COGNITIVE PROBLEM IN PATIENT WITH VESTIBULAR MIGRAINE: A QUESTIONNAIRE BASED STUDY

DWIJENDRA MISHRA

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MANASAGANGOTHRI, MYSURU-570006

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CERTIFICATE

This is to certify that this dissertation entitled **"Cognitive problem in patient with Vestibular Migraine: A Questionnaire Based Study"** is a bonafide work submitted in part fulfilment for degree of Master of Science (Audiology) of the student Registration Number: P01II21S0054. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru,

September 2023

Dr. M. Pushpavathi

Director

All India Institute of Speech and Hearing,

Manasagangothri, Mysuru-570 006

CERTIFICATE

This is to certify that this dissertation entitled **"Cognitive problem in patient with Vestibular Migraine: A Questionnaire Based Study"** has been prepared under my supervision and guidance. It is also been certified that this dissertation has not been submitted earlier to any other Universityfor the award of any other Diploma or Degree.

Mysuru,
September 2023

Dr. Animesh Barman
Guide
Professor of Audiology
All India Institute of Speech and Hearing,
Manasagangothri, Mysuru-570 006

DECLARATION

This is to certify that this dissertation entitled **"Cognitive problem in patient with Vestibular Migraine: A Questionnaire Based Study"** is the result of my own study under the guidance a faculty at All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru **Registration No. P01II21S0054**

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कर्मण्येवाधिकारस्ते मा फलेषु कदाचन।

मा कर्मफलहेतुर्भूर्मा ते सङ्गोऽस्त्वकर्मणि॥

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ABSTRACT

The vestibular system encompasses both peripheral and central connections that extend from the inner ear to the midbrain and further into subcortical structures. Any structural irregularities in this system can potentially result in Vestibular problems. Recent clinical findings indicate that individuals experiencing vertigo often report accompanying cognitive symptoms. These symptoms encompass difficulties with attention, memory, spatial perception, navigation, mental rotation, and the mental representation of three-dimensional space. Although there is increasing research interest in vestibular disorders and cognition, the relationship between specific vestibular disorders and cognition has been less explored. Thus, this study aimed to determine whether there are any cognitive problems associated with patients diagnosed with Vestibular Migraine.

A non-experimental standard group comparison research design was employed, involving a total of 65 participants. Among them, Group-I consisted of 25 individuals (with a mean age of 32.68 years) considered clinically normal, while Group II included 40 participants (with a mean age of 40.35 years) diagnosed with Vestibular Migraine. The study was conducted using an online/tele-mode, where a questionnaire was sent to the participant via email/WhatsApp. This questionnaire comprised 10 questions related to cognition, primarily selected from the Neurobehavioral Cognitive Status Examination (NCSE), along with demographic details that participants were required to complete. For each response, a score of 0 was assigned for "Yes," 1 for "Sometimes," and 2 for "No" for subsequent analysis. The maximum achievable score was 20, while the minimum possible score was 0. Higher scores indicated fewer cognitive-related problems, whereas lower scores suggested more cognitive issues.

The collected data was analyzed using the Shapiro-Wilk's test, revealing a non-normally distributed dataset. Subsequently, a Mann-Whitney U test was conducted, and results showed a significant difference in scores between Group I and Group II ($p<0.05$). Chi-square tests were performed to analyze responses to the ten cognition-related questions in relation to the overall scores assigned. These tests indicated that responses were dependent on the groups; in Group I, the number of individuals with cognitive problems was lower (resulting in higher overall scores), whereas in Group II, the number of individuals with cognitive problems was higher (resulting in lower overall scores).

An independent sample t-test was carried out to investigate the impact of associated problems like hypertension and hearing loss within the groups. The results showed no significant difference in responses within the groups, with no significant disparity found ($p>0.05$). Additionally, a Shapiro-Wilk's test was conducted for diabetes data, which also exhibited a non-normally distributed pattern. A Mann-Whitney U test was then employed for within-group comparison, and the results indicated no significant difference [/Z/= -0.310, p=0.756].

The findings from the present study suggest a noteworthy association between cognitive issues in participants diagnosed with vestibular migraine. This aligns with prior research highlighting the vestibular system's role in cognitive function, indicating that vestibular disorders could potentially lead to challenges related memory, concentration, thinking, and distractibility exhibited notable impairments and other cognitive difficulties. Establishing a connection between cognition and vestibular disorders can contribute to more comprehensive diagnostic approaches and rehabilitation, ultimately enhancing the quality of life for patients.

CHAPTER 1

INTRODUCTION

Vestibular disorders are seen in a significant number of adults. The prevalence of vestibular disorders increases with age and comorbidities (Agrawal et al., 2013). However, within the broader population, this term is often linked to dizziness sensations, such as light-headed or disoriented. The vestibular system comprises three semi-circular canals and two otolith organs, playing a critical role in preserving balance and stabilizing gaze. However, an increasing body of literature recognizes that the functions of the vestibular system go well beyond these basic reflexes.

The vestibular networks within subcortical regions travel through the midbrain and then into the inner ear, forming a complex network of interconnected pathways. Different points along these pathways are likely to affect vestibular function due to these dispersed connections. Furthermore, this network is composed of white matter and nerves, especially the vestibulocochlear nerve, a composite sensory nerve which is susceptible to injury and disrupts cell signalling (Gurvich et al., 2013).Therefore, damage to the vestibular system may lead to functional limitations and cause vertigo or dizzy symptoms. Recent clinical reports suggests that patients experiencing vertigo frequently report associated cognitive symptoms, including issues with attention, memory, spatial perception, navigation, mental rotation, and poor mental representation of three-dimensional space. These cognitive symptoms may not always be linked to specific episodes of vertigo or dizziness (Guidetti et al., 2020). Many animal studies conducted over the past few decades have consistently demonstrated that mice with vestibular injuries exhibit spatial cognition deficits (Wallace et al., 2002; Zheng et al., 2012).

Cognitive functions, including spatial memory, navigation, etc., are frequently affected in the elderly population, particularly among those with dementia. Age-related loss of vestibular cells or neurons may contribute to the development of vestibular disorders. Consequently, vestibular dysfunction could potentially be considered a risk factor for cognitive disorders, especially in older individuals (Jun et al., 2020).

Numerous research on animals have investigated the relationship between cognition and the vestibular system. They have uncovered that bilateral vestibular dysfunction can lead to unusual responses in place cells and disrupt theta rhythm, both in the hippocampus (Hitier et al., 2014) and more recently in the entorhinal cortex (Jacob et al., 2014). In earlier investigations, it was noted that individuals with bilateral vestibular loss who underwent surgery experienced bilateral hippocampal atrophy of approximately 17% affected which coincided with spatial memory impairments (Brandt et al., 2005a). Recent research has further revealed that individuals with even partial bilateral vestibular loss exhibit bilateral reductions in grey matter volume within the brain (Hüfner et al., 2007).

The correlation between untreated, persistent hearing loss and cognitive decline has been well established. However, the connection between vestibular issues and cognition has been explored to a lesser extent. Research has indicated that even minor hearing loss is associated with poorer results on memory and executive function assessments (Lin et al., 2011). Early intervention for age-related hearing loss, such as using hearing aids, may reduce the detrimental effects on grey matter atrophy, mitigating cognitive issues. Consequently, a question arises as to whether long-standing untreated hearing loss could result in sensory deprivation to the brain over time, potentially leading to cognitive problems. Similarly, one might wonder if untreated and persistent vestibular symptoms could produce similar effects.

Numerous research conducted over the past three decades have demonstrated that vestibular migraine is a frequent cause of repeated episodes of vertigo. Vestibular migraine (synonyms: migrainous vertigo, migraine-associated dizziness, benign recurrent vertigo) designates vertigo attacks which are directly caused by migraine (Moretti et al., 1980). Migraine is an episodic disease that manifests itself with nausea, vomiting, photophobia, and phonophobia that accompany severe headache. Many patients complain of symptoms such as spontaneous or positional vertigo that is either during migraine attacks or free from the attacks, intolerance of head movements, and imbalance (Kayan & Hood, 1984).

Individuals experiencing vestibular complaints often tend to adopt a sedentary lifestyle, leading to a decrease in their overall quality of life. Symptoms, particularly pronounced in crowded and visually stimulating environments, have a detrimental impact on the patient's daily activities. When the severity of the disease increases, the severity of the symptoms increases too; and comorbid complaints also occur, and concentration and memory difficulties are seen.

Migraine has been reported as the sixth most common pathogenesis of disability. In addition, migraine has been reported as the second most common factor associated with disability-adjusted life years worldwide by the Global Burden of Disease study (Feigin et al., 2017). Migraine is one of the most common pain disorders and its prevalence affects up to 25% of women and 9.4% of men worldwide (Roncolato, et al., 2000).

Vestibular migraine stands out as the most common cause of vertigo, accounting for a significant number of cases seen in specialized dizziness clinics (Von Brevern et al., 2006). It has been shown that vestibular system has a negative effect on cognitive processes (such as memory, spatial navigation, perception capacity of the body, concentration difficulties, and learning difficulties) (Smith et al., 2005). However, the relationship between vestibular migraine and cognition remains relatively less explored.

Neurophysiological studies in the literature have indicated that migraine patients may experience cognitive changes, psychomotor disorders, and memory impairments. Additionally, it has been noted that short-term migraine attacks can lead to difficulties in concentration, comprehension, communication, as well as visual-spatial and numerical memory (Rist et al., 2011)

Numerous studies have aimed to evaluate the quality of life among patients suffering from vertigo, resulting in the development of several questionnaires. One of the most frequently used tools is the Dizziness Handicap Inventory (DHI). The DHI serves as a widely accepted clinical instrument for assessing the impact of vertigo on the quality of life (QOL) across functional, emotional, and physical domains. It is important to note, however, that the DHI and other questionnaires like the Dizzy Factor Inventory, Vertigo Symptom Scale, and Vertigo-Dizziness-Imbalance Questionnaire primarily focus on physical handicaps and the emotional consequences, such as anxiety and depression. These questionnaires include relatively few questions specifically addressing cognitive dysfunction resulting from dizziness (Lacroix et al., 2016; Liu et al., 2019).

Examining the relationship between vestibular issues and cognition holds the potential to enhance the rehabilitation and management of specific disorders causing vestibular problems, should a correlation be identified. Cognitive-behavioral therapy (CBT), a psychotherapeutic approach aimed at identifying and modifying detrimental thought patterns influencing behaviour and emotions, could play a significant role. Studies have indicated that the combination of CBT and Vestibular Rehabilitation Therapy (VRT) could effectively address dizziness-related handicaps and discomfort. This suggests the possibility of CBT practitioners expanding their scope of practice in this context (Wan et al., 2018). Although these findings are preliminary, it is advisable for audiologists to consider integrating CBT as a complementary rehabilitation option for the treatment of dizzy patients alongside VRT.

1.1 Need for the study

It is evident that individuals experiencing vertigo frequently manifest associated issues such as cognitive challenges, emotional disturbances, anxiety, and fear. Research indicates that they encounter greater difficulties in tasks involving cognitive processes compared to those centered around physical mobility. Despite the availability of tools to assess various aspects, the focus on evaluating cognitive impairments in vertigo patients remains limited. Multiple studies have demonstrated a potential link between vestibular disorders and cognitive issues (Brandt et al., 2005; Smith & Zheng, 2013; Dobbels et al., 2019; Bigelow et al., 2020).

Thus, finding from this study could be used for appropriate rehabilitation and recommendations for a better quality of life. Hence, a suitable questionnaire could be used to identify cognitive problems in Vestibular migraine.

1.2 Aim of the study

The present study aims to explore any cognitive problem associated with patients diagnosed with vestibular migraine.

1.3 Objectives of the study

- To describe the nature of cognitive problems associated with vestibular migraine.
- To compare the cognitive abilities in patients diagnosed with vestibular migraine and clinically normal individuals.

CHAPTER 2

REVIEW OF LITERATURE

This review will discuss recent clinical studies regarding cognitive impairment in the context of various vestibular disorders. It will also examine recent epidemiological and survey-based studies that establish links between vestibular dysfunction and cognitive impairment. Additionally, it will explore cognitive challenges resulting from auditory versus vestibular disorders in various animal and human studies. The review will also present recent evidences connecting vestibular impairment to hippocampal atrophy and conclude by discussing cognitive management options for individuals with vestibular disorders.

2.1 Prevalence of vertigo

Murphy (2022) reported that during the period from May 2017 to August 2019, out of 901 patients, 215 individuals (24%) were referred to an otologist due to experiencing dizziness as their primary complaint. Notably, these patients often had accompanying conditions such as anxiety, sadness, migraines/headaches, and heart-related illnesses. Furthermore, in a neurologic assessment conducted by Von Brevern (2006), revealed that vertigo had a prevalence of 4.9%, migrainous vertigo was present in 0.89% of cases, and benign paroxysmal positional vertigo occurred in 1.6% of cases.

Vertigo, dizziness, and unsteadiness (VDU) symptoms have traditionally been associated with various vestibular and non-vestibular issues. In a population-based study conducted in north-eastern France, indicated that vertigo had a prevalence of 48.3%, unsteadiness was reported by 39.1% of the population, and dizziness was experienced by 35.6% of individuals. Notably, these three symptoms tended to occur together, with a prevalence of 69.4% when appearing as a group rather than in isolation.

Additionally, these episodes typically happened less frequently than once a month, and a significant majority, 90%, had a duration of less than two minutes of vertigo (Bisdorff et al., 2013).

An epidemiological study conducted within the context of the longitudinal and cross-sectional gerontological and geriatric population survey in Göteborg, Sweden (H70), focused on investigating the prevalence of balance issues, which encompassed vertigo, dizziness, and disequilibrium, particularly among elderly individuals. The study examined various age groups, revealing that 36% of women and 29% of men aged over 70 experienced balance problems. It was noteworthy that women tended to have a higher incidence of balance issues compared to men, and these problems tended to worsen with advancing age. For individuals aged between 88 and 90 years, the corresponding prevalence ranged from 45% to 51%. The most frequently reported symptom was poor balance or unsteadiness, affecting 11% to 41% of individuals, while 2% to 17% of respondents reported rotating symptoms. Conversely, other indications and symptoms were notably less common (Jönsson et al., 2004).

2.2 Hearing loss and its association with cognitive problems

Cognitive impairment often goes unnoticed for years because of its subtle onset, leading to delayed diagnosis and rendering treatment essentially ineffective. Understanding the relationship between hearing loss and cognition could have profound implications for the early detection and diagnosis of cognitive decline in older adults with hearing impairments. A literature review suggests that hearing loss is linked to difficulties in language comprehension, particularly in individuals with minimal cognitive impairment (those in the normal or pre-dementia group). However, as cognitive impairment progresses to moderate or severe levels (in the dementia group), the impact of hearing loss on cognitive function becomes even more significant (Peracino & Pecorelli, 2016).

Cognitive impairment frequently remains undetected for an extended period due to its gradual onset. This delay in diagnosis can significantly hinder the effectiveness of treatment. A growing body of evidence underscores an independent association between age-related hearing loss (ARHL) and dementia, suggesting that ARHL could serve as a viable target for preventive strategies against dementia. It is imperative to establish a causal link between ARHL and dementia (Chern & Golub, 2019; Hubbard et al., 2018). It has been observed that as the degree of hearing loss increases, cognitive test scores, particularly in memory and executive function, tend to decline (Lin, et al., 2011).

In 1976, Granick et al. conducted a study to explore the impact of moderate hearing loss on cognitive performance. They divided participants into two groups. The first group comprised 47 individuals with an average age of 71.5 years who were selected for their exceptional health. The second group consisted of 38 females, averaging 75.9 years of age, all of whom had significant physical health issues.

The results from both sample groups demonstrated a robust connection between hearing loss and scores obtained in cognitive tests. Significantly, verbal-type tests provided a more detailed insight into these associations compared to performance-based tests. These findings suggest that older individuals might possess more cognitive deficits than their test results indicate, underscoring the importance of considering hearing when assessing their cognitive capacities. Similarly, Gurr & Moffat, (2001) reported similar outcomes regarding age, hearing loss, and cognitive impairment. They observed that older adults with hearing loss had an increased risk of dementia and exhibited a more rapid decline in Modified Mini-Mental Status Exam scores compared to their non-hearing-impaired counterparts. This data suggests that hearing loss could serve as an early indicator of cognitive decline in individuals aged 65 and older. Lentz (2022) also found that hearing loss had adverse effects on auditory perceptual skills and working memory.

Studies have been conducted to investigate how hearing loss and cognitive capacity impact cognitive processing demands when individuals listen to speech in noisy environments. In these studies, cognitive load was assessed using pupillometry, which measures pupil dilation, and subjective ratings. The findings revealed that as speech intelligibility decreased, there was a gradual increase in pupil response. Additionally, when it came to enhancing speech intelligibility in noisy settings, both aging and hearing loss were associated with a reduced ability to release cognitive effort. These characteristics could potentially lead to early cognitive fatigue in challenging listening situations or be linked to shallow processing of speech in such environments. However, further research is required to gain a comprehensive understanding of the underlying mechanisms driving these findings. Furthermore, regardless of the speech intelligibility levels, individuals with better Text Reception Thresholds (TRTs) and a broader vocabulary exhibited a higher cognitive processing burden. This suggests that utilizing linguistic skills to improve speech perception is connected to an increased level of cognitive load during listening (Zekveld et al., 2011). These findings suggest that older individuals might possess more cognitive deficits than their test results indicate, underscoring the importance of considering hearing when assessing their cognitive capacities.

2.3 Physiological basis of the vestibular system and its relationship with cognitive abilities

The vestigial nature of the vestibular system establishes a close relationship with our central nervous system. This system's origins lie in subcortical structures, extending through the midbrain and ultimately reaching the inner ear via a complex network of diverse pathways. Due to the diffuse connection, Abnormality at different points along the routes are expected to affect vestibular function. Furthermore, it is made up of white matter and nerves, especially the vestibulocochlear nerve, a composite sensory nerve that makes it susceptible to various injuries and weakens cell signalling (Gurvich et al., 2013).

A potential neurological explanation for the coexistence of vestibular and psychiatric symptoms is provided by the numerous well-established connections between the vestibular system and brain regions involved in cognitive and emotion processing, despite the lack of direct evidence to support direct pathology of the vestibular apparatus in psychiatric disorders (Smith, 2005).

A study was conducted on individuals clinically diagnosed with frontotemporal dementia (FTD) to investigate the potential role of vestibular issues in the clinical symptoms of FTD. During vestibular suppression (VS) tests, it was observed that caloric nystagmus was not consistently inhibited in the group with FTD syndrome. Furthermore, individuals with FTD syndrome who experienced gait disturbances significantly reduced VS compared to those without such disturbances. This research highlighted that regardless of the underlying neuropathological factors, individuals with FTD exhibit impaired VS function, leading to difficulties in regulating their vestibular function through visual perception. This impairment in individuals with FTD syndrome may be associated with gait disturbances (Nakamagoe et al., 2016).

2.3.1 Involvement of the brainstem

The raphe nuclei and locus coeruleus are two brainstem regions associated with various psychiatric disorders, and they both have connections with the vestibular nuclei. Specifically, the raphe nuclei receive inputs from the vestibular nuclei and send out both serotonergic and non-serotonergic projections to the vestibular nuclei (Cuccurazzu & Halberstadt, 2008). Additionally, they send axon collaterals to the central amygdaloid nucleus.

Both the functioning of the vestibular system and the processing of emotions are reliant on the limbic system. A direct connection exists between the vestibular system and the brain networks responsible for emotional processing, facilitated through the parabrachial nucleus (PBN) network. According to research by Balaban and Thayer in 2001, the parabrachial nucleus (PBN) exhibits reciprocal connections with the vestibular nuclei, amygdala, hypothalamus, locus coeruleus, and prefrontal cortex. The hippocampus is traditionally associated with memory consolidation, spatial navigation, and stress response. Migraine is characterised by episodic attacks triggered by various physiological and emotional stressors. Considering that migraine attacks can be seen as recurrent stressors, there is a suggestion that changes in both the function and structure of the hippocampus may play a significant role in the underlying mechanisms of migraine pathophysiology.

Furthermore, the MV group exhibited a higher prevalence of deep brain lesions, peripheral lateral ventricle lesions, and total white matter lesions compared to the simple migraine group. When assessing lesion severity, the MV group also had significantly higher ratings for deep lesions and peripheral lateral ventricle lesions (Wang et al., 2016).

2.3.2 Cortical connections to the vestibular system

Uncertainty persists regarding the precise locations and roles of the brain areas that process vestibular input (Zu Eulenburg et al., 2012). It has been hypothesized that because the anterior cingulate cortex is thought to be a component of the human vestibular cortex (López-Larson et al., 2002), it may act as a link between the vestibular sensorimotor areas and the prefrontal affect divisions that might control motivational states.

2.4 Animal studies related to the vestibular system and cognition

Early research on spatial navigation in animals suggested that animals employed external allocentric cues and non-visual idiothetic signals like vestibular and proprioceptive information to recall their way around a familiar environment (Ossenkopp et al., 1990).

In a study conducted by Wallace et al. in 2002, a foraging task was employed to evaluate the ability of rats to navigate back to a home base two weeks after undergoing surgery. This research marked the initial comprehensive examination of spatial memory following bilateral vestibular injuries. In the absence of visual cues, the study revealed that rats with bilateral vestibular dysfunction (BVD) experienced significant difficulties with spatial memory.

According to a study by Baek et al., (2010), rats who were 14 months post-BVD were more significantly affected in a spatial memory foraging task in the dark than those 14 5 months post-op, which used the most prolonged postoperative time interval used to date. Rats with induced Bilateral vestibular damage were shown to have poor spatial memory even in bright light. Rats with BVD at 6 weeks post-op performed considerably worse in a radial arm maze challenge than sham controls (Ferrè & Harris, 2017).

It is unclear whether animals experience spatial memory impairment due to brain vestibular dysfunction. There have also been reports of attentional and non-spatial object recognition memory problems in some animal investigations using surgical BVD (Zheng et al., 2009).

2.5 Human studies based on Vestibular Disorders and cognition

The most important takeaway from recent research is that vestibular dysfunction can lead to cognitive impairment, especially in the elderly (Smith, 2017).

In a study by Grimm et al. in 2009, on patients with Perilymph Fistula Syndrome, perceptual and memory abnormalities were examined. Out of a sample of 102 patients, over 95 percent reported enduring "disorientation" in situations where there was a conflict between visual and vestibular information. This disorientation occurred, for instance, when the visual field moved while the patient remained still. Additionally, more than 85% of the patients reported experiencing some degree of memory impairment, as evidenced by their performance falling within the impaired range in tasks involving digit symbol, block design, and picture organization.

2.5.1 Related to Spatial perception

In a study conducted by Yardley et al. in 2001, individuals with various vestibular disorders underwent an assessment of their postural stability on a moving platform while engaging in both non-spatial and spatial tasks. The findings indicated that as the difficulty of the balancing activity increased, the participants' reaction times slowed down, and their performance on tasks involving both spatial and non-spatial thinking became less accurate. The authors put forth a hypothesis that monitoring direction could impose significant cognitive demands on individuals with vestibular dysfunction, potentially leading to suboptimal performance on cognitive tasks.

During dual tasks, those with vestibular disorders have a slower gait speed, more imbalance, and veering than healthy people. However, the cerebral mechanisms remain unknown. Hoppes et al., (2020) investigated if those who experience visual vertigo (VV) have different cerebral activation during dual-task walking than people who don't have VV. There were no variations in cognitive performance across the groups. When walking on uneven terrain or doing a dual task, both groups slowed down; participants in the VV group walked slower than those who didn't have the problem under all scenarios. In all situations, patients with VV demonstrated lower brain activation in the bilateral prefrontal areas than CON subjects. During dual-task walking, VV participants showed lower prefrontal brain activation than CON participants. Lower cortical activity in VV patients could be related to a shift in attention away from the cognitive task to favour dynamic balance preservation.

Gresty & Golding, (2009) conducted research on the impact on cognition in patients with vertigo due to spatial disorientation. Numerous activities were employed to assess cognitive performance in various situations, such as visual-vestibular mismatch, vection, spinning, Coriolis, balance, and flight manoeuvres. The authors concluded that significant individual differences in handling disorientation and errors on cognitive tasks were observed, and protection against disorientation is provided by familiarity with and practice on a test.

2.5.2 Related to Anxiety and depression

Ataxia and oscillopsia represent the most prominent symptoms associated with impaired vestibular function. Nevertheless, the spectrum of vestibular dysfunction encompasses a broader range of complexities, encompassing issues related to concentration, memory, anxiety disorders, and reflex deficiencies (Smith et al., 2010).

It is significantly more challenging to distinguish poor performance on cognitive assessments in humans from emotional problems. Vestibular dysfunction in humans is often associated with mood disorders, including depression, anxiety disorders like panic attacks, and phobias (Persoons et al., 2003; Furman et al., 2006; Best et al., 2006; Gurvich et al., 2013).

It has been suggested that anxiety disorders can cause vestibular-related dizziness in addition to being a direct result of vestibular dysfunction and selective serotonin uptake (Asmundson et al., 1998; Tecer et al., 2004; Best et al., 2006) Furthermore; cognitive impairments can indirectly contribute to emotional issues. However, according to research by (Halberstadt & Balaban, 2006), neurons releasing serotonin in the dorsal raphe nucleus extend into both the amygdala and the brainstem vestibular nucleus. This finding opens up the possibility that variations in emotional states can exert direct influences on the vestibular system.

2.6 Auditory vs vestibular involvement in cognitive abilities

Studies have repeatedly discovered that rats without vestibular lesions but with the tympanic membrane removed considerably outperform animals with vestibular lesions in cognitive activities (Zheng et al., 2012). This finding is in line with research on individuals with vestibular dysfunction.

Animal research has demonstrated that lesions affecting the auditory and vestibular systems have distinct impacts on learning and memory. These experiments utilized various aminoglycosides like streptomycin and neomycin, which had varying levels of toxicity for the auditory and vestibular hair cells, (Schaeppi et al., 1991). It remains unclear whether the cognitive deficits associated with vestibular dysfunction in animals are solely linked to a decline in spatial memory. According to specific animal experiments involving surgical BVD, there are also abnormalities in attention and non-spatial object recognition memory, (Zheng, et al. 2009).

The documented cognitive abnormalities observed in cases of vestibular lesions are likely closely related to the connection between vestibular dysfunction and conditions like anxiety and depression (Balaban &Thayer, 2001; Staab, 2006).

2.7 Assessment of cognitive problems and vestibular disorders

Numerous investigations have established a connection between cognitive decline and vestibular dysfunction (Martins, 2012). The research findings emphasize that cognitive impairment is a prevalent occurrence in chronic vestibular conditions, including peripheral disorders like Meniere's disease (MD). Interestingly, age might have a comparatively minor impact on cognitive dysfunction when compared to the duration of vestibular symptoms before diagnosis and treatment, as well as the specific underlying causes.

Lacroix et al. in 2016 introduced the Neuropsychological Vertigo Inventory (NVI) in French, to assess various cognitive aspects including attention, memory, emotion, spatial perception, time perception, vision, and motor abilities. The cognitive impairment of 19 patients with vertigo was measured using the English version of the neuropsychological vertigo inventory (NVI). It was found that cognitive dysfunction is similar in vestibular migraine patients to Meniere's disease patients, although it is higher in BPPV patients. The Dizziness Handicap Inventory's (DHI) inability to assess the cognitive domain is shown in the absence of difference in scores among these patients (Liu et al., 2019a).

The World Health Organization Quality of Life-BREF questionnaire, a standardized assessment tool, to evaluate the quality of life among individuals experiencing vertigo. Their findings indicated that in comparison to a healthy control group, vertigo patients exhibited a notable increase in negative emotions and a significant decline in cognitive measures and overall quality of life.

Patients diagnosed with vestibular disorders may encounter cognitive difficulties, although there is no consensus on the type or severity of these issues. Cognitive dysfunction in a well-defined group of neuro-otology patients, controlling for any confounding factors with demographic data and scores from the depression, anxiety, and stress scale, was considered. Even though evaluations of cognitive dysfunction were linked to emotional distress, they were much higher in patients who were not suffering from depression, anxiety, or stress. Thus, it was concluded that patients suffering from dizziness and vertigo have significant cognitive impairment, affecting their attention and perception of space and time (Xie et al., 2022).

2.8 Specific disorders related to vestibular problems and cognition.

In 2016, Wang et al. conducted a study to investigate the impact of migraine-associated vertigo (MV) on the cognitive status and quality of life of patients. The study found that individuals with MV exhibited notably lower scores on cognitive tests compared to those in the simple migraine group. The MV group displayed lower scores on tests such as mini–mental state examination (MMSE), tracing, memory, and

Neuropsychological Vertigo Inventory (VFT). Additionally, the MV group demonstrated higher scores on the TMT-A and TMT-B tests, with the simple migraine group following suit. The study findings revealed that individuals in the MV group reported significantly lower scores in physical, social, mental, and total health categories, indicating a lower overall quality of life. In conclusion, the study highlighted that patients with migraine-associated vertigo experience more pronounced cognitive impairment compared to those with simple migraines or healthy volunteers. Moreover, they have a heightened occurrence of brain white matter lesions and exhibit lower quality of life (Wang et al., 2016).

A longitudinal study was conducted to investigate the cognitive challenges associated with anxiety and the persistence of symptoms in individuals with Meniere's disease. The study revealed that at the baseline, anxiety was correlated with factors such as intolerance of uncertainty, avoidance of physical activity due to fear, the belief that dizziness would escalate into a severe vertigo episode, and various aspects of sickness perception. These sickness perception aspects included emotional representations, consequences, psychological causes, and perceived treatment effectiveness. These correlations were observed among individuals who both received and did not receive self-help booklets as part of the study. Consequently, the study's results suggest that in the context of Meniere's disease, anxiety is linked to intolerance of uncertainty (Kirby & Yardley, 2009).

2.9 Reading and writing difficulties due to vestibular problem

Risey and Briner (1990) identified a connection between central vertigo and dyscalculia. Their study revealed that approximately 20% of vertigo patients exhibited significant errors when performing backward counting tasks. The specific error observed involved skipping an entire decade while counting backward by twos, as illustrated in the sequence "...84, 82, 70, 78, 76, 74, 72, 60, 68, 66...”. Interestingly, these individuals often failed to recognize the error, even when presented with their responses in written form. Furthermore, patients with this condition typically struggled with mental calculations, and it took them longer to complete counting tasks. When the error was presented visually to the patients, they still had difficulty detecting it**.**

2.10 Management options for patients with vertigo and cognitive problems

A study conducted on patients with recurrent benign paroxysmal positional vertigo (BPPV) revealed that some individuals continued to experience lingering symptoms even after a successful canalith repositioning procedure. In an attempt to address this issue, Wan et al. (2018) conducted a study to determine whether the addition of cognitive-behavioral therapy (CBT) to a low-dose betahistine treatment regimen could provide better outcomes for recurrent BPPV patients compared to using high-dose betahistine alone. To assess the effectiveness of these treatments, the researchers used several measurement scales, including the 25-item Dizziness Handicap Inventory (DHI), the Hamilton Anxiety Rating Scale (HARS), and the Hamilton Depression Rating Scale (HDRS) to monitor and evaluate the duration of residual dizziness. The study's results indicated that the combination of low-dose betahistine with CBT was just as effective in treating residual dizziness as high-dose betahistine alone. Additionally, the combination therapy showed some advantages over high-dose betahistine in reducing symptoms of depression and anxiety, suggesting potential benefits worth further investigation.

A study aimed to assess the effectiveness of a comprehensive psychological approach to vestibular rehabilitation. The study enrolled 18 patients who were experiencing vertigo due to brain injuries. These individuals, diagnosed with vestibular disorders, underwent a thorough evaluation and were subsequently referred to participate in the therapy program. The treatment comprised of a behavioural exposure program to movements and activities that caused vertigo and anxiety to aid compensation for vestibular impairment and physical anxiety symptoms. Self-rating questionnaires and a sway monitor were used to assess vertigo and balance, emotional discomfort, vertigo handicap, and coping techniques. The study's findings revealed significant improvements in the 18 patients who underwent vestibular rehabilitation. Their scores on measures related to vertigo symptoms, disability caused by vertigo, psychological distress, physical flexibility, and postural stability exhibited substantial enhancements following therapy, in stark contrast to the absence of change observed during a waiting list period (Gurr & Moffat, 2001).

In a study conducted by Ferrari et al. in 2014, a comparison was made between a group of individuals diagnosed with benign paroxysmal positional vertigo (BPPV) and a control group of healthy individuals. The study aimed to assess psychiatric-psychosomatic comorbidities, including symptoms related to anxiety, sadness, somatization, and alexithymia, while also exploring potential gender differences in these manifestations. The findings of the study indicated that BPPV patients exhibited a significantly higher prevalence of affective symptomatology, encompassing conditions like depression, demoralization, phobias, and anxiety, as well as somatization symptoms, in comparison to the healthy control group. These results suggested that the female gender might be considered a risk factor for these psychiatric and psychosomatic manifestations in individuals with BPPV.

A study done by Johansson et al. in 2001, aimed to assess the effectiveness of combining vestibular rehabilitation with cognitive-behavioral therapy in the treatment of dizziness. The results showed statistically significant improvements in walking time and better coping with movements that provoked dizziness, as evidenced by changes in the Dizziness Handicap Inventory scores. However, there were no observed effects on domains related to anxiety or sadness. Therefore, the authors concluded that the combination of cognitive-behavioral therapy and vestibular rehabilitation can be effectively used to reduce dizziness in elderly individuals (Johansson et al., 2001).

Therefore, the purpose of the study was to assess whether there are any cognitive concerns associated with Vestibular migraine. It is evident from the literature review that there may be a strong correlation between cognitive problems and vestibular impairment.

CHAPTER 3

METHOD

The study aimed to assess any cognitive problems associated with patients diagnosed with vestibular migraine using a standardized questionnaire. A non-experimental standard group comparison research design was employed to analyze the cognitive issues and to compare the different parameters associated with cognition within groups. The study was conducted in an online/tele-mode and Interview.

3.1 Participants

A total of 65 subjects participated in the study. Out of the 65, Group-I had 25 subjects clinically normal. They were also asked about their otological history and if they had any hearing-related problems, hypertension and diabetes. Normal subjects with no history of vertigo or associated problems that could impact balance and equilibrium were taken for the study. Group II had 40 subjects diagnosed with vestibular migraines by otolaryngologist and audiologist. They were diagnosed with vestibular migraines based on the criterions laid down by the Barany Society and the International Headache Society (2021) with no other otological problems or associated problems like ear discharge, ear pain, or history of surgery. Barany Society and the International Headache Society (2021) gave the below-mentioned diagnostic criteria for vestibular migraine.

1. At least five episodes with vestibular symptoms of moderate or severe intensity, lasting 5 min to 72 hours.
2. Current or previous history of migraine with or without aura according to the International Classification of Headache Disorders (ICHD-3).
3. One or more migraine features with at least 50% of the vestibular episodes.

4. Headache with at least two of the following characteristics one-sided location, pulsating quality, moderate or severe pain intensity, aggravation by routine physical activity.
5. Photophobia and phonophobia.
6. Visual aura.
7. Not better accounted for by another vestibular or ICHD diagnosis.

Subjects' consent and willingness to participate in the study were considered. The consent form had information regarding the study's title, a brief description of the research topic, and the approximate amount of time it would take to complete the questionnaire. The details were also explained verbally to the subjects. The form's initial section was the consent form, which included the alternatives of "Yes" and "No" for subjects to indicate whether they would like to be a part of the study and to proceed further with the next form. If the subjects voluntarily decided to participate in the study, they had to choose 'Yes', and further questions were followed. If subjects replied with "No," further questions were not asked.

3.1.1 Subject selection

Group I: All subjects in the control group, Group I, were clinically normal, with none of them having a history of hearing loss, hypertension, or diabetes**.** The subjects of control group were screened through a self-administered General Health Questionnaire five (GHQ-5), Developed by Shamasunder et al (1986), an effective for first stage screening tool for the detection of non-psychotic psychiatric illnesses. It is simple, easy to administer, acceptable and has high validity (Shamasunder et al.,1986). The responses were collected using a Likert Scale, ranging from 1 (Not at all) to 3 (Much more than usual). Per GHQ-5 guidelines, a score of 2 or higher is indicative of a psychiatric condition. Participants were invited to take part through phone calls, WhatsApp messages, or in-person interactions. 27 potential subjects were contacted, who were also regarded as a clinically normal and, 25 subjects responded and gave their consent to participate in the study.

Group II: The clinical groups were selected from the AIISH clinical database after a detailed analysis of the case files. 7 out of 40 individuals in Group II had been diagnosed with hearing loss, 3 participants had diabetes and 11 subjects with hypertension, with all 11are under medication for hypertension and all 3 participant are under medication for diabetes. Subjects with any other medical history like the history of surgery or trauma were excluded from the study.

3.1.2 Selection of the questionnaire

The questionnaire for assessing cognition was adapted and validated by Bhattacharya (2022) at AIISH, Mysore as a part of unpublished dissertation. In the initial phase, he identified three standardized questionnaires by conducting a literature search to assess a person's cognitive symptoms. He then distributed these questionnaires to three experienced Audiologists who held RCI certification. The Symptom Checklist-90-Revised, WHODAS 2.0, and The Neurobehavioral Cognitive Status Examination (NCSE) were the three standardized questionnaires that were selected by him. According to the audiologists, the Neurobehavioral Cognitive Status Examination's (NCSE) cognition-related questions were recommended by the three audiologist to assess the cognitive ability of an Individual. The NCSE is a screening test that employs independent assessments to examine functioning in five primary cognitive ability areas: language, constructions, memory, mathematics, and reasoning. It assesses cognition in a succinct yet quantitative manner (Kiernan et al., 1987). The NCSE has 93 questions in total, out of which 10 questions are related to cognition were recommended, These 10 questions were considered for the current study.

The questionnaire had 2 sections: (a) Demographic Details and (b) Cognitive related questions selected from NCSE

Part A: Questions related to the history of BP, diabetes, tinnitus, and if they were under any medication were asked.

Part B: 10 questions from the selected standardized questionnaire were asked.

3.2 Procedure

The procedure involved two phases. Phase I involved the administration of questionnaires online or via tele-mode. Phase II involved analysis of the information gathered.

3.2.1 Phase I: Administration of the questionnaire

The researcher interviewed participants online (google meet) or over the telephone. The interview began with disclosing information pertinent to the study and vouching for informed consent. After detailed Information were provided to the participants, the questionnaire was sent via mail/WhatsApp. The Information was in English in the consent form and instruction to give response to the questions in the questioners were also in English and the questionnaire; however, the details were also instructed in Hindi and Kannada as and when required. The instructions involved regarding the procedure of the questionnaire to be administered.

The subjects were asked if they were comfortable filling the questionnaire on their own, which was sent via WhatsApp or email. If not, the questions were verbally read out along with the response options by the researcher and the subject's responses were collected. The questionnaire, demographic details, and consent form are attached as Annexure I. Group II were contacted via telephone, and the questionnaire was sent.

The subjects who were capable and willing to fill the questionnaire independently were asked to fill it themselves; for the rest, the researcher filled the form by verbally asking the questions via phone.

3.2.2 Phase II: Analysis of the information gathered

For each response in the questionnaire related to cognition, a score of 0 for "Yes," 1 for "Sometimes," and 2 for "No" were given during the analysis and an 'overall score' for the cognitive abilities of each subject for all the 10 questions was calculated. The maximum possible score was 20, and the minimum possible score was 0. The higher scores would indicate that the subject had less cognitive-related problems, and lower scores would suggest that the subjects have more cognitive problems. To assess whether the presence or absence of associated conditions (hearing loss, diabetes, hypertension) influenced the results, scores of '0', '1', '2', or '3' were assigned. A score of '0' indicated no history of any associated condition, '1' indicated one associated condition, '2' indicated two associated conditions, and '3' indicated all three associated conditions. This allowed to calculate an 'overall associated score' for each subject. The 'overall associated score' was compared to the cognitive scores of the subjects.

3.3 Statistical analysis

Overall score was analyzed using SPSS (Statistical Package for Social Sciences) version 26. The Shapiro-Wilk’s test of normality was administered to check if the overall data is normally distributed or not. Descriptive analysis was carried out for the socio-demographic variables, including mean age, gender, and associated conditions (hearing loss, diabetes, BP). The obtained data regarding the cognitive scores were compared across the groups using inferential statistical analysis. Item analysis was conducted to assess the test's overall effectiveness as well as to assess the effectiveness of the test's individual items (questions).

CHAPTER 4

RESULTS

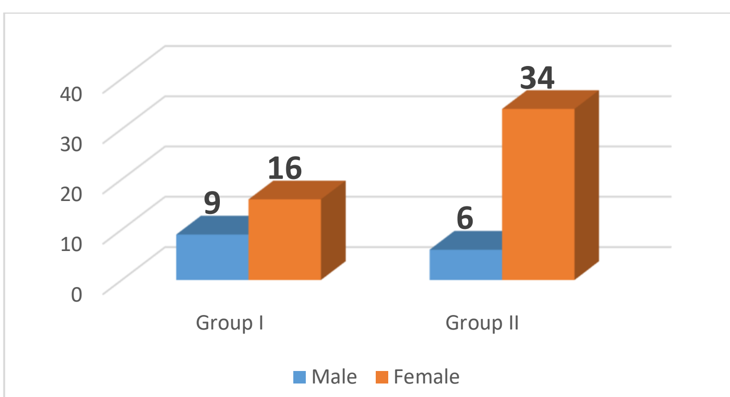
The collected data were tabulated and statistically analyzed using SPSS version 26.0 (Frey, 2017). Appropriate descriptive and inferential statistical analyses were conducted to compare between and within the group data.

4.1 Demographic Details

The total subjects taken for the study were 65 (N=65), out of which 25 were in Group I, i.e., in the control group or the clinically normal Group; 40 subjects diagnosed with vestibular migraine were categorized as Group II. Out of the 65 subjects, 15 were male, and 50 were female as shown in Figure 4.1. In Group I, the age range spanned from 23 to 68 years, while in Group II, it varied from 21 to 62 years. The mean age for Group I was 32.68 years with a standard deviation of 10.94, whereas for Group II, the mean age was 40.35 years with a standard deviation of 11.25. All 65 subjects had given their consent to participate in the study and answered all the questions in the questionnaire.

Figure 4.1

Number of subjects based on gender across the groups.



4.2 Associated condition

Group I had no history of diabetes, hearing loss or hypertension. Hence were not under any medication. However, in group II, 3 participants had diabetes and 11 subjects had hypertension, with all 11 are under medication for hypertension and all 3 participants under medication for diabetes. Subjects with any other medical history, like the history of surgery or trauma, were excluded from the study.

4.3 Otological complaints

None of the subjects in the control group, i.e., Group I, had a history of hearing loss, hypertension and diabetes. 7 out of 40 individuals in Group II was diagnosed with hearing loss, as shown in Figure 4.2. Other than subjects with reduced hearing sensitivity, subjects with other otological complaints like otalgia, otorrhea, itching sensation or blockage were excluded from the study. Figure 4.2 depicts the groups with associated factors (i.e., hearing loss, diabetes, or hypertention. A score of '0' was assigned for the subjects who reported none of these associated conditions. A score of '1' was given if the subjects had any of the associated conditions, '2' if they reported any two associated conditions or '3' if the subjects reported all the three associated conditions. Thus an 'Overall associated score' was later used to compare cognitive abilities and non-specific associated conditions.

4.4 Test of normality

The Shapiro-Wilk normality test was carried out to check whether the data followed the normal distribution or not. The results revealed that the data was normally distributed ($p < 0.05$) for the experimental group whereas for the control group it was not normally distributed as shown in Table 4.1.

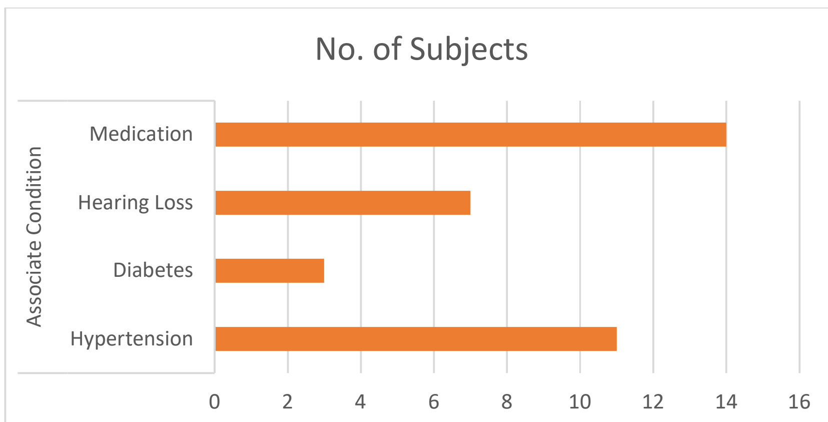
Table 4.1:

Shapiro-wilk's test results of normality for each group.

	Test Statistics	Degrees of Freedom	p-value
Group I	0.662	25	<0.001
Group II	0.965	40	0.244

Figure 4.2

Number of subjects with associated conditions in group II.



4.5 Comparison between the groups

One of the study's objectives was to check whether the individuals with vestibular migraine have any cognitive symptoms. Thus, A questionnaire was administered and for each response, scores were assigned during the analysis, i.e., 0 – for 'Yes', 1 – for 'Sometimes' and 2 -for 'No'. The overall score for each subject for all the 10 questions was calculated. Thus, higher scores indicates that the subject has a less cognitive problem, and lesser scores would suggest that the subject has significant cognitive issues. Therefore, the 'Overall score' for the subject would determine their cognitive ability (figure 4.3). It was observed that subjects diagnosed with vestibular migraine had mean overall scores of 8.77, significantly less than the control population, which had a mean score of 19.58. The details of the descriptive statistics is shown in Table 4.2. The Table depicts Median and interquartile deviation as the date did not fall within the normal distribution.

Figure 4.3

Scatterplot of the scores obtained by each participants in both the groups.

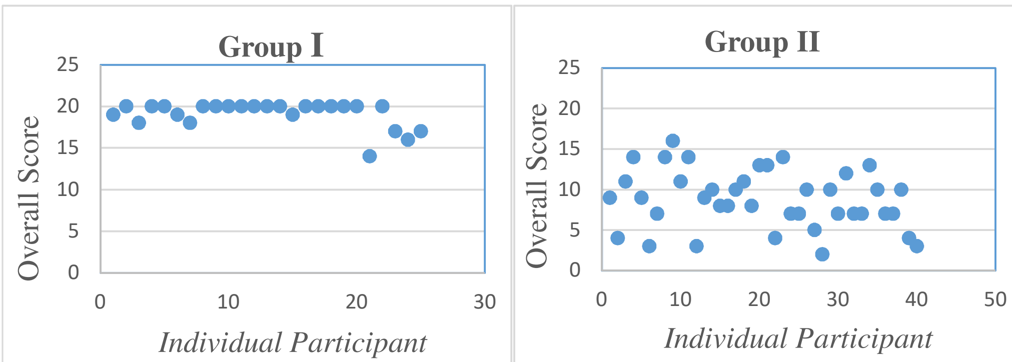


Table 4.2

Mean, Standard deviation (SD), median, and Interquartile deviation (IQR) of cognitive scores across groups.

	Mean	SD	Median	IQR	Minimum	Maximum
Group I	19.08	1.57	20	1.50	14	20
Group II	8.77	3.59	9.0	4.0	2	16

Since all the data is non normally distributed, Mann Whitney U test was administered to check if there was a significant difference between the groups. The results revealed that there was a significant difference between the two groups ($p < 0.001$, /Z/= -6.758).

Chi-square tests were done for each question, as depicted in Table 4.3. The Chi-square test revealed a significant association ($p < 0.05$) between the cognitive abilities and the groups, i.e., the responses to the cognitive-based questions changed according to the group. For Group I, the number of people with cognitive problems were less as compared to Group II i.e. experimental group as seen in Table 4.3.

Table 4.3

Chi-square test scores with respect to the cognitive-based questions between groups.

Questions	Group I	Group II	Chi-square (significance)
1. Does it seem that you can't think as quickly as before (i.e. before the diagnosis)?	Yes = 0 (0%) Sometimes = 2 (8%) No = 23 (92%)	**Yes = 13 (32.5%)** **Sometimes=25(62.5%)** No = 2 (5%)	$p < 0.001$
2. Does it seem that you find it hard to think clearly?	Yes = 0 (0%) Sometimes 6(24.0%) No = 19(76.0%)	**Yes = 14 (35.0%)** Sometimes = 25(76.0%) No = 1 (2.0%)	$p < 0.001$
3. Does it seem that you are easily more distracted?	Yes = 0 (0%) Sometimes 2(8.0%) No = 23 (92.0%)	**Yes = 24 (60.0%)** Sometimes = 16(40.0%) No = 0 (0%)	$p < 0.001$
4. Does it seem that you can't concentrate?	Yes = 0 (0%) Sometimes = 2(8.0%) No = 23 (92.0%)	**Yes = 25 (62.5%)** Sometimes = 14(35.0%) No = 1 (2.5%)	$p < 0.001$
5. Do you have trouble remembering the right words when talking?	Yes = 1 (4.0%) Sometimes=5(20.0%) No = 19 (76.0%)	Yes = 7(17.5%) Sometimes = 29(72.5%) No = 4 (10.0%)	$p < 0.001$
6. Do you have trouble understanding others?	Yes = 0 (0%) Sometimes = 0(0.0%) No = 25 (100%)	Yes = 9 (22.5%) Sometimes = 22(55.0%) No = 9 (22.5%)	$p < 0.001$
7. Do you have trouble following conversations?	Yes = 0 (0%) Sometimes = 0(0.0%) No = 25 (100%)	Yes = 7 (17.5%) Sometimes = 25(62.5%) No = 8 (20.0%)	$p < 0.001$
8. Do you have trouble with your speech?	Yes = 1 (4.0%) Sometimes= 2 (8.0%) No = 23 (88.0%)	Yes = 8 (20.0%) Sometimes = 22(55.0%) No = 10 (25.0%)	$p < 0.001$
9. Do you have trouble with reading?	Yes = 0 (0%) Sometimes = 0(0.0%) No = 25 (100%)	Yes = 5 (12.5%) Sometimes = 26(65.0%) No = 9 (22.0%)	$p < 0.001$
10. Do you have trouble with writing?	Yes = 0 (0%) Sometimes = 0 (0.0%) No = 25 (100%)	Yes = 2 (5.0%) Sometimes = 17(42.5%) No = 21 (52.5%)	$p < 0.001$

Table 4.3 illustrates that patients with vestibular migraines experienced a significant decline in cognitive abilities, particularly in the domains of quick thinking and decision-making (i.e., questions 1 and 2). Over 35% of these patients reported encountering problems in these areas, and roughly 65% to 75% of them noted experiencing such issues "sometimes." Additionally, more than 60% of patients with vestibular migraines frequently grappled with being easily distracted and maintaining concentration due to their condition (questions 3 and 4). Approximately 20–70% of these patients also struggled with memory. They faced challenges in keeping up with conversations, recalling appropriate words during discussions, and comprehending others. In contrast, over 4% continuously and 20% experience occasionally of patients in the normal group reported in question 5, no problems in these cognitive domains (questions 6, and 7). About 20% of patients with vestibular migraine experienced speech-related problems frequently whereas over 30% of them had encountered speech-related issues sometime. In contrast, 4% of the subjects in the normal group displayed any speech-related issues (question 8).

Patients with Vestibular Migraine occasionally reported reading and writing problems, with rates of 12% for reading and 5% for writing, respectively (question 9 and 10). However, fewer cognitive issues were overall seen in the reading and writing domain, and more participants chose to answer "No" to the questions than the normal. Thus, the results showed that cognitively relevant tasks like memory and concentration were more adversely impacted than other domains in Group II.

Item analysis was conducted to evaluate the effectiveness of the test's individual items (questions) as seen in Table 4.4. The Cronbach's alpha value (α) was calculated for the questionnaire to check the internal consistency and correlation of the questions, which came around 0.7 to 0.8, indicating that all 10 questions had a good internal consistency and high item correlation.

Table 4.4

Item analysis of the cognitive-based questions.

Questions	Cronbach's alpha value (α)
1. Does it seem that you can't think as quickly as before (i.e. before the diagnosis)?	**0.835**
2. Does it seem that you find it hard to think clearly?	**0.803**
3. Does it seem that you are easily more distracted?	**0.800**
4. Does it seem that you can't concentrate?	**0.805**
5. Do you have trouble remembering the right words when talking?	**0.818**
6. Do you have trouble understanding others?	**0.781**
7. Do you have trouble following conversations?	**0.799**
8. Do you have trouble with your speech?	**0.782**
9. Do you have trouble with reading?	**0.804**
10. Do you have trouble with writing?	**0.782**

4.6 Associated factors and their influence on cognition

Scatter plot shown in Figure 4.4, illustrates the experimental groups along with their associated factors, such as hearing loss and hypertension. To assess the potential impact of these confounding variables on the responses within each group, an independent sample t-test was conducted, and the results are presented in Table 4.5.

Figure 4.4

Scatterplot of the score assigned to different participants with associated factors for group II (n = 40).

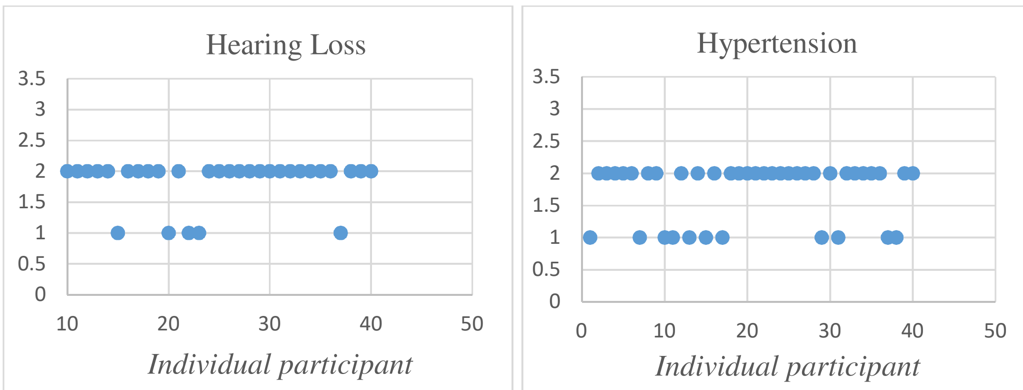


Table 4.5

Independent sample t-test for subjects with Hypertension, and Hearing loss within groups II.

	Hypertension			Hearing loss		
	t-value	df	*p*-value	t-value	df	*p*-value
Group II	**1.032**	**38**	**0.309**	**0.873**	**38**	**0.388**

From Table 4.5 there was no significant effect on cognitive scores for subjects with a history of hearing loss as well as hypertension for Group II The. Shapiro-Wilk normality test was carried out to check whether the data followed the normal distribution or not. Since the data is not normally distributed, Mann Whitney U test was administered to check if there was a significant difference in within group comparison. Results revealed that there was no significant difference was observed [/Z/= -0.310,

p=0.756] hence it can be inferred that positive history of diabetes mellitus had no significant effect on cognition scores.

4.7 Summary of the results

The results of the present study revealed a significant difference in the cognitive scores between Group I and Group II. Indicating that subjects with vestibular Migraines had cognitive-related issues. Cognitive-related questions about thinking skills, memory, and distractibility were most affected, whereas reading and writing skills were the least involved in the groups. Item analysis was conducted and a good item correlation was found for all the 10 questions. No significant association was found between associated conditions like diabetes, hypertension, hearing loss, and cognitive abilities.

CHAPTER 5

DISCUSSION

In recent years, substantial evidence has emerged indicating a connection between the decline in vestibular function and cognitive issues. The current study reveals interesting findings with respect to vestibular problems and cognitive symptoms. The outcomes indicated notable disparities in cognitive abilities between individuals experiencing vertigo and those not experiencing it. These findings could carry significant clinical implications for improved assessment and treatment.

5.1 Vestibular Migraine and cognition

The study's first objective was to determine if there is any cognitive-related problem in patients with Vestibular migraines. The Vestibular Migraine group was compared to the normal group after administering the questionnaire. The results revealed a significant difference in cognitive scores between the vestibular migraine and the normal groups. The Vestibular Migraine group gave more "Yes" responses to the items pertaining to cognition, indicating that their disorder was causing them cognitive difficulties as compared to normal.

The results of the present study corroborate those of several studies on vestibular migraine. In a controlled trial by Wang et al. (2016), involving Vestibular migraine patients and healthy individuals, it was established that the cognitive dysfunction in vestibular migraine patients was notably more severe.

Individuals with migraines often experience persistent vasomotor dysfunction. This dysfunction can lead to cerebral vasospasms, reducing blood flow volumes in perforating arterial branches and resulting in degeneration of the brain's white matter

(Avci et al., 2015). Studies using imaging techniques conducted on patients with vestibular migraines have demonstrated a higher incidence of white matter lesions when compared to the general population. Wang et al. (2016), provides confirmation that migraine patients often exhibit white matter lesions and experience cognitive impairment, including reduced memory function, responsiveness, and diminished abilities in information recognition and processing.

Regarding cognitive impairment in vestibular migraine patients, researchers have observed a significant concentration of brain activity within the parietal lobe and the hippocampus. The hippocampus is a crucial component of the limbic system of the brain. Learning, empathetic reactions, memory development, and storage are all significantly influenced by hippocampal function. Additionally, Brandt et al., (2005) reported that 17% of individuals with bilateral vestibular dysfunction exhibited signs of hippocampal atrophy. These findings strongly suggest a close association between damage to vestibular function and cognitive impairment (Wei et al., 2018).

It has been shown that short-term migraine attacks can lead to difficulties in concentration, comprehension, communication, as well as visual-spatial and numerical memory (Rist et al., 2011). The interaction and projections of the central vestibular system with the limbic system suggest a potential link between central vestibular function and cognitive processes. The integration of the vestibular network in cognitive function, both at the cortical level and within the hippocampal and limbic system, may play a significant role in understanding higher aspects of central vestibular function and dysfunction (Hitier et al., 2014; Brandt et al., 2005). Repeated episodes of migraine, involving repetitive painful experiences for patients, can lead to the gradual onset of cognitive impairment and emotional changes such as anxiety and depression. According to Zhang, (2020) Patients may also experience difficulties with concentration and other psychological problems. In the long run, these issues can significantly impact the quality of life for affected individuals. Moreover, individuals with psychotic illnesses may experience a reduction in hippocampus volume in association with increased emotional stress (Collip et al., 2013).

5.2 Domain specific Cognitive problems in patients with vestibular migraine

Table 4.4 shows that patients with vestibular migraine significantly declined their cognitive abilities. Questions related to thinking skills, memory, distractibility, and concentration were maximally affected. In vestibular migraine, The primary mechanism underlying headaches in migraine patients involves altered neural activity within the trigeminovascular system (TVS) (Daniela Pietrobon, 2012) Altered sensory modulation or integration within the thalamo-cortical network may result in symptoms such as dizziness and spatial disorientation. Elevated activity within the trigeminovascular system (TVS) and nociceptive brainstem canter's could contribute to headache episodes. Additionally, disruptions in the activity of the vestibular system could lead to transient vestibulo-ocular dysfunction or increased vestibular sensitivity, both of which are linked to migraine characteristics. (Pietrobon & Moskowitz, 2013).

Altered sensory modulation or integration within the thalamo-cortical network may result in symptoms such as dizziness and spatial disorientation. Elevated activity within the trigeminovascular system (TVS) and nociceptive brainstem centers could contribute to headache episodes. Additionally, disruptions in the activity of the vestibular system could lead to transient vestibulo-ocular dysfunction or increased vestibular sensitivity, both of which are linked to migraine characteristics.

Furthermore, vestibular system disorders have been linked to learning disabilities in children (Bundy et al., 1987). A similar reason could cause reading and writing problems for the patients in the current study. However, the present study was conducted on an adult population. Thus, further research is required to conclude. Therefore, the cognitive domains in the questionnaire pertaining to memory, thinking, concentration, speech, reading, and writing abilities would help determine if patients with vestibular migraine also suffer from these cognitive issues

5.3 Influence of Associated conditions on cognition

In the present study, several subjects within the experimental groups were associated with conditions such as diabetes, hypertension (BP), or hearing loss, as illustrated in Figure 2. The aim of this research was to investigate whether any of these conditions had an impact on cognitive abilities.

The findings of the current study clearly indicate that a history of diabetes did not exert any influence on the cognitive scores within the experimental groups. Similarly, there was no observable impact on cognitive performance in patients with vestibular migraine who had a history of hearing loss. Moreover, no significant effect was observed in vestibular migraine patients with a history of hypertension (BP).

Previous research has suggested that individuals with diabetes may face a decline in cognitive function over time, as evidenced in studies by (Gispen & Biessels, 2000; Biessels et al., 2008; Ruis et al., 2009; Creavin et al., 2012). However, in the current study, the influence of diabetes on cognitive abilities was determined to be statistically insignificant within the groups. Similarly, other studies have pointed to the possibility that individuals with hypertension may eventually experience a decline in their cognitive function (Skoog, 2003, Birns & Kalra, 2009; Knecht et al., 2009; Hajjar et al., 2011& Power et al., 2013). However, in the current study, the impact of hypertension on cognitive abilities was found to be not statistically different within the groups.

There are ample evidences that hearing loss leads to dementia and other cognitive problems (Granick et al., 1976); (Lin et al., 2011) 2011; (Peracino, 2014),; (Dawes et al., 2015); In the current study, a within-group comparison was conducted to assess whether hearing loss had an impact on cognitive problems in patients with vestibular migraine. The results revealed no significant difference, suggesting that hearing abilities did not play a substantial role in individuals suffering from both vestibular migraine and cognitive-related issues. Hence, the cognitive problems observed in subjects with vestibular migraine may be attributed to the vestibular problem itself or a combination of both factors. This finding is consistent with similar results reported in various studies.

For instance, in an animal study conducted by (Smith & Zheng, 2013), middle ear structures (specifically, the tympanic membrane and ossicles) were surgically altered to achieve partial auditory control, resulting in partial sound transmission to the cochlea. Surprisingly, they found that animals without vestibular lesions but with the tympanic membrane removed outperformed animals with vestibular abnormalities in cognitive tasks. Another supporting study suggests that spatial memory issues in animals with benign paroxysmal positional vertigo (BVD) are not primarily attributed to hearing loss but rather to vestibular deficits (Brandt et al., 2005).

Furthermore, animal research has provided evidence that lesions in the auditory and vestibular systems yield distinct effects on learning and memory (Schaeppi et al., 1991). Thus, based on the findings of the current study, it can be inferred that hearing loss may not play a significant role in affecting the cognitive problems in patients with vestibular deficits. However, to arrive at a precise conclusion, further analysis is required, taking into account factors such as the type, degree and duration, and conducting a comparison between vestibular and hearing issues.

CHAPTER 6

SUMMARY AND CONCLUSION

The current research aimed to assess if vestibular migraine patients have any cognitive problems. A non-experimental standard group comparison research design was used, and 65 subjects (25 normal, 40 vestibular migraine) participated in the survey via online/tele-mode. The clinically normal subjects had no history of vertigo. Vestibular Migraine with no other otological complaints like ear discharge, ear pain or any history of ear surgery, were taken for the study. The standardized questionnaire i.e., the Neurobehavioral Cognitive Status Examination (NCSE), used to assess cognition in individuals which was adapted and validated by Bhattacharya (2022) at AIISH, Mysuru, as part of an unpublished dissertation. This same questionnaire was employed in the present study as well, and was used to compare the cognitive scores of individuals with vestibular migraine and the data obtained from clinically normal subjects. The study revealed a significant increase in cognitive problems in vestibular migraine patients compared to the normal. It could be because of the primary mechanism underlying headaches in migraine patients involves altered neural activity within the trigeminovascular system (TVS).

Furthermore, the trigeminal nucleus is interconnected with the contralateral thalamus, which subsequently sends projections to various cortical regions, including the temporal, parietal, insular, and cingulate areas. Additionally, nociceptive centers in the brainstem, such as the nucleus raphe magnus, periaqueductal gray, and hypothalamic regions, maintain connections with both the TVS and vestibular nuclei. These reciprocal connections have the potential to regulate neural activity within both the TVS and the vestibular system.

As per the questionnaire outcomes, cognitive domains such as memory, concentration, thinking abilities, and distractibility exhibited notable impairments in contrast to domains like reading and writing skills. This discrepancy might be attributed to the specific brain regions affected by vestibular problems, such as vestibular migraine, primarily impacting the former set of domains rather than the latter. Additionally, associated factors like hypertension (BP), diabetes, and hearing loss (HL) was evaluated to determine if they exerted any influence on the cognitive abilities. The analysis revealed that diabetes, hypertension, and hearing loss did not significantly affect the cognitive performance of the experimental groups. Elevated blood sugar levels can have detrimental effects on your health, particularly by causing damage to blood vessels and impairing blood circulation. When the brain receives inadequate blood flow, it can lead to cognitive issues, affecting your ability to think clearly. Additionally, high blood sugar levels can result in an excess of serotonin and neurotransmitters in the brain. While these chemicals usually have a positive impact on nerve cells and brain function, an overabundance can have the opposite effect. This imbalance can lead to brain cell damage, nerve damage, and brain inflammation, all of which contribute to cognitive problems such as memory loss and brain fog.

In conclusion, this study revealed cognitive challenges in individuals with vestibular migraines, affecting memory, thinking, concentration, speech, and conversation, alongside reading and writing skills. Importantly, these cognitive issues persist even when comorbid conditions are present. Recognizing the multifaceted nature of vertigo, the study emphasizes the importance of proactive engagement in neuropsychological compensation, overcoming avoidance behaviors, and fostering self-assurance and independence for those facing vestibular problems. Additionally, it underscores the need to address psychological aspects like mood, cognition, and behavior when managing vestibular disorders.

6.1 Clinical Implications

The findings of the current study imply that patients with vestibular migraines may indeed face cognitive issues, as their cognitive abilities were notably lower when compared to individuals in the normal groups.

1. The results suggests that every patient should at least be screened for their cognitive abilities, if a complete diagnostic test battery is not possible.
2. The findings of the current study emphasizes the potential need for individuals with vestibular migraines to undergo training aimed at improving their cognitive abilities. Additionally, counselling could be a valuable resource to help them effectively address their challenges.
3. The study also suggests a comprehensive approach, combining Cognitive Behavioural Therapy (CBT) with Vestibular Rehabilitation Therapy (VRT), could offer holistic management and enhance the quality of life for patients with vestibular migraine.
4. Current study underscores the significance of adopting a team-based approach in the management of vestibular disorders.
5. The study's results also add information to the existing literature regarding the association of cognitive problems in patients with vestibular disorders.

6.2 Limitations of the study

The current study employed purposive, non-random sampling, potentially introducing researcher and sampling biases. Online data collection, a method used, could have impacted response patterns. Notably, the study did not address the potential influence of the severity of the vestibular disorder on cognitive abilities, nor did it account for the duration or severity of comorbid factors. Additionally, the study did not explore the impact of hearing loss management (whether untreated or treated). Furthermore, the study did not take into account the potential effects of factors such as age, gender, socioeconomic status, or education level.

6.3 Future research

The study can be done on a larger population. Additionally research on different vestibular disorders and how they relate to cognitive issues could be explored. Along with questionnaires, performance-based tests related to cognition could be done along with the questionnaire. The vestibular disorder's severity and effect on cognitive abilities can be studied. Duration and severity of the comorbid factors and their association with cognitive problems could be studied. Factors like age, gender, socio-economic status and education level and their influence on the cognitive abilities of patients with vestibular disorders can be studied.

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ANNEXURE-1

I understand the nature of the research project, and I consent to participate in this research project.	Yes	No

Part-A

Socio-demographic Details

Name:

Previously/Currently diagnosed as vestibular migraine /None:

Age (in years):

Gender:

1	Do you have any history of diabetes?	Yes	No
2	Do you have any history of blood pressure (BP)?	Yes	No
3	Are you under any medication for diabetes/BP?	Yes	No
4	Do you have a history of tinnitus (ringing sensation in the ears)?	Yes	No

Part-B

Questions related to cognitive abilities (Taken from the NCSE questionnaire)

Instructions: Please answer the following questions based on your experience during the course of your disorder or in your current condition.

1	Does it seem that you can't think as quickly as before (i.e., before the diagnosis)?	Yes	Sometimes	No
2	Does it seem that you find it hard to think clearly?	Yes	Sometimes	No
3	Does it seem that you are easily more distracted?	Yes	Sometimes	No
4	Does it seem that you can't concentrate?	Yes	Sometimes	No
5	Do you have trouble remembering the right words when talking?	Yes	Sometimes	No
6	Do you have trouble understanding others?	Yes	Sometimes	No
7	Do you have trouble following conversations?	Yes	Sometimes	No
8	Do you have trouble with your speech?	Yes	Sometimes	No
9	Do you have trouble with reading?	Yes	Sometimes	No
10	Do you have trouble with writing?	Yes	Sometimes	No