's disease, stroke, Parkinson's disease, Korsakoff syndrome, brain infections, brain tumors, seizures etc. Currently the drugs available for the treatment of cognitive disorders cannot cure the disorder, but only delay the loss of mental abilities or provide relief for short period of time. These drugs are expensive and have many side-effects[8,9]. Hence there is need for a different approach to the treatment for cognitive disorders which is effective, affordable and with no or less side effects.[10,11]. Patients with vestibular dysfunctions reported navigational and spatial memory impairments[2]. Vestibular system triggers a range of changes in cognition, emotion and personality through controlling autonomic functions[2].Caloric vestibular stimulation is a safe non-invasive method of stimulating brain areas related to cognitive function. Clinically caloric vestibular stimulation is used as a diagnostic technique to investigate vestibular function. Caloric vestibular stimulation consists of a water irrigation of the external auditory canal, which induces a change in the temperature that leads to convection currents in the semicircular canals. This evokes a slow-phase nystagmus toward the stimulated ear and it elicits sensations of virtual body rotations and vertigo[12]. Caloric vestibular stimulation modulates sensory and cognitive functions in healthy participants and brain damaged patients[13].Vestibular system can modulate cognition through hippocampus, through HPA axis through limbic system and neo cortex[4]. Vestibular stimulation activates areas of brain which are involved in learning and memory[14]. Caloric vestibular stimulation increases acetylcholine release from rat hippocampus and also enhances longterm potentiation via activation of cholinergic septo-hippocampal cells[15,16]. Vestibular dysfunction involves a complex syndrome characterized not only by reflex deficits but also by attention and memory deficits and anxiety disorders and depression[17]. This study was undertaken to provide authoritative database for beneficial effects of vestibular stimulation and to suggest vestibular stimulation as a therapy for enhancement of cognition**.**

MATERIALS AND METHODS

Animals

18 healthy, adult male albino rats of wistar strain with body weight ranging between (50-125g) were used in the present study. Rats were housed under standard laboratory conditions with food and water provided ad libitum .Rats are randomly assigned into three groups.

Group A: (n=6) control group-Partial amnesia was induced by administration of scopolamine and no vestibular stimulation.

Group B: (n=6) Partial amnesia was induced by administration of scopolamine and provided caloric vestibular stimulation with cold water for 30 days

Group C: (n=6) Partial amnesia was induced by administration of scopolamine and provided caloric vestibular stimulation with hot water for 30 days.

Materials

T-maze :(Figure-1) The T-maze is made of wood with smooth polished surface. It consists of a stem (35 x 12 cm), a choice area (12 x 12 cm) and two arms (35 x 12 cm); at the end of each arm contain a food well. The sidewalls are 40 cm high. The choice area is separated from the arms by a sliding door[6] .

Figure 1
T-maze

T-maze task

In the orientation phase, the starved rats were allowed to spend 10 minutes / day for three days in the T-maze and trained to collect food pellet from the food wells. During the acquisition test, all the rats were given six trials / day with an inter trial interval of one hour. Each trial consists of four sample and choice run. In the sample run, the rat was placed at the start end of the T-maze stem. Allowed to move towards one arm and collect the food pellet, while keeping the sliding door of other arm closed. In the choice run, the rat was placed at the start end of stem and both arms were kept open. If the rat visits the same arm as that of sample run, it was recorded as correct score and the rat was rewarded with food. Instead, if the rat visits the alternate arm, it was recorded as error and the rat was not allowed to eat food pellet. There was an interval of 30s between each run. Score was given for alternate selection of arm during choice run and a maximum score of '1' can be obtained per trial. After 3 days of orientation phase behavioral task was performed. This task was continued till we get the full score. Once the full score is recorded, ten days gap was given. After ten days retention test was conducted and memory score was recorded. From the next day onwards scopolamine was administered intraperitoneal for 9 days at 10am daily. From 10th day, cold and hot caloric vestibular stimulation was given for 30 days to group B and group C respectively. From 31st day behavioral task was conducted as explained earlier

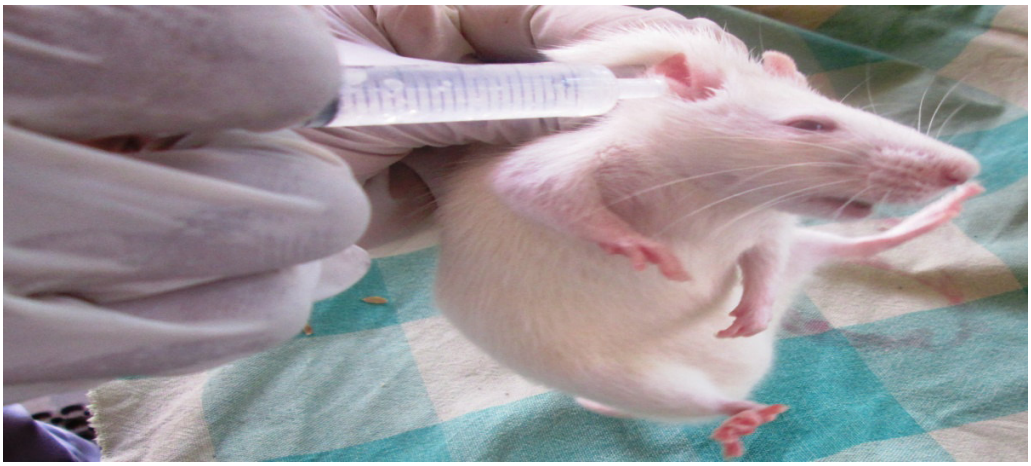
Drugs

Buscopan® tablets manufactured by Cadila Healthcare limited, is used in the present study. Each Buscopan tablet contained Hyoscine (scopolamine) Butylbromide I P 10 mg and excipients (q. s.). The tablets were powdered and mixed with 50ml sterile 0.9% w/v normal saline. It was administered by intraperitoneal injection at a dose of 1 mg / Kg. Scopolamine was injected at a dose of 1mg/Kg body weight of rat[18, 19,20, 21,22,23].

Caloric vestibular stimulation

The middle ear cavity was irrigated with hot (40 degree centigrade) or cold (15 degree centigrade) (Figure - 2) water through a polyethylene tube for 30 days[24,25].

Figure 2
Method of application of Caloric vestibular stimulation



DATA ANALYSIS
Data was analyzed by spss 20.0 by Two way ANOVA and by Bonferroni post test.

ETHICAL APPROVAL
The present study was approved by institutional animal ethical committee. (23-05-2014, No EC/6)

RESULTS

Results are presented in fig no: 1,2. Memory scores were significantly different between scopolamine induced amnesia control and hot water vestibular stimulation groups ($p<0.05$). Memory scores between scopolamine induced amnesia cold and hot vestibular stimulation groups were highly significant. (p value <0.05).

Figure 1
Acquisition memory scores in control, cold water vestibular stimulation and hot water vestibular stimulation groups. (*p value <0.05 is statistically significant. **p value<0.01 is statistically significant *** p value <0.001 is significant)

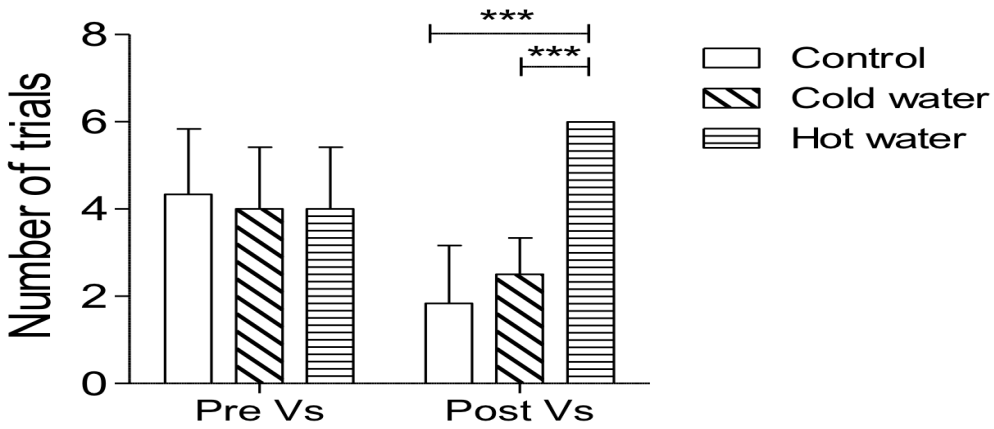
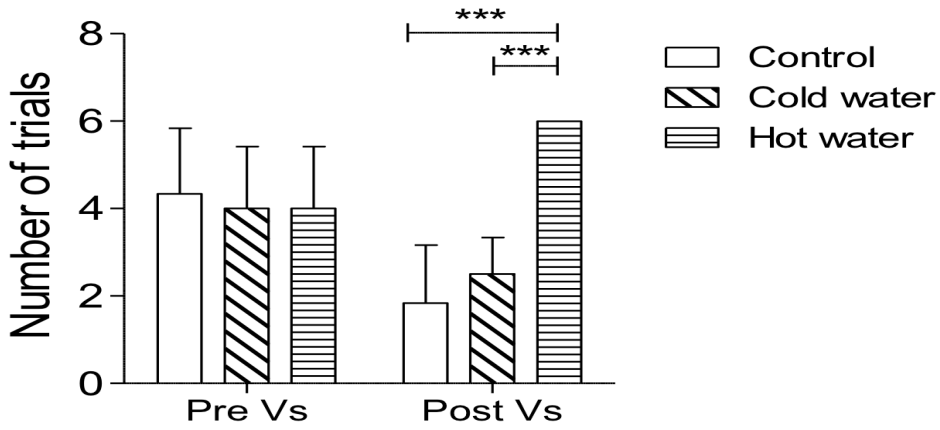


Figure 2

Retention memory scores in control, cold water vestibular stimulation and hot water vestibular stimulation groups. (*p value <0.05 is statistically significant. **p value<0.01 is statistically significant *** p value <0.001 is significant)



DISCUSSION

Vestibular stimulation influence on cognitive processes was especially prominent for otolithic and visual stimulation[26]. It was reported that Suprathreshold galvanic vestibular stimulation adversely effects cognitive process, which is task dependent[27.] CVS attenuates the pleasant and rewarding effect of acquisition through emotional circuits[28]. It was reported that vestibular stimulation contributes to the sensorimotor mechanisms of social cognition through vestibular projections to multisensory regions[29]. Most of the existing drugs for treatment of cognitive disorders acts by inhibiting cholinesterase. These drugs are effective only for few months and cause side effects. Anatomical connections exist between vestibular nuclei and hippocampus. Atrophy of hippocampus was observed followed by vestibular lesion[5]. Caloric vestibular stimulation enhances hipppocampal longterm-potentiation through stimulating acetylcholine secretion from septohippocampal cells[15,16]. Vestibular stimulation was a reliable and powerful treatment option for attention-deficit/hyperactivity disorder (ADHD), especially when combined with other training[30].In the present study we have observed significant effect of hot water vestibular stimulation. However the effect of cold water stimulation is not significant. 15 degrees centigrade may not be stimulate vestibular system effectively[15].

CONCLUSION

This study categorically confirms that caloric vestibular stimulation with hot water enhances cognition. Hence this study certainly merits further studies with higher sample size to confirm whether caloric vestibular stimulation can be recommended for enhancement of cognition.

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