CHAPTER 2

Review of Literature

Benign paroxysmal positional vertigo (BPPV) is one of the most common disorders causing giddiness. It has been estimated that at least 20% of the individuals who complain of vertigo are found to have BPPV (Luxon, 1987; Epley, 1992; Semont1988; Hallpike, 1952). Persons with BPPV complain of brief and acute episodes of severe vertigo, when a person assumes a critical head position (Cummins, 1998). Idiopathic BPPV is more prevalent in the elderly and in women, with a women-to-men ratio of 3:1 It is most often reported to occur in the fifth to sixth decade of life (Brevern, Radtke, Lezius, Feldmann, Ziese, Lempert, et al., 2007). It can affect any of the semicircular canals though it most commonly affects posterior canal and rarely, affects multiple canals.

2.1.1 Incidence and Prevalence of BPPV

Life time prevalence of BPPV has been reported to be 2.4 % (Bhattacharyya et al, 2008). Incidence of BPPV is reported to be from 0.01% to 0.9 % across different studies (Mizukoshi et al. 1988; Froehling et al, 1991; Oghalai et al, 2000). Similarly, incidence of secondary BPPV has been found to vary from one third to two third population of the total sample of BPPV depending upon the type of associated pathology (Imai, Ito, Takeda, 2005; Baloh, Honrubia, Jacobson, 1987). Incidence of head trauma among individuals with BPPV has been found to range from 8.5-27% (Hallpike, 1952) whereas incidence of Meniere's disease (MD) is reported to vary from 5 -30 % among the persons with BPPV (Li, Xeng, Li, 2010; Morita, 2009). Similarly incidence of vestibular Neuritis (VN) among the participants with BPPV varies from 0.8 to 24% (Gordon et al, 2004, Mandala et al , 2010, Lee and Ban, 2010) while Migraine

has been found to be twice as high in persons with BPPV when compared to age matched control (Lempert, 2000).

Brevern et al. (2007) studied the prevalence and incidence and co-morbid conditions of BPPV in the general population where the screening of 4869 participants with moderate to severe dizziness or vertigo were screened. The results indicated that 8% of individuals with moderate or severe dizziness/vertigo had BPPV and the life-time prevalence of BPPV was 2.4%. It was also observed that secondary BPPV was associated with sudden sensory hearing loss (ISSHL, 50.7%), Meniere's disease (MD, 28.9%) and unilateral vestibulopathy such as acute vestibular neuritis and herpes zoster oticus (20.2%). A majority of them had posterior canal BPPV. Studies have positively correlated higher incidence of BPPV with the prolonged course of disease of MD (Karlberg, Hall, Quikert, Hinson, Halmygi, 2009; Norimasa, Sebhattin, Shigenobu, Rie et al (2009); Lee, Ban, Lee, Kim, 2010). Large variation in the incidence rate among the studies has been attributed to the methodological variations and different diagnostic criteria's used by the researchers. For example, a few investigators have segregated secondary BPPV based on the case history while others have taken case history along with pure tone average to categorize participants into primary and secondary BPPV (Lee, Ban, Lee, Kim, 2010; Karlberg, Hall, Quikert, Hinson, Halmygi, 2009)

To summarize, incidence of BPPV secondary to inner ear disorder is higher than idiopathic type of BPPV. However, criteria of segregation of participants into primary and secondary BPPV is most often based on the report of case history and pure tone thresholds. No other vestibular tests have been considered. This might have resulted into some error in segregating the data, as many vestibular pathologies may not necessarily depict the typical history to diagnose them into accurate pathology.

2.1.2 Pathophysiology

Primary complaint by individuals with BPPV is arousal of dizziness triggered by movement of head position. These symptoms are felt especially while getting up from bed or turning in bed during sleep. In certain clients, symptoms can be so intense that, it can result into sensation of vertigo, oscillopia, vomiting, and fear of fall. (Brevern et al, 2001). Numerous researchers have proposed possible pathophysiology behind these symptoms. Barany (1921 cited in Riga, Bibas, Xenellis, Korees (2011) was the first author to explain the possible pathology among individuals with BPPV. He described the dysfunction of otolith organ to be the cause for the origin of BPPV. Later, Schuknecht (1969 cited in Riga, Bibas, Xenellis, Korees (2011) and Epley (1980) described the pathophysiology of BPPV in detail. They explained it with a concept called Cupulolithiasis. Cupulolithiasis explains that degeneration of utricular membrane occurs following the trauma or infection to vestibular system which ultimately results into release of "otoconia". These free floating otoconia ultimately move into the cupula of posterior semicircular canal (PSCC) which provokes rotatory nystagmus on change in head position. 'Canalolithiasis' is another theory to explain BPPV. It was first described by Hall (1979) and supported by Brandt and Steddin (1993). As per the theory of Canalithiasis otoconial particle floats freely in the PSCC rather than getting attached to the cupula. Therefore, any head movements results into movement of this otoconial debris and this induces the endolymphatic flow and cupular deflection resulting in the typical features of BPPV.

Posterior canal BPPV is the most common form of BPPV accounting for 85 to 90% of cases of BPPV (Cummins, 1998) and canalithiasis is reported as its most common cause (Cummins, 1998). Horizontal canal BPPV can also cause by canalithiasis and it accounts for 10% of cases of BPPV (Hallpike, 1952; cummings, 1998).

The anterior canal is rarely affected as the anatomical position of the anterior canal makes it improbable for debris to enter anterior canal (Nuti and Yagi 2010 cited in Eggers and Zee (2000). Involvement of multiple canals is also rarely reported.

Pathophysiological evidences of BPPV secondary to inner disorders has been studied by many investigators. Morita et al (2009) compared the incidence of otoconial deposits in semicircular canals of the temporal bones with MD and normal controls in a histopathologic retrospective study. Temporal bones of 11 individuals with bilateral MD, 14 individuals with unilateral MD and 30 normal individuals were examined histopathologically. Medical records were reviewed for clinical history of positional vertigo and duration of disease. They observed that there was a significant difference in the incidence of copular and free floating deposits in posterior semicircular canals of temporal bones with and without MD. Also there was a higher incidence of free-floating deposits in the lateral semicircular canals of cases with unilateral MD when compared with the controls. There was a significant effect of duration of the disease on the incidence of free floating deposits but there was no effect of age. There were three individuals out of the eleven individuals with bilateral MD and two of fourteen individuals with unilateral MD who were reported to be having free-floating deposits in at least one semicircular canal. Thus it was concluded that MD can be a causative factor for cupular and free-floating deposits in the semicircular canals and the symptom of positional vertigo in individuals with MD.

Similarly, Fetter (1996) proposed the pathogenic mechanism underlying secondary BPPV in individuals with VN. He proposed that most commonly superior vestibular nerve is infected in persons with VN. Superior vestibular nerve innervates lateral semicircular canal, anterior semicircular canal and utricle. Thus a lesion of superior vestibular nerve can damage the utricle and thereby dislodge the otoconia result-

ing into BPPV. Unlike these pathophysiology, relationship between migraine and BPPV is very clearly understood. It has been suggested that migraine may induce local ischemia through vasospasm of the labyrinthine arteries and this in turn may facilitate otoconia detachment from the utricular macula (Ishiyama, Jacobson and Baloh, 2000). Jeong et al (2009) also explained the possible pathophysiology of BPPV among the participants with diabetes, osteoporosis, and hyperurcemia. Vascular depletion and disturbed internal structure of the otoconia have been reported to be the most likely mechanism in these individuals for the development of BPPV.

2.1.3 Diagnosis of BPPV

Posterior canal BPPV: Clinical history in persons with posterior canal BPPV reveals sudden onset with brief episodes of vertigo lasting for few seconds in duration. It is normally reported to trigger during certain head movement such as turning in bed or bending down or moving head up upward. Turning the head side to side doesnot evoke vertigo as otoconia posterior semicircular canal is not stimulated during these actions. Some clients may also report nausea and vomiting (Fife, 1998)

Dix-Hallpike test is considered as the gold standard for diagnosing individuals with posterior canal BPPV (BPPVp). This maneuver was first described by Dix and Hallpike (1952) to detect the presence of posterior canal BPPV. It is performed by making a person to sit upright on an examination table and the head is turned 45 degrees first to the right or left side depending upon the side to be assessed. Then the client is rapidly brought straight back into a head-hanging position. This position is maintained for at least 30 s. If the nystagmus has a latency of 2 to 10 s, increases in amplitude approximately after 10 s and decreases in velocity over the next 30 s, person is diagnosed to have posterior canal BPPV. Dix-Hallpike test does not have 100 % sensitivity, as it may be negative if the test is performed during the silent phase of

BPPV. There is a dearth of literature reporting the specificity of the test (Giannoni, Vannucchi, Pagnini, 2005).

Horizontal/lateral canal BPPV: Horizontal canal BPPV may sometimes be detected by the Dix–Hallpike maneuver (Nuti, vannucchi, Pagni, 1996). However, the most reliable way to diagnose horizontal BPPV is by a supine head turn maneuver also known as Pagnini–McClure maneuver or roll Maneuver given by Mcclare (1985). In this test, the person's head is turned to one side and then back to supine face-up position after which the head is turned to the other side. Presence of horizontal nystagmus when the head is turned to one side indicates presence of horizontal canal BPPV. The nystagmus is generally most prominent when the head is turned to the affected side (Fife, 1998)

Lempert, Tiel-Wilck, (1996) and Mcclure (1985) report certain characteristics of nystagmus in horizontal canal BPPV. The nystagmus is always horizontal. A change in head position changes the direction of the nystagmus and it may geotropic or apogeotropic. Geotropic form is right beating when the head is turned to the right and is left beating when head is turned to the left side. The ageotropic is left beating when head is turned right and right bearing when head is turned to the left. Often the latency is brief, and the duration can vary from 15 to 60 seconds.

Anterior Canal and Polycanalicular Types: There is no standard test to diagnose anterior type of BPPV. However, the anterior canal form of BPPV is diagnosed with paroxysmal down-beating nystagmus, sometimes with a minor torsional component on Dix–Hallpike test. This type of BPPV is rarely reported. It may be observed briefly while treating other forms of BPPV. Its diagnosis should be considered with caution as similar type of nystagmus may be observed in persons with brainstem or cerebellar lesions. Bertholon, Bronstein, Davies, Rudge, Thilo (2002) reported 72% of persons

with positional downbeat nystagmus had central disorders, while the etiology was unknown in 24%. It is believed that a majority with unknown etiology probably had anterior canal BPPV. .

Polycanalicular BPPV involves pathology in more than one canal at the same time but is rarely reported. Combination of posterior canal BPPV along with horizontal canal BPPV is the most commonly reported polycanalicular form. In these case the nystagmus will follow the patterns of single canal BPPV.

Primary versus secondary type of BPPV

A majority of individuals with BPPV present no history of any inner ear disorder and hence are said to have primary BPPV (Brevern, Radtke, Lezius, Feldmann, Ziese, Lempert, et al., 2007). But BPPV can occur secondary, or subsequent to inner ear disorders or CNS disorders. Secondary BPPV has been also commonly reported in individuals with history of head trauma (Katsarkas, 1999). The incidence of BPPV is also known to be higher in person with migraine, than age matched control group (Ishiyama, Jacobson, Baloh, 2000). BPPV has been reported to occur in association with giant-cell arteritis, diabetes, and hyperuricemia (Cohen, Kimball, Stewart, 2004). BPPV is also reported to occur secondary to Meniere's Disease, Vestibular Neuritis and due to nonspecific vestibular pathology (Balatsouras et al., 2012; Baltsouras et al., 2014)

2.1.4 History and Clinical examination

Detailed case history is essential part of clinical examination in persons with dizziness. Case history includes many questions especially those which are linked to the duration, situation and frequency of dizziness are of great significance. In general it's been reported that if dizziness can be classified into four main categories such as Presyncope, Disequilibrium, Vertigo, Lightheadedness (Lee, 2012).. Presyncope' is

loss of consciousness which could be due to lack of cerebral blood flow or metabolic impairment. 'Disequilibrium' results from impairment of motor function of body resulting into misbalance. 'Vertigo' is a sensation of motion due to a disorder of labyrinth or its central connections. 'Lightheadedness' is a non-specific symptoms could be resulting from nonvestibular causes such as psychiatric disorder, hyperventilation, hypoglycaemia, anaemia, head trauma, and associated (Ruckenstain, 2009; Staab, 2007).

Lee (2012) categorized causes into peripheral and central vestibular causes. Disorders affecting semicircular canal, utricle, saccule and vestibular nerve are called peripheral in nature. While pathology at vestibular nuclei, cerebellum, brainstem and spinal cord and cortex. Causes of peripheral vertigo has been described as BPPV, MD, VN, Labrynthitis, Perilymphatic fistula and semicircular dehiscence. It has been reported that peripheral disorder are sudden in onset and last for few seconds to hours or days (Drachman, 1998). Causes of central vestibular are described as due to neuropathy or lesio at central vestibular system (Tracis, 2004, stab, 2007). central vertigo is characterized by constant dizziness with slow onset of disorder. Persons often complain disequilibrium along with persistent nystagmus of non-suppressant type.

2.1.5 Audiovestibular findings in individuals with BPPV

2.1.5.1 Pure Tone Audiometry

Assessment of hearing sensitivity among individuals with BPPV has been investigated by numerous investigators in the past. Moreno (2009) did a retrospective analysis of characterizing the pure tone average (PTA) in elderly persons with BPPV. PTA was compared between the elderly participants with BPPV and age matched controls. There was no significant difference between two groups of participants on PTA. Kim and Kim (2011) investigated audiological findings in cases with sudden

sensorineural hearing loss with BPPV. It was reported that audiometric threshold of persons with sudden sensorineural hearing loss with BPPV were not significantly different from those with sudden sensorineural hearing loss without BPPV.

Contrary to these findings, Song et al (2012) reported that persons with sudden idiopathic sensorineural hearing loss showed higher PTA when there was associated BPPV on the same side when compared to those without BPPV. This was observed during the initial evaluation as well as during follow-up evaluation. They further observed that the improvement in PTA was less in the group with BPPV than the group without BPPV. They hypothesized that, more occurrence of BPPV in individuals with sudden sensorineural hearing loss can be also due to reduced weakening of vestibular functioning which was not investigated using other vestibular test in their study. Wu et al (2006) investigated the audio-vestibular function and the possible mechanism of BPPV. Clients with BPPV were tested with pure tone audiometry, high frequency ABR audiometry, bithermal caloric test and vestibular evoked myogenic potential test (cVEMP). Results revealed that Primary BPPV comprised of 82 percent (70/86) of clients with BPPV. Among all of the clients, the results of pure tone audiometry were abnormal in 52 percent (45/86) of the participants. cVEMP was abnormal in 34 percent (11/32) of clients who were evaluated for all these tests and bithermal caloric test were abnormal in 28 percent (20/72) of participants. Hence it can be concluded that there are inconsistent reports about hearing sensitivity among individuals with BPPV.

2.1.5 Videonystgmography

Videonystgmography assesses the vestibular system by recording eye movements. This is considered superior to electronystagmography as it directly measures eye movements using infra-red camera. It is highly effective and noninvasive method of recording linear and torsional eye movements. VNG consists of series of tests that

include, spontaneous nystagmus test, Gaze nystagmus test, positional nystagmus test, positioning nystagmus, caloric and saccade test. These tests are carried in visual fixation/suppressions versus non-suppression condition. If the nystagmus is observed in both condition, persons is diagnosed to have central vestibular pathology. While if nystagmus observed in visual non fixation condition, it is diagnosed to have peripheral vestibular pathology.

Spontaneous Nystagmus

Occurrence of spontaneous nystagmus among individuals with BPPV has been studied by a few investigators in the past. Korres (2004) studied 168 individuals with BPPV using VNG test. Results revealed that 12.5 % of their studied population had spontaneous nystagmus. However, Asprella-Libonati (2008) and Hajiabolhassan and Tavanai (2013) reported spontaneous nystagmus to be present in only 5 % of persons with posterior canal type of BPPV. De Stefano (2011) reported 30% of individuals with horizontal canal BPPV had presence of spontaneous nystagmus while Asprella-Libonati (2014) reported 56 of the 273 clients with horizontal canal BPPV had incidence of Pseudo-Spontaneous Nystagmus. Asprella-Libonati (2014) evaluated nystagmus modification by performing the Head Pitch Test (HPT) in the upright position. Results showed that the HPT modified the beating direction of the persistent horizontal nystagmus. Thus, presence of spontaneous nystagmus appears to be less common in persons with BPPV but there is no consensus on the percentage of occurrence of spontaneous nystagmus in person with BPPV This could be attributed to the fact that type of BPPV (primary versus secondary) and type of canal (horizontal versus posterior) was not uniform across all the studies

Positional Nystagmus : There is lack of literature reporting positional nystagmus in persons with BPPV. Limited number of studies carried out report that positional nys-

tagmus is prevalent in persons with horizontal canal BPPV (Steddin and Brandt,1996; Baloh et al., 1987). Katsarka (1991) investigated two hundred and eighty five clients during episode of paroxysmal positional vertigo. ENG recording was reviewed retrospectively. In one group of participants (Group A), ENG was performed during the time the active phase when nystagmus could be elicited and in Group B (n = 44), it was recorded during passive phase (when there was no nystagmus). In Group A, there were 93 % of persons with slow phase velocity of positional nystagmus less than 6 degrees/s . There were no participants with positional nystagmus among the participants of Group B.

Watanabe (1994) assessed three clients of rebound positional nystagmus in individuals with absence of spontaneous nystagmus. These clients had positional nystagmus in the side down position and when they returned to their primary position, there was reversal of direction of nystagmus. These individuals had no other abnormalities of ocular movements, neurological and neuroradiological examinations suggestive of central nervous system disorders. Thus it was concluded that positional nystagmus can be ascribed to peripheral lesions.

Caloric test

Caloric test assesses unilateral impairment of vestibulo-ocular reflex (VOR). It has high sensitivity as well specificity among all the vestibular test (Maes et al., 2011). It provides an indirect measure of vestibular function based on the eye movements in response to vestibular stimulation. It is one of the most recommended test of unilateral vestibular defect. It also known to assist in differential diagnosis of peripheral and central pathologies. Most commonly used parameters for interpretation of caloric test include canal paresis and slow phase velocity. Some investigators report

that a canal paresis index >22% indicate significantly asymmetric horizontal canal function (Baloh and Honrubia, 1990) whereas others (Jongkees and Philipszen, 1964) have reported that canal paresis of greater than 25% on Jongkee's formula should be considered abnormal . Teggi et al (2007) proposed that slow phase velocity (SPV) less than 6 degree/sec should be considered hypoactive and more than 35 degree/sec should be considered hyperresponsive. Another parameter that has been commonly used to assess is directional preponderance. Directional preponderance value of more than 20-30% is considered abnormal.

The prevalence rate of abnormal caloric responses (Unilateral weakness) among the individuals with primary BPPV has been reported to vary from 30 % to 50% (Baloh, Honrubia, and Jacobson, 1987; M. et al., 2000) while the prevalence rate of abnormal caloric responses among the individuals with secondary BPPV has been reported as 43 % (Pollack et al, 2002) and 44% (Karlberg et al, 2000). This shows that abnormal vestibular test results are found in participants with both the primary as well as secondary BPPV. Korres et al (2001) described the ENG findings in one hundred and sixty eight persons with BPPV. Out of total one hundred and sixty eight persons with BPPV, 22% had canal paresis and 13.7% had directional preponderance, whereas 7.1% of participants had both unilateral weakness and directional preponderance. Thus it was concluded that ENG abnormalities are quite common in persons with BPPV. Similarly, Korres et al (2000) did a retrospective study in hundred individuals with BPPV out of which 42.1 % of individuals had canal paresis and 12.1% of them had spontaneous nystagmus. However, study did not categorize the participants into having primary versus secondary BPPV.

Masaoki, Hideaki, Koji, Akihiko and Makito (2013) studied the percentage of abnormal results on caloric test in terms of canal paresis in eighty individuals with the

diagnosis of posterior canal BPPV. Results revealed that 29% of the studied population had abnormal results on caloric test especially on the affected side of a person with BPPV. Hong, Yeo, Lee, Choi (2015) reviewed the clinical features of BPPV secondary to sudden sensorineural hearing loss (SNHL). Results revealed that out of 277 persons with BPPV, 24 (8.7%) had sudden SNHL. Moreover, 47 % of the persons with BPPV secondary to SNHL had canal paresis.

Similarly, Lee, Kim, Park, Byun (2013) assessed horizontal canal function using caloric test in persons with different subtypes of BPPV (Horizontal (HC), posterior, canalithiasis, cupilothiasis). Results revealed canal paresis toward the lesioned side in all subtypes of BPPV were significantly higher than those of the controls. However there was no significant difference in terms of canal paresis across the studied subtypes of BPPV. Ko et al (2014) reported a single case who had persistent spontaneous nystagmus, despite a positional change after the canalith repositioning procedure. A bithermal caloric test result demonstrated unilateral canal paresis on the affected side. However, spontaneous nystagmus subsided after a day followed by normal caloric responses on both sides.

On contrary to above findings, Domínguez-Durán, Gandul-Merchán, Abrante-Jiménez, Medinilla-Vallejo, and Esteban-Ortega (2010) conducted caloric test in 98 individuals with BPPV. Results revealed no significant difference on abnormalities observed on caloric test in individuals with BPPV and without BPPV. Thus, it can be summarized that canal paresis is common findings among individuals with BPPV, nevertheless there is large variation in the occurrence of canal paresis among the individuals with BPPV.

2.1.5.3 Vestibular Evoked Myogenic Potential (VEMP)

VEMP is a neurophysiological assessment technique used for determining the function of otolith organ (Colebatch and Halmagyi, 1992). There are quite a many physiological evidences available in the literature about stimulation of saccular afferents by air conduction or bone conduction mode (Curthoys, Vulovic, 2011; Young, Fernandez and Goldberg, 2011; McCue and Guinan, 1994). In healthy individuals, short tone bursts of high intensity through air conduction mode or moderate level of stimulus through bone conduction mode can evoke myogenic potentials of short latency. These potentials can be recorded by electrodes placed on the sternocleidomastoid (SCM) muscles. This is called as cervical vestibular-evoked myogenic potential (cVEMP). These potentials consist of a positive peak ,P13 and a negative peak,n23 (Colebatch, Halmagyi and Skuse (1994). The cVEMP response i.e. p13 and n23 peaks are reported to be an uncrossed, descending inhibitory, sacculocollic response. The absolute values of the cVEMP reported to vary based on many factors such as neck muscle tension and electrode placement (Rosengren, Welgampola, Colebatch, 2010).

Numerous researchers have investigated the clinical relevance of cVEMP in individuals with BPPV. Yang, Kim and Lee (2008) assessed 41 individuals with BPPV and 92 healthy volunteer by means of cVEMP. It was observed that nine clients with posterior canal type of BPPV and two individuals with horizontal canal type of BPPV had absence of cVEMP. P13 and N23 latencies were prolonged in total 30 individuals with BPPV as compared to normal individual and these prolongations in latencies were attributed to neuronal degenerative changes in macula of saccule. It was further reported that when an extensive neuronal damage was suspected by cVEMP by means of no response, the disease progress showed a

chronic and resistive course. Thus, it was concluded that cVEMP could be a useful method to determine a clinical prognosis of persons with BPPV.

On a similar line, Korres et al. (2011) reported the percentage of abnormal cVEMP in individuals with BPPV. A Total of 27 participants between 20 to 70 years of age and 30 age matched controlled underwent cVEMP testing. Results revealed that out of total ears of persons with BPPV, cVEMP was absent in five ears while it was abnormal in 17 ears (31.5%). Latency of P13 was found to be prolonged in 11 years while one client showed prolongation in latency for both P13 and N23 peaks. Statistical analysis showed significantly higher abnormalities on cVEMP in persons with BPPV than that of the control population. Moreover, percentage of abnormal cVEMP on the contralateral side i.e. on the non-affected side of a person having BPPV was reported to be similar to percentage of abnormal cVEMP on the affected side. Furthermore, no association has been found between cVEMP and caloric test in persons with BPPV. Similar percentage of abnormal cVEMP on either sides of person with BPPV was attributed to the degeneration of the saccule in either ear. The interaction of the two ears through pathways involving the vestibular nuclei was also provided as an explanation for similar percentage of abnormal cVEMP on either sides of person with BPPV.

Longo, onofri, Pelliccaiari and Quranta (2012) conducted a study with an objective of reporting the cVEMP findings or saccular dysfunction in individuals with BPPV and correlating them with the clinical picture. Latencies, amplitude, and threshold of VEMPs recorded from the affected and contralateral ear in the experimental group were compared with those obtained from a control group. A total 23 clients with BPPV and twenty four controls were evaluated. In individuals with BPPV, VEMPs were affected in 14 ears while it was absent in five affected ears and in two

unaffected ears. In the affected ear the latency of P13 was higher than 17.09 ms in two cases (4.3%) and the latency of N23 was higher than 24.32ms in three cases (6.5%). Contralateral ear showed delayed P13 latency in one person and delayed N23 latency in three persons. Interaural amplitude difference (IAD) was always within normal limits. There was no significant difference in the P13 latency, N23 latency, and threshold of the two groups. However number of individuals with absent or prolonged cVEMPs were significantly higher in individuals with BPPVs as compared with controls. Thus the investigators concluded that the degeneration of neural elements and their interaction with otholithic and canalicular receptors contribute the pathophysiology of BPPV.

Kim, Oh, Kim, Yang and Yang (2010) evaluated saccular function in the acute and resolved phases of BPPV. cVEMPs was recorded from 112 clients with BPPV and 50 normal controls. Abnormalities of cVEMPs in individuals with BPPV were prevalent and significantly higher compared to the healthy normal Group. However in the clinical group, difference between the proportions of abnormal responses of cVEMP were not significant between the affected and unaffected ears. The non-affected ear in the BPPV group also showed significantly higher abnormalities of cVEMP when compared to the control group. On contrary, Singh and Apeksha (2015) who recorded cVEMP in thirty individuals with BPPV and thirty age matched individuals reported no significant difference between persons with BPPV and healthy control group on any of the parameters of cVEMP.

Similarly, Nakahara, Yoshimura, Tsuda and Murofushi (2013) studied proportion of abnormality on cVEMP and caloric test in twelve persons diagnosed with pBPPV (6 with right sided BPPV and 6 with left sided BPPV) showing typical nystagmus by Dix-Hallpike maneuver and 12 controls. Incidences of abnormal responses

on the affected side were 0% for both caloric test as well as cVEMP. No significant difference between on cVEMP of persons with BPPV and healthy age matched controlled has been attributed to the type of BPPV such as primary versus secondary BPPV. Lee, Park, Lee, Sung and Park (2012) recorded cVEMP from 16 individuals with recurrent BPPV and 20 individuals with non-recurrent BPPV. VEMP abnormalities were detected in eight (50%) persons with recurrent BPPV and three (15%) with non-recurrent BPPV. Thus, cervical vestibular-evoked myogenic potential (cVEMP) abnormalities in the recurrent BPPV group were significantly higher than those in the non-recurrent BPPV group.

Similarly Xu et al (2016) recorded cervical and ocular VEMPs from 30 persons with posterior canal BPPV and 30 normal controls. cVEMP was repeated 3 times on each participant to ensure reliability and reproducibility of responses. Abnormal VEMP was defined by lack of VEMP response. Results revealed that 6.67 % of healthy participants had abnormal response on cVEMP. Similarly, 30 % of participants with BPPV had abnormal responses on cVEMPs. Thus it was concluded that more number of participants with BPPV showed abnormal responses on cVEMP as compared to the control group. Similar reports have been documented by Zhou et al (2015).

Chang and Young (2007) studied caloric and cVEMP tests in children with BPPV. They included twenty children with BPPV and twenty healthy children in the study. Each of them was assessed with audiometry, caloric and VEMP tests. The results revealed that all the children with BPPV had normal bilateral hearing. Thirteen out of 20 children exhibited normal caloric responses and abnormal responses were observed in seven children which correspond to 35% abnormality in the total BPV subject group. On the other hand 50% abnormality in cVEMP test results was ob-

served in BPPV children which included absent or delayed responses. Further they observed that when results of caloric and cVEMP test were considered together, 70% of children with BPPV had abnormality. Thus, they concluded that a combination of caloric and VEMP test results reveals higher abnormality (70%) in children with BPPV.

Similarly, Lin, Hsu and Young (2010) assessed children with BPPV by using oVEMP and cVEMP to identify whether the upper or lower brainstem is more frequently affected in them. They included fifteen children with BPV and healthy children aged 4 to 14 years. All the children were subjected to audiometry, stabilometry and both oVEMP and cVEMP. They found that all the children with BPV displayed bilateral normal hearing and clear oVEMP results but eleven out of fifteen children with BPV exhibited significant delay of cVEMP responses compared to the normal group. Although the stabiliometry test results of neither sway path nor the sway area correlated with cVEMP results, the results of stabiliometry test displayed significant difference of sway path and sway area between BPPV and healthy children irrespective of their eyes closed or open. Thus it was concluded that normal oVEMP in children with BPPV is suggestive of intact vestibulo ocular reflex pathway which routes through the upper brainstem. Whereas, delayed cVEMP results reflect the sacculecollic reflex pathway which routes via the lower brainstem suggestive of lower brainstem being more frequently affected than the upper brainstem in children with BPPV.

To summarize most of the investigators report that more number of individuals with BPPV report abnormal responses on cVEMP than healthy control group. However few reports that there is no significant difference on cVEMP individuals with BPPV and normal individuals. There is also a equivocal reports about percentage of abnormal results on the affect side versus unaffected side. Few investigators says that cVEMP is more affected on the side of BPPV while others report no such difference

between affected versus unaffected side of BPPV. There are controversial opinion regarding the abnormal cVEMP results in individuals with recurrent BPPV as well persons with nonrecurring BPPV. cVEMP has been reported to be more affected in persons with recurrent type of BPPV than noncurrent type while some report no such difference between these two groups of participants.

2.1.5.4 Differential diagnosis of BPPV

In most cases diagnosis of positional vertigo not controversial as BPPV is a benign and self-remitting disease. However, central positional nystagmus usually accompanies persistent vertigo, profound imbalance, and other neurological symptoms and signs. Since positional downbeat nystagmus is a typical finding in lesions involving the cerebellum and Anterior canal BPPV (AC –BPPV), differential diagnosis between central vestibular disorders and BPPV is very crucial. However, Anterior canal BPPV is a rare condition whose diagnosis is reserved only for typical cases without other neurological deficits. The possibility of central pathology is recommended only when repeated Canalith Repositioning Maneuvers (CRMs) fail to resolve the symptoms and nystagmus of persons with positional giddiness.

Other than central disorders, very few vestibular disorders demonstrate similar signs and symptoms as that of the BPPV. It is well documented that, Meniers's Disease (MD) is not provoked by positional change and last for few hours to days unlike BPPV which last for few seconds to minutes. Moreover, MD is often associated with hearing loss and tinnitus (Balatsouras et al, 2012). Likewise individuals with labrynthitis and vestibular neuritis demonstrate distinct signs and symptoms in terms of violent vertigo with severe vomiting and spontaneous nystagmus in 90 % cleints which

needs immediate hospitalization (Balatsouras et al, 2014). However, severity of it reduces over a week or month period. (Lin, 2012)

Meniere's disease (MD)

MD is a fairly common disorder characterized by fluctuating hearing loss, tinnitus, aural fullness and episodic rotatory vertigo. Specific sites of lesion are observed to be the most often in the cochlea, followed by the saccule and utricle. Clinical diagnosis of MD relies mainly on symptoms, electrocochleography (EcochG) and caloric testing (Zhou and Cox, 2004). cVEMP is also reported to be an important test in individuals with MD. Its either augmented, reduced or absent depending upon the stage of MD (Rauch, 2004). BPPV is known to occur secondary to many inner ear disorder such as MD, VN, and labrynthitis. Therefore it is important to review the VNG findings in these disorders as well.

VNG in MD

Halmagyi et al (2000) determined the clinical significance of an isolated directional preponderance (DP) in bithermal caloric testing. 114 individuals with complaint of giddiness were assessed using caloric test. Results revealed that of out of 114 individuals with vestibular disorder, 39 had BPPV, 14 had MD, and 5 had migrainous vertigo. About half the individuals with an isolated DP reported either MD or BPPV; in most of the other half, no definite diagnosis was made.

Proctor (2000) determined the prevalence of vestibular abnormalities and changes in vestibular function in individuals with MD. Results showed unilateral weakness in 58% of clients on the involved side and 19% on normal side. During attack only one of' the eight persons showed a reduction in SPV on the diseased side, and three showed an increased response. Spontaneous nystagmus was seen within 24 hours of an attack in 54 cases. BPPV was found in 44% of these studied participants.

Mateijsen et al (2001) investigated results on spontaneous nystagmus (SN), caloric tests and velocity step tests on a well-defined group of ninety two persons with MD. In unilateral disease a duration of disease <2 years resulted in small asymmetry on caloric test whereas a longer duration of disease gave large asymmetry and small labyrinthine preponderance to the unaffected side. On studying the shape of a audiogram, it was found that individuals having an labyrinthine preponderance to the affected side, suggested a hyperactive labyrinth belonging to a beginning of the disease who never had a flat audiogram.

Chen, Zhao, Zhuang, Xie, Jin (2015) analyzed correlation between caloric test and Head impulse test (HIT) in persons with MD. It was found that there was no difference on HIT tests among the groups with MD which were divided based on the severity of unilateral weakness in caloric test. Similarly, McGarvie, Curthoys, MacDougall, Halmagyi et al (2015) investigated persons with MD using caloric testing. It was observed that results of the caloric test was dependent on the disease stage and activity of the disease. Results of caloric test was normal when tested during remission phase for persons or in unilateral early or mild MD while mild to severe canal paresis with or without directional preponderance was observed in persons with late MD.

Shin, Kim and Park (2013) compared the vestibular abnormality in individuals with MD on caloric test, head shaking nystagmus test and vibration induced nystagmus. Results revealed that abnormal caloric results in 42 to 58% of individuals with definite MD . Furthermore, caloric testing was abnormal even in their remission period. Huang and Young (2015) assessed individuals with bilateral MD to map the inner ear deficits in each ear. Hundreds of individuals with bilateral MD were involved in the study. Each participant underwent audiometry, cVEMP, and caloric tests. Results revealed that stages of MD were not similar on PTA and vestibular tests. Blodow

(2014) compared the results of caloric testing and vHIT in MD and determined which test is more sensitive to uncover stages of MD. It was found that canal paresis was found in 67% of individuals with MD. They opined that the caloric test and vHIT are not sensitive in identifying the stages of MD.

It can be concluded that canal paresis is more prevalent in individuals with MD than healthy control group. Moreover, canal paresis is seen more number of individuals with BPPV secondary MD. Nevertheless there are inconsistent reports regarding determining the stage of MD based on the results on canal paresis.

2.1.5.4.1 VEMP in MD

Akkuzu, Akkuzu, Ozluoglu (2006) investigated the efficacy of cVEMP in differential diagnosis of sixty two individuals with either MD or BPPV. Among them, seventeen were healthy controls, 25 were diagnosed with BPPV and 20 were diagnosed with MD. Results revealed that four ears with MD had no response and six ears with MD had prolonged latencies. Among those with BPPV eight ears had prolonged latencies and one ear had decreased amplitude. Among the controls, only two ears had absent VEMP. Thus, it was concluded that the rate of VEMP abnormalities in the control ears was significantly lower than the corresponding rates in the affected ear with BPPV and individuals with MD. Similarly, Iwasaki et al (2015) studied the clinical feature and vestibular symptoms of persons with abnormal ocular vestibular evoked myogenic potentials (oVEMPs) and/or cVEMPs in the presence of normal caloric responses. Out of the 1521 studied participants, 227 were observed to have abnormal oVEMPs and/or cVEMP responses with normal caloric responses. BBPV, MD, and vestibular migraine were the common diagnoses of these clients

Hong et al. (2008) assessed cVEMP in clients with VN, BPPV, and MD. It was revealed that the cVEMP was abnormal or absent in all these disorders. Abnor-

mal cVEMP rates in the VN, BPPV, and MD group were 36.6%, 25.5% and 69%, respectively. Furthermore, more number of persons with BPPV had prolonged p13 latency when compared to the other two diseases. Huang, Wang, Young (2011) reported that maximum abnormality was observed in the audiometric test probably because hearing is the most easily measured variable and is closely related to the natural course of MD and is consistent with temporal bone studies. Followed by the audiometry, cVEMP was affected in many individuals (45%) probably due to hydropic saccular wall ruptured and collapsed into otolith membrane. Lastly only 20% of the affected ears had canal paresis which is associated with the last stage of MD which is characterized by severe dilation or collapse of ampullary walls interfering with cupular movement.

Individuals with MD have been reported to have more incidence of absent cVEMP in the affected ear than that in the unaffected ear with MD (Timmer et al., 2006). Histopathological studies have demonstrated that the saccule is greatly dilated, with saccular macula either severely degenerated, atrophied or apparently normal in individuals with MD. In order to substantiate the above findings noninvasively in live human being, Rauch et al (2004) tried to correlate findings of cVEMP with the various stages of MD. Results revealed absent cVEMP in 30% of the individuals, reduced cVEMP in 25% of the individuals, and normal cVEMP 45% of the individuals with MD. Furthermore, it was also found that presence of saccular hydrops could produce either augmented or reduced or absent cVEMP depending on the state of atrophy at the saccular macula. In cases of Meniere's attack (MD) i.e. in individuals who has severe attack of giddiness that requires immediate hospitalization, VEMP has been reported to be absent in most of the individuals. This was attributed to either distension or rupture of the saccular hydrops. Rauch et al. (2004) also reported in his anoth-

er study where normal subjects showed a frequency- dependent cVEMP threshold, with best response at 500 Hz whereas, the frequency tuning was affected in ears with MD and the thresholds were higher at all the frequencies. Besides, VEMP thresholds of unaffected ears was also significantly higher than those of normal ears. Thus, it was concluded that cVEMP threshold and frequency tuning is affected in ears with MD, supporting the hypothesis of altered saccular motion mechanics arising from hydropic distension. Similar findings have been reported by Lin et al. (2006) who has observed abnormal cVEMP results in asymptomatic ear as well. They further reported that saccular hydrops appears to precede symptoms in bilateral persons with MD which can be studied by using changes in cVEMP threshold and tuning. Thus it was proposed that cVEMP can be a useful predictor of evolving bilateral MD. Young (2012) also reported augmented cVEMP amplitude in early stage of Meniere's' Disease.

It can summarized that VEMP is more frequently affected in person with MD than normal individuals and persons with BPPV and VN. Secondly cVEMP is affected mostly in the amplitude parameters, frequency tuning and threshold parameter rather than latency parameters. Absence of cVEMP response has been associated with extended damage to the saccular duct which is found in the acute stage of MD or advanced stage of MD.

2.1.5.4.2 Vestibular Neuritis (VN)

Acute vestibular neuritis is usually caused by viral infection. The inflammation caused by the viral infection can affect superior or inferior vestibular nerves and sometimes causes inflammation of the entire vestibular ganglion. Superior Vestibular nerve (SVN) neuritis causes a reduced or absent ipsilateral caloric response, reduced contralateral ocular VEMP response, and normal symmetrical cervical VEMP (Schuknecht and Kitamura, 1981). IVN (Inferior Vestibular nerve) neuritis is report-

ed to cause reduced or absent ipsilateral caloric response, normal contralateral ocular VEMP response, and reduced or absent cervical VEMP. In the clinic, hallmark signs of acute VN are vertigo, spontaneous nystagmus, and unilateral functional loss of the lateral semicircular canal as shown by caloric testing (Halmagyi, Karlberg, Curthoys, and Todd; 2001).

VNG in VN

Chen, Young and Wu (2000) reported the findings of three dimensional videonystagmography and cVEMP test in eight individuals with VN. It was reported that two of the eight participants exhibited spontaneous nystagmus with 3 components, indicating that both horizontal semicircular canal (SCC) and Anterior semicircular canal (SCC) are affected while remaining 6 participants displayed only horizontal nystagmus meaning only HSCC was involved in them. Furthermore, all the eight individuals had canal paresis whereas only one had absence of cVEMP on the ipsilesioned side indicating that VN mainly affected the superior vestibular nerve, which innervates the HSCC and ASCC. All the participants were followed for next one year post-treatment, it was found that spontaneous nystagmus was seen in only one subject and caloric responses recovered in 30% of the individuals. However there was no significant improvement found in the cVEMP responses. Investigators proposed that since PSCC function is spared in individuals with neuritis further studies can be carried out with an objective to find out the prevalence of BPPV in such individuals. Similar reports have been documented by Hirvonen and Aalto (2009) and Pavin & Premrl (2015) who performed VNG test in persons with VN.

Lee, Park, Kim, Koo and Kim (2016) reported caloric test within normal limit during the acute phase of VN. However, unilateral caloric paresis was observed 14 days later. Therefore follow-up evaluation should be considered when the findings of

the initial caloric test are normal, but VN remains the most plausible diagnosis. Likewise Yoo, Kim, Lee, Yang, Lee, park (2015) reported frequently caloric test is abnormal in person with VN and there is a positive significant linear correlation between caloric test and HIT (Head impulse test) in person with VN. On contrary, Rodondo-Martinez (2016) assessed the relationship between video Head Impulse test (vHIT) and caloric test in individuals with VN and found no significant positive relation between vHIT and caloric test.

To summarize spontaneous nystagmus can be a useful test in differential diagnosis of persons with VN from other peripheral vestibular disorders. Unilateral weakness on Caloric test has been found to be the hallmark sign in individuals with VN unlike the individuals with BPPV.

VEMP

Viciana, Lopez-Escamez (2014) evaluated the usefulness of cVEMP and oVEMPs in fifty individuals with VN. Results revealed that 51% of participants showed an increase in P13 and N23 latencies on the ipsilateral side. In three individuals with ipsilateral abnormal cVEMP, caloric responses were normal, suggesting that onle inferior vestibular nerve is affected.

Jung, Kim, suh (2012) reviewed and compared clinical findings of individuals with VN and sudden sensorineural hearing loss with vertigo in a retrospective study. Results of the study indicated no significant difference between the two groups of participants for comorbidity, duration of spontaneous nystagmus and all the vestibular tests results except cVEMP. It was found that more number of individuals with sudden hearing loss with vertigo has abnormal results on cVEMP than individuals with only VN without hearing loss. Thus it can be summarized that cVEMP can be abnormal in individuals with VN in terms of prolonged latencies of P1 and N1 peaks.

2.2 Quality of life (QOL) in individuals with BPPV

A person with BPPV often complain of short episode of positional vertigo along with or without nausea and vomiting. As a result, it affects the overall efficiency of work at home as well at office. It also arouses many psychological reactions such as anxiety, fear and depression resulting from inability to perform many day to day task thereby reducing overall QOL (Lopez, Gamiz, Perez and Finana, 2005; Brevern et al, 2007). Severe subjective impairment and avoidance behavior has been reported in 70% of individuals with BPPV (Breven et al, 2007).

The economic burden among the individuals with dizziness due to vestibular disorders including BPPV was investigated in 4,294 clients, multinational REVERT database from 618 centers (Benecke, Agus, Kuessner, Goodall and strupp, 2013). It was revealed that 69.8 % of participants with dizziness who were still employed had lessened their work load, 63.3 % had lost their working periods and 4.6 % has changed their job. Thus it was concluded that dizziness due to various vestibular disorders including BPPV, has a significant impact on work productivity. Moreover, it was reported that the self-assessment of impact of vertigo and dizziness is influenced by the person's personality, anxiety with regard to his/her experience of vertigo and frequency of recurrence with unpredictable nature of dizziness. Therefore subjective perception through client using self-assessment questionnaire should be an essential part of assessment.

Scales assessing disability as well self-perceived Handicap

Subjective scales are used in individuals with dizziness for both clinical as well as research purpose. It provides an information regarding one's own perception regarding his/her disability and helps to improvise the existing clinical coun-

selling**.** Questionnaire that are most relevant and promising for assessing an effect of vertigo on everyday life has been described as questionnaire assessing self-perceived handicap. These questionnaires assess the effect of vertigo on day to day activities across the various domains (Duracinsky et al., 2007).

Questionnaire that assess both disability and handicap due to dizziness

The Dizziness Handicap Inventory (DHI) was developed by Jacobson (1990). It consist of 25 questions that assess conditions in which dizziness increases or decreases (Impairment), effect of dizziness on performance of day to day life (disability) and effect of disability on self-perceived handicap. The vestibular Disorders Activities of Daily Living (VADL) primarily evaluates an effect of vestibular impairment on day to day activities (Cohen and Kimball, 2000). Likewise, The Activities –specific Balance confidence scale is designed to illustrate difficulties faced by elderly people's in everyday life and fear of falling (Powell and Mayers, 1995). The Vertigo Handicap Questionnaire (VHQ) assesses limitations in performing physical and everyday activities on social life and leisure (Yardley and Putman, 1992). (Refer Table 2.1). Among these four questionnaire, the DHI is most commonly used questionnaire to quantify the impact of dizziness and has been translated into many languages such as Swedish (Jarlsater and Mattsson, 2003), Chinese (Poon, Chow, Au, Hui, Leung, 2004), French (Nyabenda, Briart, Deggoui, Gersdorff, 2004), Dutch (Vereek, Truijen, Wuyts, Heyning, 2010), Portuguese (Brazil) (Castro, Gazzola, Natour, Ganaca, 2007), German (Kurre, Van gool, Bastiaenen, Gloor-Juzi, Straumann, 2009), Norwegian (Tamber, Wihelmsen, Strand, 2009) and Marathi (Mishra and Vanaja, 2011). High internal consistency and satisfactory test-retest reliability has been demonstrated for the total scale as well as in some studies for the subscales (Jacobson, Newman, 1990; Whitney,

Brown, Fuman, 2004). Other studies have also found similar results for the total scale, (Tamber, Wilhelmsen, Strand, 2009; Asmundson, stein, Ireland, 1999; Perez, Gamendia, 2001).

Table 2.1 **Questionnaire assessing disability as well as handicap perceived by individuals with dizziness**

Questionnaire Author	**DHI Jacobson (1990)**	**VDL Cohen (2000)**	**ABC Powell (1995)**	**VHQ Yardley (1992)**	**VAP Alghwiri etal (2012)**
Dimensions (Total items and domains)	25/3	28/3	16/1	22/4	Total questions 34
Dimensions as per domains	Functional: 9 items Emotional: 9 items Physical: 7 items	Functional: self-care and intimate activities (12 items), Amputation (9 items), Instrumental (7 items)	Most important activities essential to independent living	Handicap of restriction of activity. Social anxieties. Fear about vertigo and severity of vertigo	It is based on ICF model
Item scaling	Yes/No/Sometimes, 4/0/2	1-10 scaling, 1 independent 10-too difficult, no longer perform	0-100 continuum	5 point verbal scale(1-Nohandicap, 5-Max Handicap	Responses to each of 34 questions are rated on a scale of 0 to 4 Total score is divided by 34.
Score	0-100(0-No handicap,100- Max. Handicap)		0-100 0-No confidence, 100, complete confidence	0-100	Total score ranges from 0 to 4
Internal consistency Cronbach coefficient	0.89	0.97	0.96	0.93	.58 to .84
Test-Retest reliability (Intraclass coefficient)	0.97	0.87-0.97	0.92	Not evaluated	0.95

Questionnaire that assess both handicap as well as symptoms of dizziness

These questionnaire assess symptoms perception, its psychological consequences along with limitation causes by dizziness in few domains of life (Duracinsky et al., 2007). Questionnaire such as VDI (Vertigo, Dizziness, Imbalance), UCLA-DQ (UCLA-dizziness questionnaire), (DFI, The Dizzy Factor Inventory) are discussed under this section in Table 1.2. The UCLA –DQ, Dizziness Questionnaire contains five item assessing the frequency and severity of dizziness. Impact on everyday activity, QOL and fear of dizziness (Honrubia, 1995). However validity and reliability of questionnaire across various disorders is not been evaluated. Vertigo, Dizziness, Imbalance (VDI) questionnaire measures feeling of dizziness and unsteadiness and their psychological consequences in individuals with dizziness (Prieto, 1999). The dizziness Factory Inventory (DFI) developed by Hazlett et al (1996) assesses three dimensions through 44 questions: Symptom factor, client's perception of significant responses and activity level. However, its validity and reliability is not been investigated. ADLQ is a 7 item questionnaire developed by Black et al (2000) as a outcome tool for assessment of efficacy of vestibular rehabilitation on symptoms as well as daily activities with peripheral vestibular disorders. (Refer Table 2.2)

Table 2.2 *Questionnaire assessing both symptoms and handicap perceived by individuals with dizziness*

Questionnaire	**VDI**	**UCLA-DQ**	**DFI**	**ADLQ**
Author	Prieto (1999)	Honubria (1996)	Hazlett et al (1996)	Black et al (2000)
Dimensions (Total items and domains)	36/2	5/5	44/3	Total 7 items questionnaire
Dimensions as per domains	VDI symptoms feelings and unsteadiness		Symptom factors (22 items), obvious response of significant others to dizzy (11 items) and Activity level (11 items)	Assesses the individualized improvement in the score after vestibular rehabilitation
Item scaling	6-point like from 1 (all the point) to 6 (never)	5-point verbal scale	5-point verbal scale	5 point scale
Score	0(absence)-100 (best)	1 (best) to 5 (worst)	1 (best) to 5 (worst)	1 (best) to 5 (worst)
Internal consistency	0.86	Not evaluated	Not evaluated	Not evaluated
Test-retest reliability	0.81	Not evaluated	Not evaluated	Not evaluated

Questionnaires that assess vestibular symptoms

These questionnaires quantifies the number and frequency of long and short term vertigo, symptoms and sensation, anxiety arousal and somatization (Duracinsky et al., 2007). Under this category questionnaire such as Vertigo symptom scale (VSS); EEV (European evaluation of Vertigo (EEV), MD-Patient Oriented Severity Index are discussed (Table 2.3). The Vertigo Symptom Scale (VSS) provides information about regarding the symptoms such as number and frequency of long and short term vertigo automatic sensations and anxiety arousal, and somatization (Yardley et al, 1992).

Whereas The Europian Evaluation of Vertigo (EEV) evaluates the five major symptoms of vestibular syndrome: Illusion of movement, duration of illusion, motion intolerance, neurovegetative signs and symptoms (Magnibeto et al, 2001). MD Patient-Oriented Severity Index, MD-POSI (Murphy and Gates, 2001) has four dimensions of client's symptoms and functional status during and between attacks of MD. The Vestibular Rehabilitation Benefit Questionnaire (VRBQ) was developed by Morris et al (2008) as a refined version of the PQ (Patient oriented questionnaire). It consists of 22 items which are grouped into 3 parts: dizziness and anxiety (6 items), motion-provoked dizziness (5 items), and HRQOL (11 items) (Table 2.3)

Table 2.***3*** *Questionnaire assessing symptoms perceived by individuals with dizziness*

Questionnaire	**VSS**	**EEV**	**MD-POSI**	**VRBQ**
Author	**Yardley (1992)**	**Magnibero (2001)**	**Murphy (1999)**	**Morris et al (2008)**
Dimensions (Total items and domains)	27/4	5/5	16/4 + 4 single items	22/3
Dimensions as per domains	Acute attack of vertigo scale Vertigo of short duration Somatization scale (SOM) Autonomic symptom scale	Illusion of movements, Duration of illusion, Motion intolerance, Neurovegetative symptoms instability	During: effects during attack Between: effects between an attack Daily Effects Job effects	Dizziness and anxiety Motion Provoked dizziness HHR-QOL (11 items)
Item scaling	6 point verbal scale (0- never, 5- very often, more than once a aweek)	The score of each item is average over last eight days	5 point rating scale (0-4) and 6 point scale (0-5)	7 point verbal scale

Score	0-5	Total score 0-20, higher the score, severe the symptomology		Higher score indicates severe QOL
Internal consistency	0.69-0.83 according to dimensions	Not evaluated	Not evaluated	0.73
Test-retest reliability	0.89 -0.98	Not evaluated	Not evaluated	0.74-0.92

Questionnaire assessing general quality of life

Questionnaire depicting general quality used for assessment of difficulties faced by individuals with any disorder in different spheres of life. It's generic nature allows one's to use it for comparing quality of life across different medical condition, culture and persons. It can be easily administered as it rely upon self-report of person. It is also widely used as a measures of outcome study. SF-36

Many researchers use scale that assess general QOL such as SF-36, WHOQOL-BREF along with disease specific scale. SF-36 is a multidimensional scale that assess the impact of disease on well-being and functional status. It has 36 items covering 8 health domains: Physical domain (PF; 10 items); role limitation due to physical problem (RP; 4 items); bodily pain (BP; 2 items), Vitality (VT; 4 items), general health perception (GH; 5 items); social functioning (SF; 2 items), role limitation due to emotional problem (RE; 4 items); mental health (MH, 5 items) and one item measuring change in health.

WHOQOL-BREF

WHOQOL-BREF is a generic questionnaire developed by WHOQOL Group, 1998 as a multilingual, multidimensional profile of QOL for cross cultural issues

(WHOQOL group, 1998). It has four subscales measuring physical health, psychological well-being, Social relationship and satisfaction with the environment.

Activities of daily living, dependence on medical substance and medical aids, vitality level and overall excretion energy and fatigue, mobility, pain and discomfort, sleep and rest and work capacity is covered under Physical domain. psychological domain assess aspects such as bodily image and appearance, positivity and negativity in thought , self-esteem, spirituality, personal beliefs and thinking, learning, memory and concentration. The Social relationship consists of relationship both personal as well as social support from other Environmental domain consists of availability of resources in terms of health and social care, freedom, and social security Accessibility and quality, home environment, opportunities for acquiring new information and skills, participation in and opportunities for recreational activities, physical environment (pollution/noise/traffic/climate) and transport. It uses 5 point responses and in all formulated 26 statements. Total score ranges from 26- 136, wherein 26 indicated most affected QOL while 136 showed no effect on QOL.

Relationship between various scales assessing disability, handicap and general QOL

Fielder, Denholm, Lyons, Fielder (1996) assessed the self-perceived handicap and general QOL using DHI and SF-6 respectively among individuals with dizziness and healthy normal individuals without dizziness. The questionnaires were administered in individuals who were awaiting an ENT OPD. Results revealed strong association between the eight dimensions of the SF-36 and disease severity, measured by the Dizziness Handicap Inventory questionnaire. Results showed that individuals with dizziness had significantly higher self-perceived handicap and more affected QOL as

compared to normal control group. Furthermore, difficulty was displayed in the domains of physical, social functioning and vitality of SF-36.

. Thus it was concluded that General health status is significantly affected by both the presence and severity of vertigo and SF-36 can be a useful tool in assessing general QOL in individuals with giddiness.

Similarly, Enloe, Shiels (1997) evaluated the relationship between the disease specific questionnaire, DHI and general outcome measure, the SF-36 and their usefulness as a outcome measure in rehabilitation program. Health-related QOL between individuals with vestibular disease and the general population was also compared. 95 individuals, aged 25 to 88 were assessed. Method involved comparing the scores of both questionnaires before and after six to eight weeks of vestibular rehabilitation. Results reveled that individuals with dizziness has lower quality of life and higher self-perceived handicap compared to the normal individuals. Moreover, it was also found that scores on both the scales improved after 6-8 weeks of vestibular rehabilitation program significantly. In addition, each test was found to be moderate to high reliability. However, the DHI was reported to be more responsive to change than the SF-36. Similar reports have been documented by Whitney, Hudak, Marchetti (1999) on comparison of DHI scale with ABC Scale. Piker, Jacobson, Mccaslin, Hale and Tran (2012) assessed if there is a significant difference exist between individuals and spouses for the self-reported vertigo severity and dizziness handicap in a prospective study using DHI and DHI-SP (Spouse) and VSS (Vertigo severity scale. Methods consisted of administration of DHI and DHI-SP in 50 individuals with the complaint of dizziness, along with their spouses. Results of the study indicated the mean score of DHI in individuals with dizziness had moderate self-reported dizziness related handicap. While the mean DHI-SP total score showed severe self-report dizziness handicap

(i.e., on average the spouses perceived the individuals with dizziness to have a severe dizziness handicap. However, the mean differences between the individuals with dizziness' and spouses rating of dizziness severity and handicap were not statistically significant and the association between these 2 distributions of scores was statistically significant. Contrary to DHI, on VSS, the mean differences between these two samples were statistically significant. That is, spouses perceived the individuals with dizziness's vertigo severity to be significantly greater than the individuals with dizziness himself/herself.

Moderate to strong association has been documented between the SF-36 (Medical Outcomes Study 36-item short-form health survey on QOL) and DHI but the DHI has been found to be more responsive to recover after vestibular rehabilitation than the SF-36 for individuals with dizziness with unilateral/ bilateral peripheral vestibular dysfunction. Moderately strong negative association (Spearman Rank Order association coefficient) has been also documented between the scales depicting vestibular activities in day to day life such as VADL and the Activities Specific Balance Confidence Scale and DHI. However, the VADL is reported to be more responsive to higher levels of impairment than the DHI. Furthermore, the Brazilian DHI showed moderate association with the WHOQOL-BREF scale in individuals with complaint of dizziness.

2.2.2 Factors Affecting QOL

2.2.2.1 Frequency and Duration of dizziness

Self-perceived handicap and QOL can vary depending upon the characteristics of the disorders such as duration and frequency of dizziness. There are few questionnaires which specifically assess frequency and severity of dizziness and its impact on

QOL. The University of California, Los Angeles Dizziness Questionnaire (UCLA-DQ) is one such scale which assess the frequency and severity of dizziness on a 5-item scale. Honubria, Bell, Harris (1996) assessed s the impact of dizziness using Activities of Daily Living (ADL) and UCLA-DQ and their relationship with fear and frequency of disorder results showed a significant relationship between frequency of dizziness, fear of dizziness with Activities of Daily Living (ADL) and second item, and the other 3 items of the UCLA-DQ questionnaire ($P<.01$).

Cohen, Kimball, and Adams (2000) conducted a study to investigate an associations of VADL with characteristics of vestibular disorders such as frequency of vertigo and functional impairment assessed using posturography. Subjects involved in the study were asymptomatic, healthy adults, individuals with BPPV, individuals with chronic vestibulopathy excluding MD, postsurgical vertigo, and post-concussion vertigo, and family members. The VADL, the DHI, , and computerized dynamic posturography were used as a part of assessment . Results revealed that VADL is sensitive tool in differentiating of healthy persons from person with dizziness. However it was not found to be a sensitive toll in differential diagnosis of vestibular pathologies. . Furthermore it was found that person with dizziness perceived themselves as more independent than their spouses perceived them to be. Scores were weakly correlated with vertigo frequency and posturography scores for conditions with unreliable kinesthesia and absent or unreliable vision.

Martin, Perez, Garmendia, Garci, and A-tapia (2001) administered DHI and UCLA-DQ in order to find out different dimensions of disability and handicap in individuals with dizziness. Method involved assessment of self-perceived handicap and quality of life using DHI and UCLA-DQ respectively. Total 337 individuals (170 females, 167 men) were included in the study. All of them underwent through detailed

case history, pure tone audiometry, caloric testing and rotatory tests. On associational analysis it was found that, there was a strong association between vestibular handicap and the third item of the UCLA-DQ (limitation of daily activities) and the fourth (QOL) question of the UCLA-DQ. Good association was found with fifth (fear) items of the UCLA-DQ. Correlation of frequency of vertigo was similar for all the subscales of the DHI and the fourth (QOL) and fifth (fear) items of the UCLA-DQ. On the other hand, other associations were either moderate- to-weak or evident. To summarize, QOL in individuals with dizziness was found to be associated with limitation in carrying out daily activities, frequency of vertigo attacks and fear invoked by these attacks. Hsu, et al (2005) investigated the QOL using SF-36 and the Hospital Anxiety and Depression Scale (HADS) in elderly individuals who has the complaint of dizziness. The normative data used for comparison were obtained from 2002 nation-wise survey and women aged from 65-74 years. Results of the study indicated that all the individuals with dizziness had lower score in all eight domains especially in role limitation due to physical problem (RP) compared to normal population. Association matrix for the dizziness characteristics, dizziness severity, social functioning and HADS score with eight domain score of the SF-36 were assessed. Out of the three variable relating to the characteristics of dizziness, only the frequency of attacks correlated with SF-36 subscale especially in Physical domain and social functioning On further analysis, the mean HADS score was significantly correlated with all eight domains, especially the mental health domain of SF-36. Thus authors concluded that more is the frequency of attacks, severe is the impairment of physical functioning.

Similarly, in a quest to find out an association of various factors related to dizziness with the self- perceived handicap in persons with dizziness, Dros, Maarsinhgh, Beem, Horst, Riet, et al (2011) did a cross-sectional study in 2006 on Dutch popula-

tion to investigate the impact of Dizziness on everyday life using DHI. Dizziness was defined as individuals who report a giddy or rotational sensation or a feeling of imbalance or light- headedness, and or a sensational of impending faint. Exclusion criteria used were individuals who were unable to speak Dutch or English. Test included were four elements of individual's history, eleven physical examination, and six diagnostic tests. All the selected tests were administered on 417 individuals with dizziness with the age range of 65-95 years. Results revealed that DHI score varied from 0 to 88, with median score of 34 and interquartile range from 22 to 50. Total 182 individuals were mildly disabled by their dizziness (score 0-30), 179 moderately disabled (score 31-60), and 56 severely disabled (score 61-100). Frequency of attacks and psychological distress due to associated anxiety or depression were found to be major determinant of perceived impairment in older individuals. Thus it was concluded that, 60 % of the dizzy individuals experience moderate to severe impact on everyday life due to dizziness irrespective of their etiology. There were six factors such as nature of dizziness (chronic dizziness, more than 6 months), frequency of dizziness, duration of dizziness (less than one minute), having anxiety and depressive disorders, use of sedative drugs, and poor functional ability were identified to have maximum impact of dizziness on everyday life. Thus authors concluded that apart from frequency of vertigo and fear associated with vertigo, duration, chronic versus acute characteristics of vertigo plays an important role in self-perceived handicap of person with dizziness. Nevertheless, study failed to uncover the effect of many other associated factors like type of vestibular pathology (central versus peripheral) and effect of degree of dysfunction of vestibular system shown on one versus more than one vestibular test on the self-perceived handicap in individuals with dizziness Thus it can be concluded that fear

and frequency of dizziness plays an important role in perception of self-perceived handicap due to dizziness

2.2.2.2 Effect of age and gender

Takano et al (2010) explored the QOL in 120 elderly individuals with dizziness using WHOQOL-BREF and DHI. There were more female participates involved in the study. Results revealed that individuals aged over 81 years scored higher in the functional, emotional, and physical aspects of the DHI and on the physical aspect of the WHOQOL-BREF. Authors hypothesized that this could be due to because the sensory systems involved with body balance and sensory-motor integration deteriorate with age. Among other domains of WHOQOL-BREF, social relationship was least affected. DHI Moderate negative association was found between the total scores of both instruments. Female subjects had higher score in all domains of the Brazilian DHI compared to males in this study. Male subjects had better QOL scores in environmental domain and perception of health than female. Female subjects scored better in functionality domain than male. There were no significant differences among factors in both instruments for all age groups as well as gender groups.

Similarly, Voorde, Loonen, Leeuwen (2012) did a study to assess QOL in individuals with dizziness. 2,252 individuals completed the DHI which assessed self perceived handicap. The results were classified into three categories: mild, moderate, and severe impairment based on the total score of DHI. The three domains of the DHI representing physical, functional, and emotional aspects of dizziness were compared. DHI scores of men versus women, between diagnoses, and the relationship between DHI and age were also investigated. It was found that almost 70% of participants had moderate or severe complaints. The handicap perceived by the clients was primarily reported to be due to the limitation in carrying out many day to day functions and in-

crease in dizziness in certain positions depicted by physical domain. Physical and functional factors and less by emotional factors. Gender wise analysis showed that female participants with psychological disorders such as anxiety disorder had significantly higher DHI scores on all subscales. Moreover, older clients reported more impairment than younger ones.

Similar reports have been documents by other researchers like Whitley, Whrisley, Marchetti, Furman (2006) who determined whether person's self-reported handicap correlates with scores obtained from the modified Clinical Test. Participants for the study were 159 individuals referred with dizziness or imbalance as their primary complaints.. The DHI, and the Health Utilities Index Marks (HUIM) 2 and 3 were used as a outcome measures. Results revealed that the scores for the DHI and HUIM were overlapping for male as well as female participants though the scores on DHI did not correlate with age, HUIM 2 and 3. However scores of both the scales showed a negative association with increasing age. Furthermore, there was a poor yet positive associations between the Dizziness Handicap Inventory and the firm surface conditions of the modified Clinical Test for the Sensory Interaction on Balance but no useful association with the foam conditions.

Kurre (2012) explored whether women and men with dizziness differ in terms of self-perceived disability, anxiety and depression. Secondly the associations between dizziness and anxiety, depression were also assessed. Participants were recruited from tertiary center for vertigo and balance disorder. They rated their global disability as a mild, moderate or severe. They filled out the DHI and the two subscales of HADS. Total 202 participants with primary complaint of dizziness were enrolled in the study. Results revealed that score on both the scales was not differing significantly. However there was a trend of a higher abnormal anxiety and depression in male

participants as compared to female participants.. Moreover, there was a high occurrence of abnormal depression felt among severely disabled individuals by dizziness than clients without depression.

Handa, Kuhn, Cunha, Schaffleln, Ganança (2005) compared the impact of dizziness on QOL, in individuals diagnosed as BPPV and/or MD , in crisis and out of crisis. Additionally influence of gender, age and impaired semicircular canal was assessed in these individuals with giddiness. The DHI was applied in 70 participants with BPPV, 70 with MD and fifteen with both. When comparing the groups, results evidenced higher averages in crisis as well as out of crisis for MD group than for positional vertigo group. In addition, scores on DHI were poorer in individuals who had both MD with BPPV than those who had only MD or only BPPV. Furthermore, physical aspects were found to be more affected than functional and emotional aspect in both groups in both in crisis and off crisis period. Moreover, DHI score did not differ significantly between male and female participants as well as between younger and older participants with BPPV.. Thus authors concluded that individuals with MD has worse QOL as compared to individuals with BPPV, both during in and out of crisis. The damage on QOL was independent of gender, age possible reason postulated by the authors for more self-perceived handicap in individuals with MD than individuals with BPPV was uncertain nature of chronic character of the disease, with fluctuating, recurrent and long lasting clinical manifestations that may impair not only the physical capabilities, but also the activities of the subjects.

Piker and Jacobson (2014) compared the responses obtained in elderly individuals with that of younger individuals using a structured dizziness case history. 133 individuals with the complaint of dizziness were considered for the study. All of these individuals had undergone vestibular function testing and had completed structured

case history. These participants were divided into two age groups i.e. young adult and old adult. Age range for the young adult group was 18-64 years while it was 65 years and above for old adult group. Results of the study revealed that younger adults have significantly more complaint of true vertigo and associated nausea and vomiting as compared older individuals. Furthermore, participants from older adult group reported more tendency to fall and unsteadiness. BPPV was also found to be common in older group than younger group.

It can be summarized that there is no consensus with regard to effect of age and gender on self-perceived handicap among individuals with dizziness. Differences in the results could be attributed to the difference in the inclusion criteria of participants, severity of associated vestibular impairment, type of vestibular disorder etc.

2.2.2.3 Effect of Associated Hearing loss

There are few studies documenting the effect of associated of hearing loss on self-perceived handicap and general QOL among the participants with dizziness. Sodeman, Bagger-Sjoback, Bergenius, Langius (2002) evaluated self-report QOL in individuals with meniere'MD. Results revealed that individuals with MD rated their QOL significantly worse than did normal healthy participants in both the physical and the psychosocial domains of SF-36. Furthermore, it was found that vertigo mainly influenced the physical dimension, whereas associated tinnitus and hearing loss among the participants with MD influenced the psychosocial dimension. Hence it was concluded that associated hearing loss affects QOL adversely in persons with dizziness.

Lacerda et al (2012) evaluated the effect of auditory prosthesis in perception QOL, in persons with dizziness and hearing loss. Results revealed that use of

auditory prosthesis provided an improvement in the QOL, which reflected consequently better auto-confidence and reduction of the fear of fall. Chia at al (2007) assessed the relationship between individuals with hearing impairment and health-related quality of life (HRQOL) in an older population. Individuals with bilateral hearing loss who regularly used their hearing prosthesis had better QOL than those with the same impairment who did not use hearing aids or who only used them occasionally. However, it was also found that persons with unilateral or high-frequency hearing loss did not affect HRQOL s than individuals with bilateral hearing loss. It can be seen from above studies that associated hearing loss especially bilateral hearing loss in individuals with dizziness results into poorer QOL than persons without associated hearing loss.

2.3.1 Association between self-perceived Handicap and vestibular assessment

Numerous researchers studied the relationship between the DHI and its relationship with functional balance performance assessed using various vestibular test in individuals with dizziness. Robertson, Ireland (1995) investigated the association of Dizziness Handicap Inventory with computerized dynamic posturography. The DHI and Computerized Dynamic Posturography (CDP) were used to assess 101 consecutive individuals referred for neurotologic evaluation of dizziness. Most of the participants, regardless of diagnosis had some level of preexisting handicap, most often in the DHI Physical subscale. Generally, individuals with bilateral lesions scored higher in all DHI subscales. No clinically useful associations emerged between DHI and Computerized Dynamic Posturography (CDP) testing, although DHI scores were marginally higher in individuals failing CDP conditions. Thus authors concluded that there is no association between functional balance ability of a person with that of self-

perceived handicap in individuals with dizziness. Plausible reason for finding no association was attributed to the underlying individual's anxiety and differences in coping strategies.

Mann, Whitney, Redfern, Borello-France, Furman (1996) compared functional reach distance (FR) and right single leg stance (SLS) time among individuals with peripheral vestibular pathology having different degrees of handicap as indicated on DHI . 28 participants with complain of dizziness were involved in the study. Three trials were taken for each of functional reach and sight single leg stance. In addition, each subject filled out the DHI. Trials were randomized to prevent fatigue or practice effects. Results revealed no association between the DHI score and either functional reach distance or single leg stance time. However, when the subjects were divided into groups based on DHI a significant difference was found for functional reach distance; between participants with lesser perception of handicap versus grater perception of handicap on DHI r. However no difference was found between the two groups in single leg stance time. Within the two DHI groups, a high association was seen in group 1 (DHI < or = 49/100) between score on DHI and functional reach distance and single leg stance times, while no association was observed in group II.

Similarly, Chae (2012) investigated if there is any relationship exists between the head shake with that of dizziness handicap inventory in individuals with VN after vestibular compensation. Despite the complaints of dizziness, some individuals with unilateral compensated vestibular weakness showed normal results on Sensory Organization Test (SOT), which is being widely used for the evaluation of vestibular function compensation. Therefore authors compared Head shake sensory organization test with DHI in detecting balance problems in participants with VN. A

prospective analysis was conducted in all the individuals with VN between September 2009 and April 2011. 32 persons with uncompensated VN were enrolled in this study. Vestibular scores of SOT and equilibrium score ratios of HS-SOT which were obtained after 1 week and 1, 2, and 6 months of the first attack of VN were explored with changes in DHI score. Results revealed that HS-SOT has a stronger relationship with the DHI than SOT by periods. One month after VN, the association between DHI and SOT, HS-SOT were -0.301, -to -0.625respectively. Six months after VN, the association between DHI and SOT, and HS-SOT Conditions 2 and 5 were -0.053, and -0.394 respectively. Thus authors concluded that HS-SOT is more sensitive than SOT during the compensation of VN. Specifically, during the compensation of VN, HS-SOT Condition 5 was more correlated with DHI than HS-SOT Condition.

Likewise, Jacobson, Newman, Hunter, Blazer (1991) assessed if there is any relationship exist between the balance function test and Dizziness Handicap Inventory. Components of the balance function examination (electronystagmography, rotational testing, and platform posturography) and self-perceived dizziness handicap, as quantified by the DHI was carried out in 367 individuals with dizziness. The results indicated that maximum associations existed between DHI and the sensory organization subtests of platform posturography. Furthermore, greater perceived handicap was documented for individuals with (1) spontaneous nystagmus and (2) decreased postural stability quantified by posturography Bill, Beninto (2000) compared functional performance, balance impairment along with self-perceived handicap between individuals with unilateral peripheral vestibular hypofunction (UVH) and bilateral peripheral vestibular hypofunction (BVH). Study involved 85 participants with some kind of vestibular pathology. Out of them, 41 had unilateral vestibular pathology (n=41) and 44 had bilateral vestibular pathology (n=44). All the participants com-

pleted the DHI to obtain a measure of disability. Functional performance was measured with a modified Timed Up and Go Test (TUG). Balance impairments were measured with computerized posturography and balance tests. Results of the study indicated poorer balance in individuals with bilateral vestibular pathology but similar TUG scores and self-perceived handicap , as compared with subjects with UVH. Furthermore, weak to moderate associations was found between posturography, TUG scores, and DHI scores. Perez, Martin, Garcia-Tapia (2003) investigated if there is any relationship exist between self-perceived handicap assessed using DHI and impairment of vestibular system assessed using posturography, rotational chair test and caloric test. Similarly, severity of vertigo was assessed using UCLA-DQ and relationship between objective tests and UCLA-DQ was assessed. All the participants with dizziness underwent caloric test, rotatory test, and computerized dynamic posturography to estimate impairment. Results of the study revealed fair relationship between severity of dizziness and self-perceived handicap. Similarly, fair relationship was observed between results of caloric test, posturography and rotational chair test as the only pathologic finding and DHI. Similarly, fair relationship was observed between UCLA-DQ and objective vestibular test. However no association was found when they were assigned to groups of vestibular impairment.

Loughram, Gatehouse, Kishore and swan (2006) determined whether person's self-perceived handicap assessed through DHI has any association with objective measure of balance assessed using posturography. Total 159 individuals referred with dizziness or imbalance as their primary complaints were involved in the stud. The DHI, and the HUIM 2 and 3 were used as a outcome measures. Results revealed that the scores for the DHI and HUIM were comparable between the male and female participants and though the scores on DHI did not correlate with age, HUIM 2 and 3 did

showed a negative association with increasing age. Furthermore, there was a weak, positive associations between the DHI and the performance on posturography especially on the firm surface conditions but no useful association was observed with the foam conditions. Similarly weak negative associations was found between the HUIM 2 and 3 and performance on posturography. On similar line, Basta et al (2005) investigated the influence of otolith disorder assessed using cVEMP and oVEMP on human postural control which was assessed using gait test, Sensory Organization test (SOT) and Romberg test. Results revealed 78 % of the participants with otolith dysfunction had postural imbalance on SOT.

McCaslin, Jacobson, Grantham, Piker, Verghese (2011) conducted a study with an aim of determining the extent to which saccular impairments indicated by absence of cVEMP and impairments of the horizontal semicircular canal revealed by canal paresis affect results of posturography and self-perceived handicap assessed using DHI. Method involved assigning the subjects to one of the four groups based on the results from balance function testing: Group 1 involved participants with absence of cVEMP unilaterally,), Group 2 involved participants with abnormal canal paresis only, while Group 3 involved participants having affected cVEMP as well as abnormal caloric response), and Group 4 had individuals without any vestibular abnormality. .This group acted as normal group. Total 92 adults were involved in the study out of which 62 were seen for balance function testing due to the complaints of dizziness, vertigo, or unsteadiness and 30 served as controls. All subjects underwent, cVEMPs, caloric test and submitted self-report measures of self-perceived dizziness handicap by means of DHI and Posturography (SOT). Results revealed that there was no significant difference in mean SOT equilibrium scores between the 4 groups for Condition 1, Condition 2, Condition 3, and Condition 4. However there was a significant differ-

ence in mean SOT equilibrium scores between the four groups for Condition 5 and 6. When performance on Condition 5 and 6 was analyzed, the control group demonstrated significantly less anteroposterior body sway (i.e., better performance) than all three impaired groups. In addition to this finding, group1 revealed significantly less anteroposterior sway (i.e., better performance) than group 2 and 3. On DHI test, Group 3 had maximum score on DHI scale than other two groups. Thus this study has elucidated how functional ability and self-perceived handicap varies as per the abnormal results on various vestibular tests. However, there was no relationship found between sensory organization test (SOT) and objective test such as VEMP and caloric. Author suggested that this could have been due to non-segregation of central versus peripheral vestibular pathology among the participants and non-inclusion of other vestibular tests such as oVEMP which assesses the utriculo-ocular pathway to categorize the groups. Moreover, no relationship was found between total DHI score and abnormal results on vestibular test such as caloric, VEMP. Therefore it was concluded that generalization about the relationship between the functional/physical domains of DHI with abnormal results on caloric or VEMP can't be done.

Most of the above mentioned studies underlie that if DHI is severely affected in any persons with dizziness, he would also represent abnormality in more number of vestibular tests. However no association was found between actual dynamic functions of vestibular function and DHI. Therefore further studied were conducted for investigating/confirming the relationship between dynamic functions of vestibular function and DHI by many researchers. Whitley, Whirley and Furman (2004) attempted to explore the relationship between dynamic vestibular function and self-perceived handicap by forming the groups of individuals having dizziness into mild, moderate and severe degree of self-perceived handicap depending on the score of DHI. A sig-

nificant relationship was found between dynamic vestibular function and self-perceived handicap among the individuals with strongly affected and mildly affected groups and strongly affected groups. However relationship was not found between the dynamic function and self-perceived handicap among moderately affected group.

Similarly, numerous researchers studied the relationship between self-perceived handicap assessed using DHI and its relationship with functional balance performance in individuals with dizziness. Vereeck, Truijen, Wuyst, Paul (2006) used DHI, Romberg with Jendrassik maneuver, standing on foam, tandem Romberg, single-leg stance, the timed up and go test, the Dynamic Gait Index (DGI), tandem gait, and the 10-m walking test as a outcome measure. Results of the study indicated that the mean DHI total score was 35.1, ranging from 0 to 96. There was a mild association found between DHI and the static balance tests, single-leg stance with eyes closed and for single-leg stance with eyes open. Whereas a weak association was found between the Romberg test with Jendrassik maneuver with the DHI. In contrary to all, there was a moderate positive relationship between the walking test and DHI while the connection with the DGI was the strongest one.

On a similar line, Whitney, Wrisley, Brown and Furman conducted a retrospective study in 2012, on 81 subjects who had some kind of vestibular pathology. Study was conducted to determine if the individuals with mild versus moderate versus severe self-perceived handicap on DHI differ in terms of their functional abilities as well. Functional abilities were assessed for the participants with different degrees of self-perceived handicap on the Dynamic Gait Index (DGI), the 5 times sit to stand test (FTSST), the Activities-specific Balance Confidence (ABC) scale, gait speed, and the Timed "Up and Go" (TUG) during the same session. Numbers of falls within the last 4 weeks were also recorded. The gait tasks was assessed besides the other functional

tests. . For the TUG test, it consisted of asking the participants to stand on a chair without armrests, walk 3 meters, and then return to the chair. Time to complete the task was recorded with a stopwatch to the nearest 0.1 second. Similarly, scoring was done for rest of the functional assessment test. Results of the study indicated that significant differences were found on ANOVA statistical test across the three groups of participants of DHI (Mild, Moderate and severe) on the DGI, the FTSST, ABC, and number of falls. A significant difference was also found between DHI groups (mild vs. severe and moderate vs. severe) on the DGI with greater DHI scores exhibiting more impaired walking. The FTSST was different between DHI groups (mild vs. severe and moderate vs. severe) with slower FTSST scores with higher DHI scores. Thus authors concluded that individuals who perceive a greater handicap as a result of dizziness demonstrate greater functional impairment than individuals who perceive fewer handicaps from dizziness.

Thus it can be summarized that, few authors report weak to no relationship between computerized dynamic posturography (CDP) and self-perceived handicap. However, few author report moderate association of DHI with Rotational chair, Sensory Organization subtests of the platform posturography, Romberg test, four square step test, sit to stand test,. Above all, Caloric responses and cVEMP have been reported to have no association with DHI. Nevertheless when participants were categorized as per the degree of impairment computed based on the responses on vestibular tests such as caloric test and cVEMP, there was a significant difference found between the groups of participants. In general the subjects who reported less perception of handicap showed better less impairment on vestibular test than those who reported more perception of handicap.

2.4.1. Quality of life in individuals with BPPV after Vestibular Rehabilitation

Rehabilitation for individuals with BPPV includes a variety of repositioning maneuvers such as the Epley maneuvers, Gufoni maneuvers, and Semont techniques. Lynn et al (1995) conducted a randomized double blind study with placebo controlled trials in order to investigate the efficacy of PRM in 36 individuals with unilateral BPPV. It was revealed that 61% of the studied population had self-reported resolution of vertigo after PRM as compared to 20% of the individuals who were provided placebo maneuver. Robert et al. (2000) investigated the effect of PRM in person with primary and secondary BPPV using the DHI. All audiological and vestibular tests were carried out to differentiate primary from secondary BPPV. Both groups indicated a marked improvement in symptoms on DHI after the PRM. However from the secondary type of BPPV group two individuals had increase in DHI score. Nevertheless, plausible cause behind increase in DHI score has not been discussed.

On the other side, Yimate et al. (2003) reported success rate of PRM treatment in 75.9% individuals with BPPV as compared to 48.2% in control group. Similarly, White, Savvidas, Cherian and Oas (2005) reported success rate of PRM in 72% in individuals with Posterior canal BPPV. Likewise Breven, Seeling, Ratdke (2006) reported 80% of success rate in 80 persons with BPPV using PRM as compared to 10% of the clients in the sham group at the end of 24 hours. Differences in efficacy results could be due to methodological differences and associated vestibular pathologies along with BPPV which were not investigated using detail audio-vestibular tests.

Lopez-Escamez, Gamiz, Fernadez-Perez, Gomez-Finana (2005) determined the long-term effects on quality of life in individuals with BPPV after being treated

with particle repositioning (PRM). The SF-36 and DHI Short form were completed before treatment, 30 days, 180 days, and 360 days post treatment. The Dix-Hallpike maneuver was also completed at each of these times. This differs from previous studies as the maneuver was used to identify BPPV, but not used after the BPPV was treated. The result of study indicated that 88% of individuals treated with particle repositioning had a negative Dix-Hallpike one year after treatment. The scores on the questionnaires indicated that their QOL post treatment was significantly improved.

Seok, Lee, Hoon Yoo, and Lee (2008) reported that 61% of individuals treated for BPPV had residual dizziness after successful repositioning procedures. It was further reported that residual dizziness lasted on an average for ten days and was completely recovered in all individuals after three months. The investigators hypothesized for residual dizziness as remaining otoconia debris that were not repositioned and not dense enough to cause nystagmus when freely floating or the cause of a different vestibular lesion that may "coexist" with BPPV, or the need for the central nervous system to adapt once again after the particles have been repositioned. As per them, these causes result in the continued negative effects on QOL. Additionally, it was found that the longer a person suffered from BPPV, more likely it was that they would have residual dizziness. This indicated that the sooner BPPV can be treated the less residual dizziness a person may have, which will help to improve their QOL faster.

Likewise Dorigueto et al (2009) also conducted a longitudinal study to investigate the recurrence of persistence of BPPV post treatment. They followed one hundred individuals for one year after a canalith-repositioning maneuver to treat their symptoms of BPPV. It was found that 96% of those treated did not have symptoms of BPPV immediately following canalith-repositioning maneuver and during that year only 26% of the subjects had recurring BPPV and 4% had persistent BPPV. For the

4% of individuals that had persistent BPPV a treatment called for Vestibular Rehabilitation (APVR) was administered during the year. Thus it was concluded that the use of APVR treatment in persistent BPPV subjects lead to a better QOL and less symptoms of BPPV. This study differed from other studies

Pollak, Segal, Stryjer, Stern (2012) compared the various aspects of the psychological reports and possible changes after treatment in persons with BPPV. To investigate the stated objective, DHI and HADS were administered before and after the treatment of BPPV. Results revealed that the scores for all the items did not change before and after treatment of BPPV except for the physical domain. Thus it was concluded that there is a lack of a significant change in emotional reactions in individuals with BPPV even after treatment of their condition. Thus author recommended that clinician treating person with BPPV should be aware that the disease is not just affecting physically aspect but it also has a serious impact on the individual's emotional state.

Martellucci et al (2016) assessed the factors related to residual dizziness (RD) in clients who underwent successful canalith repositioning procedures (CRPs) in person with BPPV. 97 individuals with BPPV of the posterior semicircular canal (pSCC) were initially enrolled. Diagnosis was assessed based on the Dix-Hallpike test and typical case history. All the participants underwent CRPs until nystagmus disappeared. Three days after the successful treatment, presence of RD (Residual dizziness) was investigated.. The Dizziness Handicap Inventory (DHI) was obtained from clients at the time of diagnosis and at every subsequent visit. A logistic regression analysis showed that the probability of RD (Residual dizziness) increased with the increase of the emotional subdomain score of the DHI questionnaire.

Silva et al (2016) described an effect of Otolith Repositioning Maneuver (ORM) on dizziness symptoms, QOL, and postural balance in elderly people with BPPV. Method involved assessment of 14 elderly people that underwent the Otolith Repositioning Maneuver and reevaluation after one week. Results showed that scores of DHI had reduced significantly across all the domains after the ORM. However there were 50 % of the participants who reported imbalance even after treatment. Posturography was carried out on all of these participants and it was found that, those who had abnormal results on posturography had lesser improvement on DHI. . Therefore, it was concluded that a longer follow-up period and a multidisciplinary team are required to establish comprehensive care for elderly clients with dizziness complaints.

Comparison of QOL between PRM and Semont Maneuver in individuals with BPPV

Varela, Magro, Perez (2001) compared the PRM with Semont maneuver at 1 week of follow-up and 3 months of follow up in individuals with BPPV. 74% versus 71% improvement was noted for PRM and Semont procedure respectively at the end of 1 week and 93.5% versus 77 % at the end of 3 months follow-up. On contrary to this, Massoud et al (1995) and Varela, Magro, Perez, (2001) revealed no significant difference between the two maneuvers in the individuals with posterior canal BPPV. Radtke, Neuhauser, von Brevern, Lempert (2004) reported better improvement in individuals with posterior BPPV using PRM (95%) than Semont (58%) Maneuver in a randomized double blind method.

QOL in persons with Horizontal/ Lateral Canal BPPV

In general review of literature indicates that there is no consensus on best treatment for lateral canal BPPV. Nuti (1998), Casani et al. (2002) used Roll maneuver in individuals with lateral canal BPPV and reported a success rate of 75%. However, the studies used unclear endpoints to record the progress, and lacked control groups to allow comparison between the treatment and the natural rate of resolution of this condition. Asprella (2005), Nuti (1998), Casani et al. (2002) investigated an efficacy of Gufoni maneuver and forced prolonged positioning, another techniques used for effective treatment of Horizontal canal BPPV and reported success rate of 72% in individuals with horizontal semicircular canal.

2.5.1. Comparison of QOL among various vestibular disorders

Several investigators have studied the QOL by means of various self-assessment questionnaire designed to assess either activities of daily living or self-perceived handicap or general QOL. Oghalai, Manolidis, Barth, Stewart, and Jenkins (2000) conducted a study on 100 geriatric individuals to determine the prevalence of undiagnosed BPPV and its effects on functional impairment. It was found that out of the total population screened, 9% of the subjects had BPPV and their Activities of Daily Living (ADL) score when compared to those who did not have BPPV were significantly lower. They further reported that individuals who had BPPV had a higher prevalence of falls than those who did not have BPPV. It was further reported that individuals with BPPV were more likely to have depression than those who did not have BPPV. Scores on Instrumental Activities of Daily Living (IADL) and Mini Mental Status Examination (MMSE) were shown to be significantly different between the individuals with and without BPPV. Thus it was concluded that individuals with BPPV has a higher depression rate which reduces their ability to participate in normal activities, resulting in isolation.

Handa, Kuhn, Cunha, Schaffleln, Ganança (2005) compared the impact of dizziness on QOL, in individuals diagnosed as BPPV and/MD, in crisis and out of crisis. The Dizziness Handicap Inventory was applied in 70 participants with positional vertigo, 70 with MD and 15 with both. When comparing the groups, Dizziness Handicap Inventory results evidenced higher averages in crisis as well as out of crisis for MD group than for positional vertigo group. In addition, scores on DHI were poorer in individuals who had both MD with BPPV than those who had only MD or only BPPV. Possible reason given by the authors for more self-perceived handicap in individuals with MD than individuals with BPPV is uncertain nature of chronic character of the disease, with fluctuating, recurrent and long lasting clinical manifestations that may impair not only the physical capabilities, but also the activities of the subjects.

Gross, Ress, Viirre, Nelson, Harris (2000) did a study to provide a detailed description of several persons diagnosed with both BPPV and MD. Total 151 individuals with BPPV were considered for the study, out of which 45 were found to have a codiagnosis of MD. Based on the temporal relationship investigators determined the onset of MD preceded that of BPPV in all but one case. There was a female-to-male ratio of 2:1. Results of the study revealed that in 41 individuals with unilateral MD, 18 had bilateral BPPV, 16 had BPPV of the same ear, and 7 had of contralateral side. Overall, it was observed that BPPV was limited to the same ear as the MD, except for two individuals who had BPPV secondary to MD. In addition, it was found that all of these individuals with both MD and BPPV presented with intractable BPPV. It has been postulated that intractable BPPV may be attributable to one of three possible mechanisms: improperly performed (Canalith Repositioning Maneuver) CRP, cupulolithiasis, or obstruction within the membranous duct of the posterior semicircular canal. Authors asserted that all CRPs in their clinic were performed by the same indi-

vidual who is expert with the CRP technique. Furthermore, CRP was repeated until reduction or resolution of vertigo or nystagmus was encountered. All the participants had undergone more than one CRP session. They further suggested that individuals with BPPV fall within a continuum between canalithiasis and cupulolithiasis. According to earlier theory, a higher degree of cupulolithiasis will result in a higher chance of CRP failure. However intraoperatively authors found 14-15 otolith particles in posterior/horizontal canal of individuals with intractable BPPV made them to refute the theory of cupulolithiasis. Therefore another pathophysiological mechanism is explained by these authors which says that hydropic distention or rupture may injure the maculae of the saccule and utricle via vascular compromise or distortion of its surface, resulting in release of otoliths into the endolymph. Periodic hydropic distention, as seen in the natural course of MD, may result in repeated release of otoconia. Alternatively, permanent damage to the maculae due to hydropic distention and collapse of the membranous labyrinth may result in macular fibrosis. This could manifest itself with permanently free-floating otoliths within the endolymph. Furthermore, author also hypothesized that macular damage of the utricle may be a more likely explain the mechanism of the coexistence of canalithiasis and the recurrent and permanent forms of BPPV Because the saccule is anatomically separated from the utricle and semicircular canals by the endolymphatic valve of Bast.

Leon et al (2012) compared self-perceived handicap and health-related QOL (HR-QOL) in person with complaint of vertigo due to peripheral vestibular disorders. Method involved assessment of disability using disease specific questionnaire, DHI and measure of general QOL using SF-36. Pathological conditions of the subjects considered in the study were BPPV, VN, MD, post-trauma and others. Results revealed that individuals with VN and Meniere's groups had higher level of disability

than individuals with BPPV on DHI scale. On the SF-12 scale, greater deterioration was perceived in physical than other domains. Furthermore, significant inverse associations were found between the physical component of the SF-12 and the physical, emotional and functional aspects of the DHI questionnaire. Author concluded that The DHI and the SF-12 are useful, practical and valid instruments for assessing the impact of dizziness on the QOL in persons with dizziness.

Voorde, Zaag-Loonrn and Leeuwen (2012) assessed level of impairment in clients with dizziness. Total 2,252 persons with primary complaint of dizziness due to various vestibular as well as non-vestibular causes were involved in the study. All of them filled the Dutch version of DHI. Results revealed that dizziness due to hyperventilation disorder has maximally affected self-perceived handicap followed by individuals with unknown peripheral syndrome, VN and BPPV. Least self-perceived handicap was observed in persons with Migraine.

Kim, Kim, Joo, Park and Han (2012) assessed and compared the degree of dizziness resulting from different peripheral vestibular diseases such as BPPV, MD, and VN. Korean form of Dizziness Handicap Inventory (K-DHI) was administered on 150 individuals who were either diagnosed as BPPV or MD or VN. Results showed that scores were significantly higher in individuals with definite MD than those with BPPV or VN and for the subcategories of persons with BPPV, persons with lateral canal BPPV showed significantly higher scores than posterior canal BPPV.

Thus it can be concluded that most of the investigators report that individuals with BPPV have less affected QOL on self-assessment questionnaire than individuals with MD and VN. Individuals who have more than one vestibular pathology such as BPPV with MD will results into more affected self-perceived handicap than individuals who have only one vestibular pathology. However, there are dearth of studied in-

vestigating QOL in individuals with BPPV secondary to other vestibular pathologies such as VN and other inner ear disorders.