

Beneficial effects of vestibular stimulation on learning and memory: an overview

Editorial

The vestibular system is considered the entryway to the brain and is said to have the most important influence for everyday functioning. Recent studies underline the function of vestibular system is not just maintaining balance and equilibrium or reflexes but beneficial in advanced functions like improving cognition, improving diabetic condition, reducing stress etc. As the vestibular system remains enigmatic among the human senses it is fast becoming one of the most thoroughly and broadly researched topic.¹ Stimulating vestibular system in a controlled way has shown many benefits like decreased self-stimulation, decreased hypersensitivity, increased postural security, increased concentration and attentiveness, increased balance, increased body awareness, calming effects, reduction of abnormal muscle tone.² Although cradles, which apply a basic form of passive vestibular stimulation, have existed for a very long time ago to develop various strategies to achieve vestibular stimulation have started in 17th century. Ancient Greek and Roman physicians used motion devices to calm, soothe and even cure people.³ Various motion devices, like hanging beds, conventional swings, rotating chairs and rotating beds were used for vestibular stimulation and later in 18th century reappeared in the name of famous scientists like Cox's chair or Hallaran's swing.^{4,5} Day today life vestibular stimulation can be achieved by activities like jogging, jumping (in a trampoline), playing merry go rounds (rotatory stimulation), swinging (linear stimulation), dancing. Experimentally vestibular system can stimulate by placing surface electrodes on mastoid process i.e. stimulating the vestibular nerve. This method is called Galvanic Vestibular Stimulation.⁶ Caloric Vestibular Stimulation is a method using cold/hot water/air against the tympanic membrane to stimulate current in the endolymph of the vestibular organs.⁷ Vestibular stimulation is also achieved by rotational and linear motion devices.^{8,9} Magnetic and infrared vestibular stimulation are the new advanced techniques in vestibular research.^{10,11}

Several reports suggested that spatial learning deficits in animals and humans after vestibular lesions or loss. It has been found that head direction cells¹² in the anterior thalamic nuclei and location-related firing of 'place cells' in the hippocampus was abolished in rats after bilateral labyrinthectomy.^{13,14} Neuronal tracers, electrophysiology, immuno-histochemistry, functional imaging and also indirectly through behavioural studies in animals and humans has revealed that the vestibular system is massively connected to the cognitive areas of the brain like hippocampus and parahippocampal region, parieto-insular vestibular cortex (PIVC), anterior parietal cortex, posterior parietal and medial superior temporal cortices, cingulate gyrus and retrosplenial cortical regions.¹⁵ Place cells (important for identifying specific location, time representation of the past (spatial memory) and the future (navigational planning) and Head Direction cells (HD cells) are direction specific cells essential to navigate without landmarks (e.g., an unknown environment) are two categories of cells are mainly influenced by vestibular inputs.¹⁶ So vestibular atrophy primarily affects these cells and impairs the generation of theta rhythm by place cells.¹⁷ Patients with chronic bilateral vestibular deficits suffers bilateral hippocampal atrophy and spatial memory impairment. vestibular stimulation enhances Long Term Potentiation (LTP) in

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CA1 area of hippocampus especially by activating septohippocampal cells and causes long-lasting increase in synaptic transmission of Ach.¹⁸ As the decrement of Serotonin and brain derived neurotrophic factors strongly affected in the regulation of synaptic plasticity and neurogenesis, various experiments have proven that vestibular stimulation is beneficial in increasing serotonin level in brain.¹⁹ Another study has proven that rotatory vestibular stimulation increase in the dendritic arborization and synapses in the hippocampal pyramidal neurones which improves the performance in the spatial learning tasks. Vestibular stimulation not only increases Ach level but decreases the AchE activity.¹⁹ Vestibular stimulation inhibits HPA and SAM axis so create a stress less condition which modulates learning and memory.²⁰

Even though the effectiveness of vestibular stimulation in improving learning and memory reported in various studies, the extent of beneficial effects in dementia are not deeply explored. Hence, large scale studies are recommended to ensure the effectiveness and therapeutic effects of vestibular stimulation in dementia.

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Conflict of interest

The author declares no conflict of interest.

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