CHAPTER – 1

INTRODUCTION

In human beings, balance is maintained through three sensory inputs i.e. vestibular, visual, and somatosensory systems. These sensory inputs are integrated at the vestibular nuclei and give rise to two major reflexes- vestibulo-ocular reflex (VOR) which stabilizes our vision during head movement and vestibulo-spinal reflexes (VSR) which helps us to maintain posture (Herdman, 2000). Cerebellum serves to fine-tune inaccurate motor outputs. Among the three sensory system, both peripheral vestibular and central vestibular structures play more crucial role in maintaining balance. The semicircular canals, the saccule, the utricle, and the vestibular nerve constitute the peripheral vestibular system. The vestibular nuclei, cerebellum, brainstem, spinal cord, and the vestibular cortex creates the central vestibular system.

Disorders affecting peripheral or central vestibular system can affect maintenance of balance and lead to dizziness or vertigo. Some of the disorders affecting peripheral vestibular system include benign paroxysmal positional vertigo (BPPV), Meniere's disease (MD), vestibular neuritis (VN), perilymph fistula, labrynthitis, herpes zoster oticus, labyrinthine concussion, and superior canal dehiscence syndrome while central vestibular disorders include migraine, vertebrobasilar insufficiency, stroke, transient ischemic attack, tumor, and multiple sclerosis. Determining the cause of vertigo is not easy as many of these pathologies result in similar symptoms.

In many cases clinical history and examination provides some qualitative information about vestibular function. However, examining clients with vestibular tests provides more accuracy in diagnosis of disorder than just clinical examination

(Gordon, Shupak, Spitzer, Doweck, Melamed 1996). Many times persons with vestibular problems have auditory problems which may or may not be related to the vestibular disorder. Hence administration of a battery of audio-vestibular tests will help in differential diagnosis of vestibular disorders. Electronystagmography (ENG) or videonystagmography (VNG) tests are most widely used vestibular tests to assess vestibular function. ENG/ VNG consists of battery of tests such as spontaneous nystagmus, gaze testing, smooth pursuit tracking (horizontal and vertical), optokinetic testing, positional test, caloric test and the Dix-Hallpike test. Caloric test and positioning test (Dix-Hallpike test) are useful in detection of peripheral vestibular pathology. Whereas saccade test, gaze testing, smooth pursuit tracking (horizontal and vertical), optokinetic testing, positional test are more sensitive in detection of central vestibular disorders. VNG differs from ENG in terms of method by which eye movements are recorded. VNG uses infrared technology to record eye movement. This helps in capturing horizontal and vertical eye tracings. This allows the clinician to visually assess for torsional eye movement for the diagnosis of benign paroxysmal positional vertigo (BPPV). The VNG/ENG is also very useful in identification of bilateral vestibular loss although the rotational chair test is better at the diagnosis of bilateral vestibular disorders.

Cervical vestibular evoked myogenic potential (cVEMP) was added to the tests battery for assessment of vestibular functioning as a test of assessing saccular function or inferior vestibular function or test to assess vestibulo-colic reflex (Colebatch & Halmagyi, 1994). cVEMP test has been proposed as a very useful tool in classification of individuals with vestibular neuritis into superior, inferior or complete vestibular neuritis. Another variant of VEMP called oVEMP has been also found to be Clinically applicable in diagnosis of many vestibular disorders. It is also

reported to be assessing functioning of superior vestibular nerve or utricular part of vestibular system (Magliulo et al, 2014). Both the tests have been also found to be useful in predicting prognosis of disorder in many other vestibular disorders such as MD and BPPV (Rauch, 2006; Akkuzu et al, 2006).

Assessment of persons with dizziness also needs an assessment of other sensory systems which helps in maintaining body balance using posturography. Thus, various tests are available for assessing persons with dizziness with different index of sensitivity and specificity for differential diagnosis of vestibular disorders.

1.1 Audio-vestibular findings in persons with BPPV

One of the most common vestibular disorders causing vertigo is Benign Paroxysmal Positional vertigo (BPPV). BPPV may be idiopathic or may be associated with other otologic pathology. Individuals with BPPV without a prior history of otologic pathology have been described as having primary BPPV or idiopathic BPPV, while persons with BPPV with a definite history of prior otological pathology are said to have secondary BPPV (Katsarkas, 1999). Idiopathic BPPV is more prevalent in the elderly with an age of onset in the sixth decade and is more common in women, (Brevern et al., 2007). Secondary BPPV may be caused because of various disorders such as vestibular neuritis, labrynthitis, or Meniere's disease (MD) that damage the inner ear and detach the otolith from the utricular macule (Karlberg et al., 2000; Lee, Ban, Lee, & Kim, 2010; Hughes & Proctor, 1997).

Conventionally BPPV is diagnosed based on the history of brief attacks of intense positional vertigo and torsional nystagmus on Dix-Hallpike test (Bhattacharya et al, 2008). However recent studies have shown that persons with BPPV may show abnormality on other audiovestibular tests also (Imai, Ito, Takeda, 2005). However there is still no consensus with regard to results on audiovestibular test battery in

individuals with BPPV. Moreno (2009) did a retrospective analysis of characterizing pure tone average (PTA) in elderly persons with BPPV. The results revealed that there was no significant difference between the PTA (average of thresholds at 500 Hz, 1000 Hz and 2000 Hz) of elderly persons with BPPV and the age matched healthy controls. Similarly Kim and Ban, (2012) 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, Wu et al. (2006) reported higher PTA in 52 % of the participants with BPPV. Thus, variation is present for hearing sensitivity among persons with BPPV.

Studies have also attempted to document the results on vestibular tests using VNG as well as VEMP in persons with BPPV. Korres (2004) reported that 12.5 % of persons with posterior canal BPPV had spontaneous nystagmus; while De Stefano (2011) reported spontaneous nystagmus only in individuals with horizontal canal BPPV. Few investigators have reported spontaneous nystagmus to be present in only 5 % of persons with BPPV (Hajiabolhassan & Tavanai, 2013). Thus, studies do report presence of spontaneous nystagmus in persons with BPPV, but there is no consensus on the percentage of persons with BPPV showing spontaneous nystagmus. Also there is a dearth of studies investigations on Gaze Nystagmus, positional nystagmus and saccade nystagmus in persons with BPPV.

The prevalence rate of abnormal caloric responses among the individuals with BPPV has been reported to vary from 30 % to 50% (Baloh, Honrubia, & Jacobson, 1987; Pollack et al., 2002; Karlberg et al., 2000; Wada, Naganuma, Tokumasu, Ito, & Okamoto, 2009). Contrary to above findings few investigators have reported no significant difference on abnormalities observed on VNG in individuals with BPPV and without BPPV (Domínguez-Durán et al., 2011)

Clinical relevance of cVEMP in individuals with BPPV has been also studied (Güzin Akkuzu, Akkuzu, & Ozluoglu, 2006; Yang, Kim, Lee, & Lee, 2008; Korres et al., 2011; G Longo, Onofri, Pellicciari, & Quaranta, 2012). It has been reported that latencies of P13 and N23 peaks in individuals with BPPV did not differ significantly from the latencies in healthy controls. However, more number of individuals with BPPV had prolonged latencies as compared to normal individuals and these prolongations in latencies were attributed to neuronal degenerative changes in macula of saccule. Further, research has suggested that cVEMP can be a useful method to determine a clinical prognosis of persons with BPPV (Zhou, 2015; Xu et al., 2016). However, there are incongruent reports regarding the abnormal results on cVEMP on affected versus unaffected side in persons with BPPV. Some report that both ears are equally affected due to an interaction of the two ears through pathways involving the vestibular nuclei (Zhou, 2015; Xu et al., 2016) whereas others report more abnormalities on the affected side (Sreenivasan, Sivaraman, Parida, et al., 2015; J. D. Lee et al., 2013). Hence there are variations in terms of abnormal results on cVEMP tests in persons with BPPV. Moreover, there is no consensus with regard to the side of impairment on affected ear with BPPV versus unaffected ear with BPPV.

1.2 Self-perceived handicap and general quality of life in persons with BPPV

Dizziness can lead to considerable impairment in daily life functioning associated with social isolation, functional disability, falls, and mobility restriction. Quality of life among individuals with primary complaint of dizziness has been assessed using disease specific questionnaire (DHI) and questionnaire that assesses general quality of life such as WHOQOL-BREF, SF-36. It was observed by Leon et al (2012) that all the domains of both the questionnaires were affected indicating poor quality of life (QOL) in individuals with dizziness. They further reported that Physical

domain of both the questionnaire were maximally affected in all the participants. While Lin, Tsai, Lee, & Wu (2002) reported that functional domain of DHI to be most prevalent as compared to physical and emotional domain.

Association of self-perceived handicap with functional impairment depicted by the objective vestibular test has been studies by many researchers. Most of the research in this area is focused on reporting the amount of imbalance/ postural instability using vestibular functional tests such as Sensory Organization test (SOT), rotational chair test, Romberg test, DGI (Dynamic gait Index) and its effect on self-perceived handicap using DHI. Whitley, Whirley and Furman, (2004) reported that self-perceived handicap is moderately associated with tests that assesses the dynamic function while few researchers report that quality of life is weakly associated with posturography (Robertson & Ireland, 1995; Jacobson & McCaslin, 2003). Nevertheless it has been reported that an individual's with abnormal results on more number of vestibular tests will report higher self-perceived handicap than persons with impairment on less number of vestibular tests (McCaslin, Jacobson, Grantham, Piker, Verghese, 2011).

Various factors like type of vestibular pathology, associated hearing loss, tinnitus can also have an effect on quality of life among individuals BPPV. For instance, self-perceived handicap in persons with BPPV secondary to MD is reported to be higher than idiopathic BPPV (Handa, Kuhn, Cunha, Schaffleln, & Ganança, 2005). Studies have been carried out to investigate if the non-pathological factors such as age and gender can have an effect of self-perceived handicap and QOL of persons with BPPV. A majority of the researchers report no significant difference for the self-perceived handicap between male and female participants with dizziness (Takono et al, 2010; Whitley, Whrisley, Marchetti,

Furman, 2006), though females with BPPV reported higher self-perceived handicap on DHI as compared to males with BPPV (Voorde, Loonen, Leeuwen, 2012). Patrícia, Handa, Kuhn, Cunha, Schaffleln, and Ganança, (2005) reported no effect of age on self-perceived handicap among the participants with dizziness. On the other hand, Voorde, Loonen, and Leeuwen (2012) reported that older clients with dizziness have more self-perceived handicap than younger ones with dizziness. Similarly, there are equivocal reports on the effects of associated hearing loss on self-perceived handicap and general quality of life among the participants with dizziness. Soderman, Bagger-Sjoback, Bergenius, and Langius (2002) reported that associated tinnitus and hearing loss among the participants with MD influenced the psychosocial dimension on SF-36 scale but there was no significant effect of associated hearing loss and tinnitus on DHI. Similarly, Cruz et al (2006); Lacerda, Oliveira, Sérgio, Canto, and Cheik (2012) reported that associated hearing loss especially bilateral hearing loss in individuals with dizziness results in poorer quality of life than persons without associated hearing loss. On contrary, few have reported no effect of associated hearing loss on self-perceived handicap in persons with dizziness (Gopinath, McMahon, Rochtchina & Mitchell, 2009). Thus, a review of literature suggests that the quality of life is affected in persons with dizziness. However there is a paucity of research documenting an effect of these factors specifically in individuals with BPPV.

NEED OF THE STUDY

Need to study audiovestibular findings in persons with BPPV

BPPV is primarily a vestibular disorder; however, there are inconsistent reports in the literature regarding the presence of hearing loss in persons with BPPV. A few investigators report that hearing sensitivity is within normal limits in persons

with BPPV in both ears (Moreno, 2009) whereas others report that hearing sensitivity is affected in persons with BPPV. Wu et al., (2006) reported that the hearing loss is more on the side of BPPV while Kim & Kim (2011 report that hearing loss can be present on either side of BPPV. Hence there is a need to study hearing sensitivity in persons with BPPV.

Dix-Hallpike test is the confirmatory test for diagnosis of BPPV but a battery of vestibular tests is recommended to be performed in persons with the complaint of vertigo. The vestibular test battery used for assessment of persons with complaint of dizziness includes but not limited to tests to check for spontaneous nystagmus, gaze evoked nystagmus, positional nystagmus, caloric tests and recording of VEMP.

Spontaneous nystagmus has been reported to be a hallmark sign in acute stages of VN, Labrynthitis and many central pathologies (Proctor, 2000; Halmagyi, Karlberg, Curthoys, & Todd; 2001; Pavlin-Premrl et al., 2015; Hirvonen & Aalto, 2009). A few investigators who have studied spontaneous nystagmus in persons with BPPV have reported equivocal findings. Hence there is a need to investigate occurrence of spontaneous nystagmus among the individuals with BPPV.

Positional nystagmus is associated with many peripheral as well as central pathologies (Bertholon, Bronstein, Davies, Rudge, & Thilo, 2002; Watanabe, 1994). Its characteristics in vision denied versus vision enabled condition are useful in differential diagnosis of peripheral from central vestibular pathologies. It has been more commonly observed in central vestibular pathologies and in acute stage of peripheral vestibular pathologies. BPPV is known to occur during acute as well as latent stage of vestibular disorders (Watanabe, 1994). Therefore positional nystagmus may exist in persons with BPPV secondary to other vestibular disorders. However there is scarcity of literature documenting occurrence of positional nystagmus in

primary versus secondary BPPV. No study has been carried out to the best of researcher's knowledge on the occurrence of positional nystagmus in persons with BPPV secondary to MD, VN or other peripheral vestibular pathology.

Gaze evoked nystagmus has a 100 % specificity in identification of central pathology (Chen et al., 2011). Characteristics of gaze evoked nystagmus such as direction changing versus non direction changing nystagmus in vision enabled versus vision denied condition, is used for differential diagnosis of persons with vestibular pathology (Vanni, 2014; Rohmeier, 2013). Not many studies have investigated the occurrence of gaze evoked nystagmus in different types of persons BPPV.

Caloric test has been reported to possess maximum sensitivity and specificity in diagnosis of persons with vestibular pathology (Maes et al., 2011). It is reported to provide information about the integrity of vestibulo-ocular reflex or horizontal semicircular canal or superior vestibular nerve. The studies that have investigated the occurrence of canal paresis among persons with BPPV, have reported that the persons with BPPV have large variability in terms of occurrence of abnormal results on caloric test (Korres et al., 2011; Longo, Onofri, Pelliccaiari & Quranta, 2012; Kim et al., 2015). These variations are assumed to be due to the inclusion of both primary as well secondary type of BPPV among the studied population. Therefore there is a need to study and compare the results of caloric test in persons with primary and secondary BPPV

cVEMP provides information about the saccular functioning or inferior vestibular never or vestibule-colic reflex. . It has been reported to be a useful tool in assessment of persons with differential diagnosis of vestibular disorders (Miner, 2005; Welgampola & Colebatch, 2005; Zapala, 2007). It has also been reported to be a valuable assessment tool in persons with BPPV to predict the success of treatment and

chances of recurrence (Yang, Kim & Lee, 2008; Longo, Onofri, Pelliccaiari & Quranta, 2012, Lee, Park, Lee, Sung & Park, 2012). However, there is no consensus on the parameters of cVEMP that are affected in persons with BPPV. Few authors report latency to be the most likely affected parameter, while others report amplitude to be one of the most affected parameter (Akkuzu, Akkuzu, & Ozluoglu, 2006; Yang, Kim & Lee, 2008; Korres et al., 2011; Zhou, 2015; Xu et al., 2016). This discrepancy could have been due to an unidentified vestibular pathology associated among the studied population with BPPV. Hence, there is a need to compare cVEMP parameters in persons with primary and secondary BPPV. Thus, a review of literature indicates the need for investigating the audiovestibular profile of persons with BPPV and compares the results of audiovestibular tests in persons with primary and secondary BPPV.

Need for studying 'self-perceived handicap' and 'quality of life' in persons with BPPV

Dizziness has been reported to affect daily functioning, social life and psychological well-being of persons with dizziness (Tamber, Wilhelmsen, & Strand, 2009; Asmundson, Stein, & Ireland, 1999; Perez, & Gamendia, 2001). Disease specific questionnaires such as DHI assess the impact of dizziness or vertigo on daily activities of a person. DHI quantifies the handicap perceived by a person in different domains such as physical, Functional and Emotional. Questionnaires such as WHO QOL- BREF are used to assess the general quality of life. WHOQOL-BREF assesses the quality of life in four domains, physical, psychological, social relationship, environmental. The information reported by a person in these various domains can be useful in counseling, planning management strategies and in assessing outcome of rehabilitation.

A majority of the studies reported in the literature have used either DHI (Handa et al., 2005; Enloe & Shield, 1997) and/or WHOQOL-BREF (Fielder, 1996) in persons with dizziness. However, there is a dearth of studies assessing self-perceived handicap and general QOL specifically in persons with BPPV. It is recommended that both disease specific and generic questionnaires be used for such assessment. Disease specific questionnaire such as DHI will assesses how activities in everyday life that are dependent on balancing are affected by dizziness, whereas WHOQOL-BREF assesses the impact of dizziness on overall activities in daily life. Various factors such as life style, occupation and socioeconomic status can have an effect on QOL and these factors are not same across countries. Therefore, it is not appropriate to generalize the QOL reported by persons living in other countries to those living in India.

Furthermore, self-perceived handicap has been found to be greater in individuals having abnormality on more number of vestibular tests than in individuals showing impairment on less number of vestibular tests (Jacobson, Grantham, Piker & Verghese, 2011; Whitley, Whirley & Furman, 2004). So it can be speculated that self-perceived handicap in persons with secondary BPPV will not be same as that reported by persons with secondary BPPV. However, to the best of the researcher's knowledge, there is no comparison between self-perceived handicap or general quality of life of persons with primary and secondary BPPV.

Many characteristics of dizziness such as duration and frequency of dizziness may have an impact on the self-perceived handicap. It has been found that frequency of dizziness has more effect on self-perceived handicap than duration of dizziness (Perez, Granero, Martin, & Graciatapia, 2001, Honrubia, Bell, Harris, Baloh, & Fisher, 1996; Aggarwal, Bennett, & Biienias, 2000). Nevertheless there are reports documenting no effect of duration or frequency of dizziness on self-perceived

handicap (Dros et al., 2011; Hsu et al., 2005). However, there are no studies documenting effect of duration and frequency on self-perceived handicap and QOL in persons with BPPV. Frequency and duration of vertigo or dizziness may vary depending on the associated pathology. Hence, there is a need to investigate their effect in persons with primary and secondary BPPV.

A few investigators report no associated hearing loss in persons with BPPV, while some report significant hearing loss in individuals with BPPV. Researchers have reported equivocal findings on the effect of associated hearing loss on QOL. A few studies have reported that QOL is more affected in persons with dizziness having an associated hearing loss (Soderman, Bagger-Sjoback, Bergenius, & Langius, 2002; Cruz et al., 2006) while Gopinath, McMahon, Rochtchina & Mitchell (2009) reported no significant effect of associated hearing loss on QOL. Also very few studies have investigated the effect of associated hearing loss specifically in persons with BPPV.

Quality of life is known to differ even within group of individuals diagnosed to have same disorder. This has been found to be due to various non-pathologic variables such as age and gender of the studied population. Effect of age and gender on self-perceived handicap has been studied by many investigators in individuals with dizziness. Some studies report that females report more handicap than males on DHI (Voorde, Loonen, & Leeuwen, 2012) while others report that no such difference exists (Piker & Jacobson, 2014; Loughram, Gatehouse, Whitley, Whrisley, Marchetti, & Furman, 2006; Cheng et al., 2012). Similarly, there are contradictory reports with regard to the effect of age on QOL. QOL has been found to be more affected in older individuals than younger individuals with complaint of dizziness in some studies (Voorde, Loonen, & Leeuwen, 2012), while some investigators have reported no such trend (Piker & Jacobson,2014; Handa, Kuhn, Cunha, Schaffleln, & Ganança, 2005).

Inconsistent reports in the literature substantiate that there is a need of studies investigating the effects of age and gender in persons with BPPV. Thus a review of literature highlights the need for investigating self-Perceived handicap and general QOL in persons with BPPV. There is also a need to study the factors affecting the self-perceived handicap and general QOL in persons with BPPV.

Aim of the study

Aim of the present study was to investigate audiovestibular profile in persons with BPPV and study the Quality of Life (QOL) in persons with BPPV

Objectives of the study

1. **To study Audiovestibular findings in persons with BPPV, both primary and secondary BPPV**
    - To study the hearing sensitivity of individuals with BPPV.
    - To study the Spontaneous Nystagmus, positional Nystagmus and Gaze evoked Nystagmus in persons with BPPV
    - To study caloric Nystagmus in persons with BPPV
    - To study the response rate, latency, amplitude parameters of cVEMP in persons with BPPV

2. **To evaluate the quality of life in individuals with BPPV, both primary and secondary**
3. **To investigate the factors affecting quality of life in individuals BPPV, both primary and secondary**
    - Effect of age and gender
    - Effect of frequency and duration of dizziness
    - Effect of Associated hearing loss