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A SURVEY OF AUDIOLOGISTS' CLINCAL PRACTICES AND THEIR FORMAL EDUCATION AND TRAINING IN THE ASSESSMENT AND MANAGEMENT OF ADULTS WITH VESTIBULAR PATHOLOGIES

by

Ashlee Blohm

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THESIS APPROVAL PAGE

This is to certify that the thesis prepared by Ashlee Blohm, entitled A Survey of Audiologists' Clinical Practices and their Formal Education and Training in the Assessment and Management of Adults with Vestibular Pathologies has been approved by the thesis committee as satisfactorily completing the thesis requirements for the degree Doctor of Audiology (Au.D.).

Peggy Korczak
Peggy Korczak, Ph.D.
Chair, Thesis Committee

5-3-12
Date

Diana C. Emanuel, Ph.D.
Committee Member

05/03/12
Date

Tricia Ashby-Scabis
Tricia Ashby-Scabis, Au.D.
Committee Member

5/3/12
Date

Janet V. Delany
Janet Delany, Ph.D.
Dean of Graduate Studies

May 12, 2012
Date

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ABSTRACT

A SURVEY OF AUDIOLOGISTS' CLINCAL PRACTICES AND THEIR FORMAL EDUCATION AND TRAINING IN THE ASSESSMENT AND MANAGEMENT OF ADULTS WITH VESTIBULAR PATHOLOGIES

Ashlee Blohm

A survey of audiologists' clinical practices and their formal education and training in vestibular topic areas was sent to 900 practicing audiologists. A total of 334 surveys were returned, both in print and online. The results of the survey were primarily focused on the participants' reported comfort levels in providing a number of vestibular assessment and treatment procedures. These comfort levels were evaluated as a function of the participants' levels of education (i.e., Master's degree, Au.D., or Ph.D in hearing science) as well as their years of clinical experience conducting these procedures (i.e., 0-5 years, 6-10 years, and 10+ years).

The results of this survey indicated that the audiologists' years of clinical experience had a broad impact on participants' self-reported comfort levels in administering and interpreting several assessment procedures as well as providing treatment procedures, such as vestibular rehabilitation therapy. In contrast, it appears that audiologists' level of higher education had only a minimal effect on participants' mean comfort levels in the administration and interpretation of various vestibular assessment and treatment procedures. A review of 59 academic programs in audiology that are

currently accredited by ASHA indicated that there are typically very few courses specifically focused on vestibular topics. It is hypothesized that if more academic courses as well as hands-on lab exercises related to these vestibular-based topics were available to students, then it is likely that audiologists' comfort levels in administering and correctly interpreting various vestibular diagnostic tests and rehabilitation test protocols would likely increase.

Future research in this area is necessary to determine more specific ways to enhance audiologists' education in the assessment and management of individuals with vestibular disorders.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

Dizziness is a common medical complaint, especially in the adult population. Estimates of the prevalence of dizziness in the general population vary. However, it remains the third most common reason for a physician visit in American adults (Gans, 1999; NIDCD, 2008). Symptoms of dizziness vary widely between individuals and can result from a number of disorders within a variety of body systems. Individuals experience and report a range of symptoms from a floating or lightheaded feeling to severe vertigo, falls, and nausea. It is critical to take a thorough case history and assist the patient in appropriately labeling their specific symptoms if an efficient diagnosis is to be made. Some common etiologies of dizziness are related to cardiovascular disease, autoimmune disorders, neurologic disease, visual disturbances, and psychiatric involvement, as well as disorders of the inner ear (Desmond, 2004). Disorders of the inner ear are thought to contribute to the majority of these dizziness cases, at a rate of approximately 85% (Gans, 1999).

Because such a high percentage of dizziness cases are related to a dysfunction within the inner ear system, vestibular evaluation is a clinical area in which audiologists should be well trained (AAA, 2011; ASHA, 1999). Little research has been done related to current vestibular assessment and treatment procedures that are being used regularly in clinical practice. Additionally, there is a lack of research on audiologists’ formal education and clinical training in the areas of vestibular assessment and treatment. These educational factors are critical to them being able to provide the best level of care for their patients with these types of disorders (Helfer, 1999; Nemes, 2000). It is hoped that the data obtained from this survey will provide insight into the specific areas of vestibular practice that are in need of additional formal education and/or clinical training for both the Doctor of Audiology (Au.D.) students as well as practicing clinicians.

This literature review will focus on the anatomy and physiology of the peripheral and central portions of the vestibular system, the assessment techniques that are available to evaluate the integrity of the vestibular system, and rehabilitation exercises used to treat vestibular dysfunction. In general the assessment procedures can be divided into two major categories, screening or low-tech assessment procedures and diagnostic or high-tech assessment procedures. The low-tech assessment procedures that will be reviewed are the Gans Sensory Organization Performance (SOP) test, which is also known as the Clinical Test of Sensory Integration and Balance (CTSIB); the Dynamic Visual Acuity Test (DVAT); the Head Shake Test; and the Vertebral Artery Test. The high-tech assessments that will be discussed are Electronystagmography/Videonystagmography (ENG/VNG); Rotary Chair Testing; Computerized Dynamic Posturography; and the Vestibular Evoked Myogenic Potential (VEMP). Treatment procedures discussed in this review are Vestibular Rehabilitation Therapy (VRT); the canalith repositioning maneuvers; and the Brandt-Daroff exercises. Additionally, an evaluation of the current training and formal education of audiologists in these topic areas will be discussed.

Chapter 2

Review of the Literature

Dizziness is the most common medical complaint of patients over 70 years of age and the third most common in American adults overall (Gans, 1999; NIDCD, 2008). Upwards of 90 million Americans will experience this symptom at some point during their lives while 2.4 million suffer from more chronic episodes. More broadly, chronic issues with balance are reported by nearly eight million Americans (NIDCD, 2008). Estimates of the cost of medical care for these patients range from one to eight billion dollars a year (Gans, 1999; NIDCD, 2008). It is thought that there are many more individuals that suffer from episodes of imbalance than are currently reported (Desmond, 2004). A study performed by Yardley and colleagues (1998) surveyed a random group of patients visiting a general medical practice. More than 20% of the respondents to the study (ages 18-65 years) noted that they had experienced dizziness within the past month. Of those who reported experiencing dizziness, half of these individuals associated the dizziness with some level of handicap (Yardley, Owen, Nazareth, & Luxon, 1998).

Symptoms of dizziness are not restricted to any specific population (Desmond, 2004). The incidence of complaints related to balance problems typically increases with age. It has been reported that almost 18.3% of individuals over 60 years of age have experienced dizziness that significantly impacted their lives, either by necessitating a physician visit, using medication or interfering with normal activities (Sloane, Blazer and

George, 1989). In individuals over the age of 75 years, dizziness is the most common reason for a visit to the doctor (Koch & Smith, 1985). Additionally, women tend to present with dizziness and imbalance complaints more often than men (Desmond, 2004). Dizziness can also affect the pediatric population, although these cases are much less common than in adults (Tusa, Saada, & Niparko, 1994).

Symptoms of vestibular disorders can range widely in both their presentation and their severity (Goebel, 2001). Therefore, when audiologists are taking a case history, it is critical to obtain a detailed description of the client's vestibular symptoms, triggers that bring on the dizziness and a description of the duration of any vestibular symptoms so that the audiologist can correctly label, diagnose, and manage vestibular pathology. Descriptions of dizziness vary widely between individuals who experience vestibular symptoms. An often misused term used to describe dizziness is vertigo (Goebel, 2001; Jacobson & Shepard, 2008). True vertigo is defined as rotation or spinning of either oneself or of one's environment (Goebel, 2001; Jacobson & Shepard, 2008). Disequilibrium can be described as a general imbalance or dizziness regardless of head movement or position (Jacobson & Shepard, 2008). These symptoms of unsteadiness can be related to vision-related problems or psychological involvement. Another symptom often described by individuals with vestibular dysfunction is a feeling of faintness or lightheadedness. This description is termed presyncope and can be attributed with various cardiovascular issues and reduced blood flow. An individual experiencing a feeling of presyncope can be at risk for syncope, which is an actual loss of consciousness during the vertiginous event. When clients are able to appropriately describe the symptoms of dizziness, it increases the ability of the clinician to make a correct diagnosis and to develop an appropriate test battery and treatment procedure for the client (Goebel, 2001; Jacobson & Shepard, 2008).

Another subset of Dizziness and balance problems can result from many different etiologies. It has been reported that nearly 85% of all balance-related cases are attributed to disorders of the inner ear (Gans, 1999). In addition to inner ear disorders there are several categories of disorders that can result in vestibular symptoms. Some of the most common categories of medical pathologies that result in vestibular symptoms include: cardiovascular disease, psychiatric disorders, autoimmune disease, disorders of the visual system, and neurologic disease (Desmond, 2004). Cardiovascular disease, such as vertebrobasilar insufficiency and cerebrovascular disease (stroke), can affect an individual's equilibrium by restricting the blood flow to the vestibular labyrinth (Desmond, 2004; Jacobson & Shepard, 2008). Psychiatric disorders namely panic and anxiety disorders, can present with vestibular symptoms that are typically noted as being continuous or of long duration (Goebel, 2001). Autoimmune disease can also affect the function of the balance system through the destruction of the neural connections and pathways that process vestibular input. The types of autoimmune diseases that fall into this category include: HIV, AIDS, and lupus. Overall balance uses input from various musculoskeletal sensors in an individual's body in order to maintain upright posture. Thus, any disorders of the musculature or other proprioceptive sensors can impact in an individual's ability to maintain balance. A large portion of proprioceptive disorders stem from disease or abnormalities of the cerebellum. Disorders of the visual system can have a significant impact on an individual's ability to maintain overall balance. Any disease that presents with visual disturbances can increase the client's ability to accurately process the cues from their visual field and be able to appropriately react to changes in their environment and maintain their stability. Several neurologic diseases can also present with vestibular dysfunction. Post concussive syndrome, autonomic insufficiency, migraine, multiple sclerosis, and epilepsy are all examples of neurologic disorders known to be associated with vestibular symptoms (Desmond, 2004; Goebel, 2001; Jacobson & Shepard, 2008; Jacobson, Newman, & Kartush, 1997).

Within the category of balance-related disorders that involve the inner ear, there are also a variety of etiologies (Gans, 1999). Some of the potential vestibular causes of balance disorders due to involvement of the inner ear include: Meniere's disease, vestibular neuronitis, benign paroxysmal positional vertigo (BPPV), acoustic neuroma/vestibular schwannoma, labyrinthine infarction, perilymphatic fistula, labyrinthitis, autoimmune inner ear disorder, vestibulotoxicity, superior canal dehiscence syndrome, presbystasis, and a variety of genetic syndromes (Goebel, 2001; Hester & Silverstein, 2002; Jacobson & Shepard, 2008; Pikus, 2002; Hester & Silverstein, 2002).

In order to discuss how both the peripheral and central portions of the vestibular organ are evaluated a brief review of the anatomy and physiology of each portion of the vestibular system is necessary. In this literature review the anatomy and physiology of the peripheral system will be discussed first, followed by a discussion of the anatomy and physiology of the central vestibular system.

Anatomy and Physiology of the Peripheral Vestibular System

The human vestibular system is divided into two parts, the peripheral vestibular system and the central vestibular system. The peripheral portion of the vestibular system is composed of two types of sensory structures. These structures are the three semicircular canals (SCCs) and the two otolith organs, shown in Figure 1, below. Each ear contains a set of these five sensory structures for balance. These sensory structures lie within the membranous labyrinth of the inner ear system, which is filled with endolymph fluid.

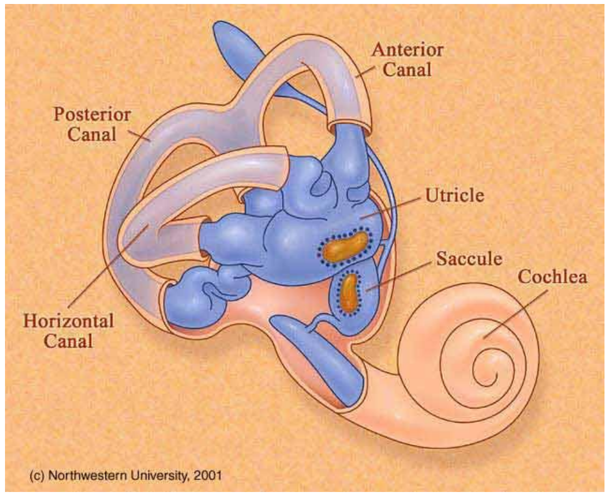

Figure 1. Sensory structures for hearing and balance, which are present in the peripheral auditory system. Reprinted from Northwestern University, with permission.

Within each inner ear, there are three SCCs, each oriented in a different plane of space. The names of the three SCCs are: the anterior or superior SCC, the posterior SCC, and the lateral or horizontal SCC. The horizontal canal is tilted up at a 30 degree angle and the anterior and posterior canals are rotated from the sagittal plane by 45 degrees (Lyaskowski, 2005).

At the base of each SCC there is a widened area or bulb known as the ampulla. Within each ampulla there is a bundle of hair cells known as the cristae ampullaris. Each hair cell in a semicircular canal contains approximately 70 stereocilia and one longer projection, called the kinocilium (Barin, 2009a). The stereocilia for the hair cells in the SCCs are organized in increasing lengths as they approach the kinocilium, similar to that of an organ pipe (Lyaskowski, 2005). The stereocilia on the hair cell then project into the cupula, which is a viscous or gelatinous mound that sits on top of the cristae ampullaris.

There are two types of hair cells, type I and type II, found in the peripheral vestibular system. These hair cells are similar to those found in the cochlea. Each of these hair cells has both afferent and efferent nerve connections to the brain (Barin, 2009a). The afferent fibers attach directly to both type I and type II hair cells. The afferent fibers that attach to the type I hair cell enclose the cell membrane in a chalice-like connection, known as the calyx (see Figure 2 below). In contrast, the afferent fibers for type II hair cells attach directly to the base of the hair cell. The attachments of the efferent fibers are different between the two hair cell types. Type I hair cells have an indirect attachment as the efferent fiber attaches to the afferent fiber below the hair cells, as shown by the dark red attachment in Figure 2 below. In contrast, the efferent fibers form a direct attachment to the base of the Type II hair cells. Both the afferent and efferent connections for the Type I and Type II hair cells are shown in Figure 2.

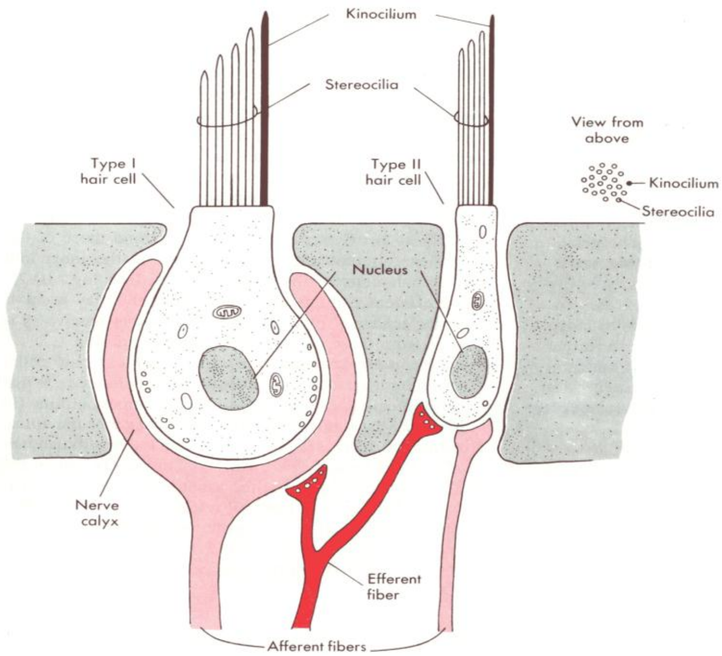

Figure 2. Afferent and efferent nerve connections on type I and II vestibular hair cells. This figure was published in “Physiology”, R. Berne & M. Levy, Copyright Elsevier (1993), with permission.

Each hair cell has a resting or spontaneous neural firing rate, which in humans is approximately 70-90 spikes per second (Barin, 2009a). At rest, the neural input from each inner ear is essentially equal. However, if motion is detected within the ampulla of the SCCs, the hair cells in one ear are excited and thus the neural spikes from that ampulla are increased above the spontaneous firing rate. Simultaneously, the neural firing rate from the hair cells in the opposite ear decrease relative to their resting rate and the input from this side is inhibited. The hair cells in the SCCs are particularly sensitive to angular acceleration, or head turns.

Each semicircular canal is functionally paired with the SCC of the mirrored contralateral system that lies in a parallel plane of space (Wall & Vrabec, 2001). These pairings are shown in Figure 3 below. The horizontal SCCs in each ear constitute one pair, the posterior SCC in the right ear is paired with the anterior SCC in the left ear, and the posterior SCC in the left ear is paired with the anterior SCC in the right ear (Desmond, 2004). This pairing results in an equal and opposite reaction in the contralateral SCC whenever motion of fluid is detected in that plane of space.

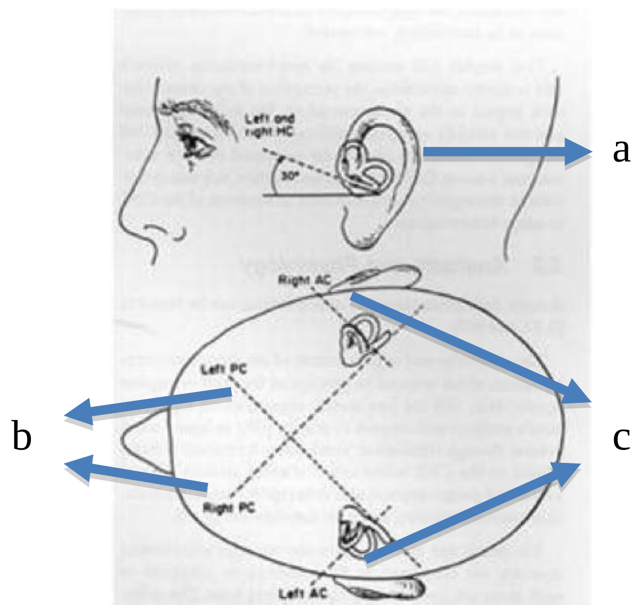

Figure 3. Orientation of the three semicircular canals (SCCs). These are the horizontal SCCs (a), the posterior SCCs (b), and the anterior SCCs (c). Modified from A. Desmond, 2004.

This pairing function of the SCCs is important to understanding the physiology of these structures. The SCCs orient the body to angular head motions of pitch (head nod), yaw (head shake), or roll (head tilt) (Wall & Vrabec, 2001). An example of the importance of the pairing function of the SCCs occurs when an individual turns their head 90 degrees to the left. This head motion will produce a reaction of the endolymph fluid in both horizontal SCCs being shifted to the right. The motion of the endolymph fluid exerts pressure on the stereocilia of the hair cells within the ampulla of each horizontal SCC. Figure 4 shows the response of the SCC in response to a left head motion. The stereocilia in the ipsilateral or right horizontal SCC will bend toward the kinocilium, which, in turn, sends an excitatory signal to the central vestibular system. Conversely, the stereocilia of the contralateral or right horizontal SCC will be simultaneously deflected away from the kinocilium and will send an inhibitory signal to the central vestibular system (Desmond, 2004). The brain will then interpret this excitatory signal from the left side and inhibitory signal on the right side as the head moving toward the left and will instruct the eyes to move in an equal and opposite direction, in this case, 90 degrees to the right. The other pairings of SCCs react similarly to head and body movement in their respective planes of motion (Bear, Connors, & Paradiso, 2001).

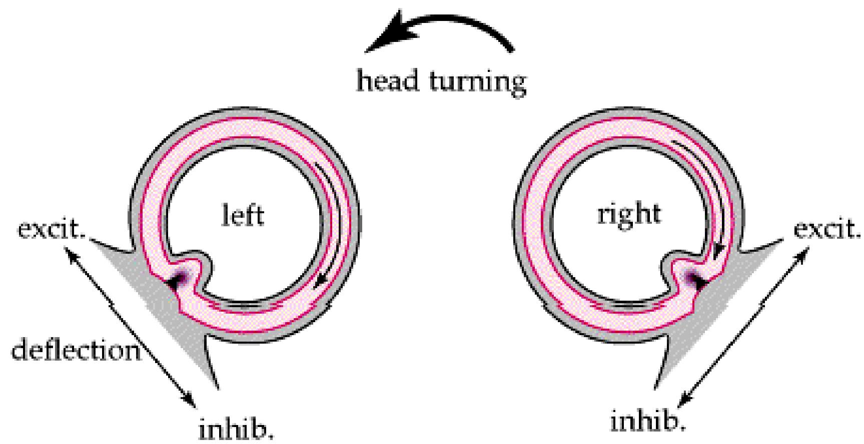

Figure 4. Endolymph motion in response to a leftward head movement. Reprinted from Springfield Technical Community College.

The second major components of the peripheral vestibular system are the otolith or macular organs. There are two otolith or macular organs in each ear. These are the utricle and saccule. These structures are specifically designed to detect linear acceleration horizontally and vertically, as well as forces of gravity (Wall & Vrabec, 2001). The utricle detects head and body movement in the horizontal plane, while the saccule senses head and body movement in the vertical plane (Wall & Vrabec, 2001).

There are also type I and type II hair cells within each of these otolith organs. The hair cells in each of these otolith organs are embedded in a gelatinous membrane known as the otolithic membrane, which is similar to that of the cupula in the SCCs. Within the otolithic membrane are the calcium carbonate crystals, termed otoconia. The otoconia, or ear rocks, have a key function within the utricle and saccule. Because the otoconia are denser than the surrounding endolymph fluid, they produce a sense of gravitational pull that is transferred to the hair cells. Within the utricle and the saccule, there is a centerline or stripe known as the striola, shown as the dotted line in Figure 5 below.

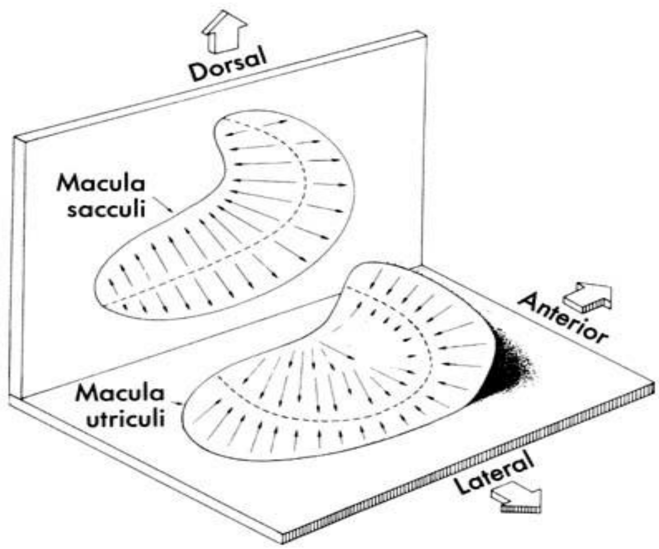

Figure 5. Organization of the hair cells in relation to the striola in both the utricle and saccule. Reprinted from C. Wall & J. Vrabek, 2001.

The striola is curved in shape, which allows for sensation of linear acceleration along multiple trajectories as shown in the figure above (Wall & Vrabek, 2001). In the utricle, the kinocilium of the hair cells are polarized toward the striola. While in the saccule, they are polarized away from the striola.

When the hair cells in the utricle are bent toward the striola depolarization occurs, leading to excitation. The opposite effect occurs in the saccule, where a deflection of the stereocilia toward the striola leads to hyperpolarization and inhibition of the cell (Lyaskowski, 2005). As the head tilts, the otoconia shift atop the macula and then press against the hair cells in that region of the structure. When the input from this portion of the peripheral vestibular system is processed at a higher level in the central nervous system information can be inferred about the location of the head on both the horizontal and vertical plane as well as the extent of the force in that direction (Wall & Vrabek, 2001).

Anatomy and Physiology of the Central Vestibular System

Information from the peripheral vestibular sensory organs is delivered to the central nervous system via the afferent branch of the vestibular portion of the VIIIth nerve. This vestibular portion of the VIIIth nerve is divided into two parts. These two branches are the superior branch of the vestibulocochlear nerve and the inferior branch of the vestibulocochlear nerve. Afferent fibers from the utricle, the anterior portion of the saccule, the horizontal SCCs, and the anterior SCCs provide input to the superior branch of the vestibulocochlear nerve. The posterior SCCs and the posterior portion of the saccule provide input to the inferior portion of the nerve (Barin, 2009a). These afferent fibers converge and proceed through the internal auditory meatus to the ipsilateral vestibular nuclei and portions of the cerebellum (Barin, 2009a; Bear et al., 2001). The majority of afferent vestibular fibers, approximately 70%, project directly to the cerebellum (Lyaskowski, 2005). The remaining fibers extend to one of the four main vestibular nuclei, the superior, lateral, medial and inferior.

As discussed by Lyaskowski (2005) each vestibular nuclei has a different association to various reflex pathways regarding the vestibular system. The superior vestibular nucleus has efferent projections that extend to the oculomotor nuclei and it is important in the function of the vestibulo-occular pathway. The lateral vestibular nuclei consist of two sub-nuclei, the dorsal lateral and the ventral lateral vestibular nuclei. The dorsal lateral portion contributes to the lateral vestibulospinal tract. The ventral lateral portion provides input to the vestibuloocular pathway, the vestibulospinal tract, as well as vestibulothalamic pathways. The lateral vestibular nuclei are important in the vestibulo-ocular, vestibulocolic, and vestibulospinal pathways. Less is known of the function of the medial vestibular nucleus. It projects to the cerebellum and contributes information in regard to cervicovestibular pathways. Lastly, the inferior vestibular nucleus receives much of the afferent information from the otolith organs. It provides information to the cerebellum and reticular formation and is particularly important in regard to the vestibulospinal pathways (Lyaskowski, 2005). The vestibular nuclei receive input from the vestibular systems as well as fibers rising from the cerebellum, spinal cord, and ocular system. Thus, the pathways involving the vestibular nuclei incorporate information regarding posture, movement, vision, and orientation of the body in space (Nandi & Luxon, 2008).

The output from the vestibular nuclei provides input to the vestibular oculo-motor pathways and the vestibulospinal pathways. The vestibular oculomotor pathways initiate and control the eye motions in response to vestibular input (Goebel, 2001; Jacobson, Newman, & Kartush, 1997). The vestibulospinal pathway provides information to the postural muscles in regard to various head motions (Goebel, 2001; Jacobson, Newman, & Kartush, 1997).

One of the essential pathways involving the vestibular system is the vestibulo-ocular reflex or VOR. This reflex pathway enables an individual to stabilize vision while the head and/or body is moving (Desmond, 2004; Lyaskowski, 2005; Nandi & Luxon, 2008). The VOR reflex arc uses information about direction and acceleration of movement from the vestibular system and compensates for this head or body motion by causing an equal and opposite movement of both eyes. The movement of the eyes is controlled by a series of 6 muscles, collectively known as the extra-ocular muscles. The function of these muscles is described below.

The six extra-ocular eye muscles include: the lateral, medial, superior and inferior rectus muscles as well as the superior and inferior oblique muscles. The extra-ocular muscles have a paired function that works congruently with the semicircular canals in the corresponding plane of space (Barin, 2009a). The lateral rectus pulls the eye toward the ear, while the medial rectus pulls the eye toward the nose. The superior rectus lifts the eye up and off midline and the inferior rectus pulls the eye down and off midline. The superior oblique pulls the eye up and shifts it about 50 degrees off center and the inferior oblique pulls the eye down and 50 degrees off center. The medial, superior, and inferior recti as well as the inferior oblique muscles are innervated by the oculomotor nerve; whereas, the superior oblique is innervated by the trochlear nerve and the lateral rectus muscle is innervated by the abducens.

The function of the VOR is to maintain stability of vision during active head motion. The VOR pathway receives input from the vestibular system and responds with compensatory eye movements. This reflex is based on input from the vestibular system and remains intact even when visual input is unavailable. The following figure illustrates the process of the VOR in response to a head turn to the left.

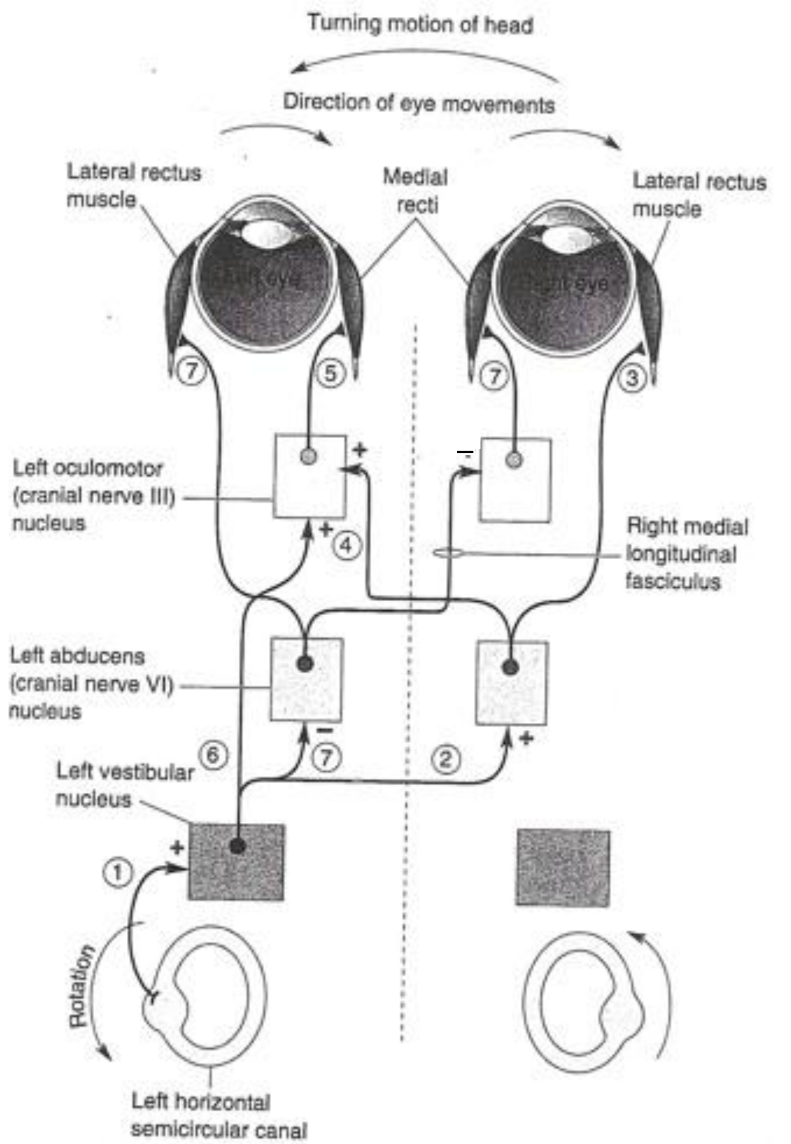

Figure 6. Illustration of the VOR pathway that shows what happens when there is a head movement to the left. The positive signs indicate excitation while the negative signs indicate inhibition. Modified from "Neuroscience: Exploring the Brain" by M. Bear, B. Connors, & M. Paradiso, 2001.

Figure 6 above shows an individual's head being turned toward the left. When this head movement occurs, the left horizontal semicircular canal is excited. This excitatory signal is then sent ipsilaterally to the left vestibular nuclei as shown by label number 1. The left vestibular nuclei then sends an excitatory signal to the right abducens nucleus, which in turn causes the lateral rectus muscle of the right eye to contract thus shifting that eye to the right (this process is highlighted by numbers 2 & 3 in Figure 6). An excitatory signal from the left vestibular nuclei is sent directly to the left occulomotor nuclei and to the medial rectus muscle of the left eye (numbers 4-6). The right abducens nerve also sends an excitatory signal to the left oculomotor nucleus (number 4). This excitatory input causes a contraction of the left medial rectus muscle, pulling the left eye to the right (this process is highlighted by number 5 in Figure 6). The result of these excitatory signals is that both eyes are shifted to the right congruently. At the same time this excitatory process is occurring, an inhibitory signal is sent from the left vestibular nucleus to the left abducens nucleus (number 7). The inhibitory signal extends directly to the lateral rectus muscle of the left eye and the medial rectus muscle of the right eye (via the right oculomotor nucleus) reducing any muscle tension that would pull the eyes to the left (as shown in number 7 in the above figure). These equal and opposite motions enable the eyes to maintain stable focus on a target despite various degrees and angles of head motions (Bear, Connors, & Paradiso, 2001).

Another pathway that the vestibular system provides critical information to is the vestibulo-spinal reflex arc. This pathway has three major components, the lateral and medial vestibulo-spinal and the reticule-spinal tracts (Nandi & Luxon, 2008). This reflex assists in maintaining appropriate posture and muscle tone of the torso and limbs (Nandi & Luxon, 2008). The vestibulo-spinal reflex arc receives information from the basal ganglion, reticular formation and the cerebellum. When information from these centers converges with sensory information from the vestibular system any change in posture or movement of the head or body can be appropriately accounted for by counteracting muscle movements (Nandi & Luxon, 2008).

The central portion of the vestibular system incorporates data from various structures and systems throughout the body. The information that is acquired assists the brain in determining where the body is positioned in space, the direction and force of any movement, as well as any necessary movements of the extra-ocular or skeletal muscles needed to assist in maintaining appropriate posture and gaze (Bear et al., 2001; Lyaskowski, 2005; Nandi & Luxon, 2008; Wall & Vrabec, 2001).

Assessment Procedures

The peripheral and central portions of the vestibular system can be evaluated using a number of different assessment techniques. These tests can be separated into two overall categories, which are low-technology (low tech) assessments and high technology (high tech) assessments. Low-tech assessments are typically screening procedures, which involve little or no formal equipment, and they can be administered in either a physician's or audiologist's office. Typically these assessments involve the reporting of raw data and whether the individual's performance was considered a pass or fail of the screening. An example of a screening test is the test of dynamic visual acuity. In this test the subject's baseline visual acuity is assessed and the examiner records the line on a Snellen eye chart that corresponds to the patient's visual acuity. The patient is then asked to move their head from side to side and to read the eye chart again while the head is in motion. A shift in the patient's visual acuity of three lines is considered a positive finding, or the individual has failed this screening measure. It is likely that the training of Au.D. students in these low tech assessments typically comes from vestibular courses provided in graduate school, whereas practicing audiologists receive training by either by attending a course in vestibular assessment and/or reading about the topic. In contrast, high tech assessments often require sophisticated equipment and possibly a special testing environment, such as a rotary chair booth. High tech assessments can also be administered by a physician or audiologist, but require intensive training to properly administer and interpret the results. An example of high tech assessments is the ENG/VNG test. High tech assessments are generally more diagnostic in nature.

This review will focus on available low and high tech assessment procedures that are used by clinical audiologists. The four low-tech assessments that will be described in this review are: the Bedside Assessment of Postural Control (e.g. Gans Sensory Organization Performance or SOP test or CTSIB); the dynamic visual acuity test; the head shake test; and the vertebral artery test. The four high-tech tests that will be described are: the Electronystagmography (ENG)/Videonystagmography (VNG) test; the rotary chair test; the computerized dynamic posturography test, and Vestibular Evoked Myogenic Potential test. This literature review will provide a brief description of each of these assessment procedures and will also discuss how the findings from these assessment procedures are interpreted.

Low-tech assessment procedures.

Bedside Assessment of Postural Control.

The Gans Sensory Organization Performance or (SOP) test is used to evaluate an individual's ability to integrate sensations from the visual, somatosensory, and vestibular systems in order to maintain postural control (Gans, 2002). This test has also been referred to as Clinical Test of Sensory Integration and Balance (CTSIB). In this test, the individual's equilibrium is evaluated by systematically reducing input from the visual and somatosensory systems. The input from the somatosensory system is "sway referenced" by having the subject stand on a thick foam pad or with their feet in tandem. In the eyes closed or vision denied conditions, the normal input from the visual system is disrupted. Therefore, the sway referencing and/or disruption of the input from the various sensory systems allows the clinician to tease or separate out the input from each of these three sensory systems to determine which is affecting an individual's overall balance (Gans, 2002).

The SOP test involves seven different test conditions in which the clinician rates the degree and direction of postural sway for their client. These different test conditions are shown in figure 7a below. The individual's performance in each test condition is then rated by the clinician indicating whether the client maintained their balance (N), swayed (S), or fell (F). If the individual swayed or fell consistently to the left or the right, the clinician would then make note of the direction or the sway, by labeling L (left) or R (right).

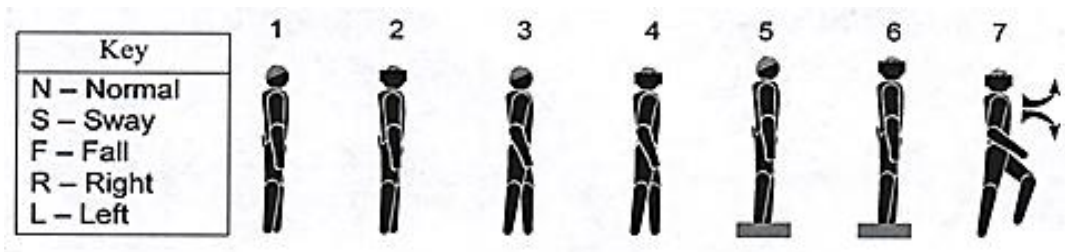

Figure 7a. Seven different test conditions of the Sensory Organization Performance (SOP) test and the key for reporting the results of each test condition. Reprinted from Gans, 2002.

In the first two test conditions, the individual stands with feet shoulder width apart with eyes open (1) and closed (2). Condition 1 is a stable reference condition for most individuals and it allows the individual to rely on cues from all three sensory systems to maintain their balance. In contrast, test condition 2 removes the visual input and thus reduces the amount of sensory information available to the individual to use in maintaining their balance. Test conditions 3 and 4 aim to narrow the individual's base of support by having the individual stand with one foot in front of the other, again with eyes open (3) and eyes closed (4). In these test conditions, the amount of information from the somatosensory system is limited to a smaller center of gravity relative to conditions 1 & 2. Thus the brain is challenged to interpret this changing information from the somatosensory system. Test conditions 5 and 6 involve the individual standing on a thick foam pad, thus sway referencing the input from the somatosensory system. The individual's eyes are open in condition 5 and closed in condition 6, which reduces the input from the somatosensory system further. The seventh condition consists of the stepping Fukuda test, in which the individual is asked to march in place with their eyes closed. These conditions are shown in Figure 7a, above.

Test results are considered normal if the individual does not fall and/or sway to either side in any of the test conditions. In individuals with various central nervous system (CNS) pathologies, falls or sways are typically seen in multiple test conditions. The test conditions often affected by CNS involvement are those that reduce input from the somatosensory system (numbers 3-7 on figure 7b). A SOP test pattern that is consistent with CNS involvement is shown in figure 7b.

In contrast, individuals who have disorders related to inner ear vestibular pathologies typically present with falls and/or sways in test conditions 6 and 7. This occurs because the individual is forced to rely exclusively on input from the vestibular system in condition 6. In condition 7 the individual is getting distorted somatosensory input and visual input is denied, leaving the input from the vestibular system as the only consistent source of information to maintain balance. An example of a SOP test pattern due to peripheral vestibular involvement is shown in figure 7c (Gans, 2002). The Fukuda stepping test (condition 7) is considered abnormal if an individual rotates more than 45 degrees in either direction during the test. Abnormal responses on the Fukuda stepping test alone may suggest an abnormality of the peripheral vestibular system (Jacobson & Shepard, 2008).

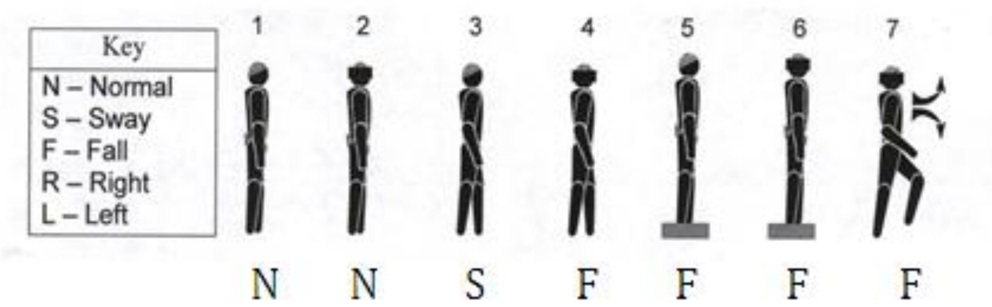

Figure 7b. SOP pattern consistent with Central Nervous System (CNS) involvement. Modified from Gans, 2002.

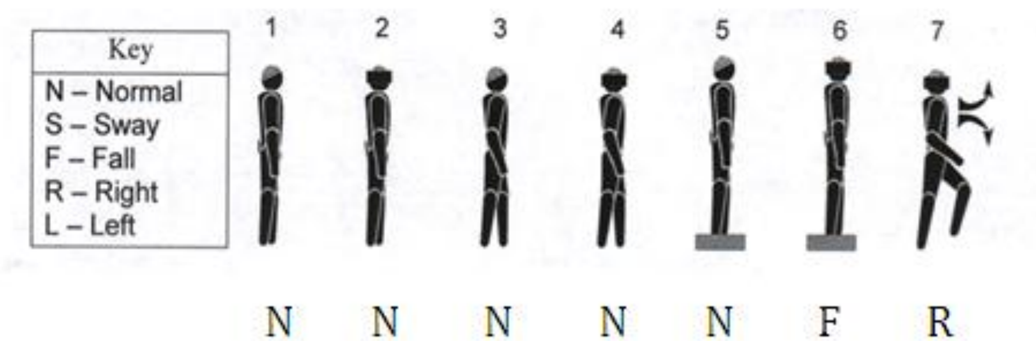

Figure 7c. SOP pattern consistent with vestibular involvement. Modified from Gans, 2002.

Dynamic Visual Acuity Test.

The dynamic visual acuity test (DVAT) is used to evaluate the integrity of the vestibulo-ocular reflex (VOR) (Jacobson & Shepard, 2008). The VOR is responsible for maintaining eye stability in response to active head motion. Individuals with damage to the VOR often present with the symptoms of blurry or bouncing vision while the head is moving. This symptom, termed oscillopsia, is the basis of the DVAT.

In the DVAT test, an individual is required to read the lowest line possible on a Snellen eye chart while standing still. This line on the eye chart then serves as the patient's baseline for their visual acuity. The individual is then asked to read the eye chart while his or her head is tilted forward 30 degrees and is rotated from side to side at approximately 1 to 7 Hz (Fife, 2000; Jacobson & Shepard, 2008). The shift in the number of lines on the eyechart from the baseline recording to the recorded response obtained during head rotation should be no more than one line for individuals with normal functioning vestibular systems. A shift of greater than two lines is considered abnormal. Abnormal results can be indicative of bilateral hypofunction or a poorly compensated unilateral weakness (Fife, 2000; Jacobson & Shepard, 2008). It has been noted that the DVAT can also be useful in measuring an individual's progress throughout a vestibular rehabilitation program (Clarke, 2010).

Head Shake Test.

The head shake test is useful in determining the symmetry of the vestibular labyrinth in each ear. When an individual's head is actively shaken from the left to the right, the inputs from each inner ear are stored in the vestibular nerve pathways of the brainstem (Goebel, 2001). This phenomenon, known as velocity storage, is the basis of the head shake test. In the head shake test an individual's head is rotated from left to right at approximately 2 cycles per second, for 20 seconds (Goebel, 2001; Jacobson & Shepard, 2008). The input from each vestibular system that is stored during the active head rotations releases when the head motion is stopped. The clinician immediately performs a visual inspection of the eyes and notes the presence of any nystagmus. Nystagmus is an eye motion with two specific components, the fast component and the slow component. The slow component of nystagmus is a slow drift of the eyes to one side. The fast component, or beat, of the nystagmus is a reflexive movement to return the eyes toward the center or the initial position. If the individual's vestibular systems are intact, input from each of the systems will be equal and they will cancel each other out. Thus, the individual will not present with any nystagmus. However, if the systems are asymmetric, or otherwise disordered, nystagmus will appear. Horizontal nystagmus appears in individuals with a unilateral vestibular pathology, and typically beats toward the healthy ear (Jacobson & Shepard, 2008). Prolonged, vertical, or biphasic nystagmus can be indicative of a more central lesion (Goebel, 2001; Jacobson & Shepard, 2008).

Vertebral Artery Test.

The vertebral artery test is used to assess the function of the vertebral artery system and is used to screen for any indication of vertebrobasilar insufficiency (VBI) (Richter & Reinking, 2005). VBI is caused by an occlusion or reduction of blood flow within the vertebral or basilar arteries. This group of vessels provides blood flow to the posterior portion of the brain, which controls some of the major life function such as breathing, swallowing, vision, and movement (Goebel, 2001). The vertebral arteries travel within the transverse canals of the cervical vertebrae (back of the neck) and enter the skull via the foramen magnum at the base of the skull. The vertebral artery test is performed to ensure that positioning tests that result in bending the neck do not cause a reduction in blood flow to this portion of the brain. Information gained by performing the vertebral artery test is important to ensure patient safety during positioning tests such as the Dix-Hallpike and should be done prior to these types of assessments (Central Michigan University, 2009).

In the vertebral artery test, an individual will be seated and asked to lean forward with their hands or elbows on their knees, thus extending the neck. The head is then tilted up and turned to one side (e.g., to the right) while the clinician watches for any symptoms related to the head motion. This procedure is then repeated with the head being to the opposite side (Central Michigan University, 2009; Gans, 2002). Individuals with compromised vertebral artery function or VBI may present with symptoms such as syncope, dizziness, nausea, lightheadedness, slurred speech, difficulty swallowing, and visual changes (Central Michigan University, 2009; Richter & Reinking, 2005). An individual who does not experience the symptoms described above is thought to have a normal functioning vertebral artery system. However, if an individual experiences any related symptoms or is unable to sustain conversation and/or their position during testing the assessment is recorded as being positive. This result is considered a contraindication for any procedures that involve cervical manipulation or rotation (Central Michigan University, 2009; Richter & Reinking, 2005).

High-Tech Assessment Procedures.

Electronystagmography (ENG) or Videonystagmography (VNG).

The electronystagmography (ENG) or videonystagmography (VNG) test allows for an evaluation of the vestibular system by recording the movements of the extra ocular eye muscles (Barin, 2009b; Goebel, 2001; Jacobson & Shepard, 2008). In the ENG test, surface electrodes are place on the outer canthi of the right and left eye to record the conjugate horizontal movements of the eyes while another pair of electrodes is placed above and below one eye to record the conjugate vertical movements of the eyes. These electrodes are able to monitor the movements of the eyes by measuring the strength the corneoretinal potential (CRP) (Baloh & Furman, 1989). The CRP produces electrical energy that changes based on the eye movement within the skull as shown in figure 8 below.

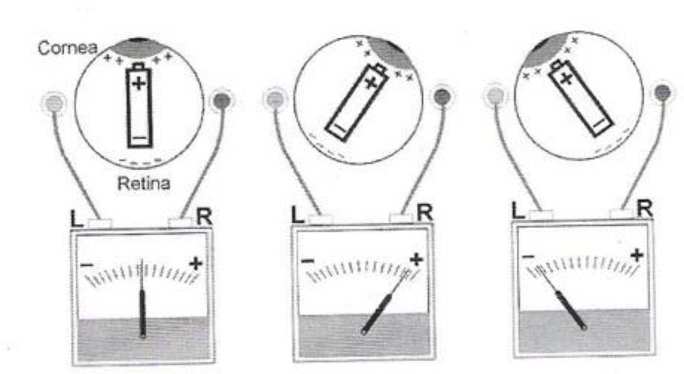

Figure 8. Measurement of the corneoretinal potential. Reprinted from "Intro to ENG/VNG" by K. Barin, 2009.

The cornea of the eye has a positive energy while the retina is negative (Barin, 2009b; Goebel, 2001). This organization within the eye results in a positive measurement when the eye rotates to the right and a negative measurement when the eye rotates to the left on the horizontal channel. Within the computer software, a positive measurement, or eye movement to the right, is shown as an increase from the baseline and a negative measurement, or eye movement to the left, is shown as a negative deflection from the baseline on the horizontal channel only (Barin, 2009b). An example of this computer output is shown in Figure 9A. Eye movements in the vertical plane are recorded on a separate channel as shown in Figure 9B. In the vertical channel an upward eye movement results in a positive deflection from the baseline while a downward movement results in a negative deflection. The computer system for ENG/VNG allows the audiologist to measure the velocity, amplitude, and frequency of the individual's eye motions that occur during testing.

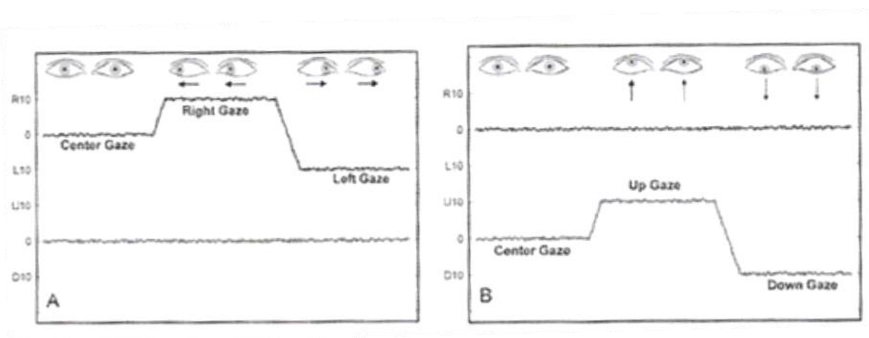

Figure 9. Normal ENG tracings to horizontal (A) and vertical (B) eye movements. Reprinted from "Intro to ENG/VNG" by K. Barin, 2009.

The primary difference between the ENG and VNG is the manner in which these eye motions are being recorded (Barin, 2009b; Jacobson & Shepard, 2008). In the VNG assessment, the individual wears a set of video goggles that records an image of both horizontal and vertical eye movements. Two primary advantages of performing a VNG assessment are: (1) the ability to record torsional, or rotational, eye movements and (2) the ability to visualize all the eye movements that occur throughout the testing. This is especially important for the eyes closed test conditions (Jacobson & Shepard, 2008).

The ENG/VNG assessment is typically broken down into three parts. These are oculo-motor tasks; positional and Dix-Hallpike testing; and caloric stimulation to assess the integrity of the horizontal SCCs (Barin, 2009b; Jacobson & Shepard, 2008; Resnick, 1977).

Oculo-motor tasks.

The oculo-motor portion of the ENG/VNG exam consists of four tasks, during which the subject is asked to focus on targets on a light bar. The light bar is placed four feet in front of the subject at a level equal to their eyes (Barin, 2009b). The first of these four tasks is the saccade test. The saccade test consists of an individual focusing on targets that jump horizontally in various places along the light bar. Saccade testing assists in determining a site of lesion within the central nervous system. This test can be performed using fixed or random protocols, but random saccades are recommended (Jacobson & Shepard, 2008). In both the fixed and random protocols the targets are presented on the light bar in the range of +/- 30 degrees from the center for approximately 60 to 90 seconds (Barin, 2009b). Fixed saccades are presented at equal time intervals and degrees from center, while random saccade testing is varied in the timing and angle that the target is presented. The eye movements in reaction to this task are analyzed in terms of velocity, latency, and accuracy of the eye motion relative to the target movement. Abnormalities in saccade testing are suggestive of CNS pathology.

The second test within the oculo-motor tasks is tracking or smooth pursuit testing. In the tracking task an individual is asked to focus on a slowly moving target on the light bar. This target is typically moving back and forth horizontally in a sinusoidal motion. The target movement is presented at several different frequencies from 0.2 to 0.8 Hz (Barin, 2009b; Jacobson & Shepard, 2008). Generally the three frequencies that are used are 0.2, 0.4, and 0.6 Hz (Jacobson & Shepard, 2008). The individual’s eye movements are recorded in response to the target movements and are evaluated based on the gain, symmetry, and phase of the response. Gain is essentially the measurement of how accurately the system produces conjugate eye movements in the opposite direction of the head motion. It is calculated as a ratio of the amplitude of the eye motion divided by the amplitude of the head motion. Symmetry evaluates the gain differences between eye movements to the right and eye movements to the left. Phase describes the timing in the response and whether the eye movements lead or lag behind the presentation of the target. Abnormalities of gain, symmetry or phase on the tracking portion of the test indicate CNS dysfunction (Jacobson & Shepard, 2008).

A third test in the oculo-motor evaluation is gaze testing. The gaze assessment evaluates an individual's ability to steadily focus on a target without producing any eye movements, or nystagmus (Jacobson & Shepard, 2008). The individual is asked to focus on a target that will be presented at 25 to 30 degrees to the left, right, up or down from the center presentation (Barin, 2009b; Jacobson & Shepard, 2008). The individual is asked to focus on a target in each of these positions for approximately 30 seconds (Baloh & Furman, 1989). The clinician then notes the direction of any nystagmus that occurs. The gaze assessment can be indicative of either central or peripheral dysfunction depending on the pattern of nystagmus. However, a pattern of nystagmus that is vertical, torsional or changes direction is typically suggestive of a central finding (Jacobson & Shepard, 2008).

The last test of oculo-motor function is the optokinetic assessment. The optokinetic assessment is used to assess the integrity of the velocity storage system. True optokinetic testing requires filling at least 90% the individual's field of vision with visual targets. A series of moving targets are presented moving in both a clockwise and counter clockwise direction. They are presented to the right and then to the left separately, at a slow speed of 20 degrees/sec and at a faster speed of 40 degrees/sec (Barin, 2009b). The individual is asked to follow or count these targets with their eyes. This task creates a nystagmus beating in the opposite direction of the target movements. Optokinetic responses are measured in terms of the difference in velocity gain between target movements to the right and to the left. An asymmetry between these measurements of more than 25% is considered abnormal and indicative of central lesions (Jacobson & Shepard, 2008). The optokinetic system has significant interaction and overlap with the smooth pursuit system in the brain. In many clinical situations a test environment appropriate for true optokinetic testing, one that fills 90% of an individual's visual field, is difficult to obtain. Because the use of the light bar does not effectively tease out the function of the optokinetic system from that of the smooth pursuit system these test results should be interpreted with caution. In this situation optokinetic testing can be used as a cross check for the results of smooth pursuit or tracking assessments, but it is less sensitive to disorders specific to optokinetic function (Jacobson & Shepard, 2008).

Positional Testing and the Dix-Hallpike Maneuver.

In the positional testing portion of the ENG/VNG test battery the patient is moved into various body and head positions (Jacobson & Shepard, 2008). There are typically three main positions, which are: supine, head/body right, and head/body left (Barin, 2009b; Jacobson & Shepard, 2008). In the supine position, the individual is instructed to lay on their back with their head elevated approximately 30 degrees. A horizontal nystagmus that occurs in this position can be indicative of BPPV. Head/body right and head/body left involve the patient rotating their head or body 90 degrees on the examination table. Nystagmus in these later conditions typically results from peripheral system involvement, with the exception of vertical nystagmus, which indicates a more central cause (Barin, 2009b; Jacobson & Shepard, 2008).

The Dix-Hallpike Maneuver is used to diagnose BPPV. BPPV is the most common peripheral vestibular disorder and occurs in approximately 64 out of 100,000 individuals (Froehling, Silverstein, Mohr, Beatty, Offord, & Ballard, 1991). BPPV is caused by otoconia displacement into one of the SCCs. There are two types of BPPV, cupulolithiasis and canalithiasis (Herdman & Tusa, 2004). Cupulolithiasis is caused by the displaced otoconia being embedded into the cupula within the affected SCC. Canalithiasis is a more common form of BPPV and is thought to be caused by the otoconia floating within the endolymph of the affected SCC. In each of these types of BPPV, head movements cause an exaggerated deflection of the cupula of the SCC and the individual experiences an acute feeling of vertigo (Herdman & Tusa, 2004). The Dix-Hallpike Maneuver is used to provoke this cause of vertigo and diagnose BPPV.

The Dix-Hallpike Maneuver begins with the individual sitting on an examination table with their head turned to the right 45 degrees (Dix & Hallpike, 1952; Herdman & Tusa, 2004). The individual is quickly brought to supine position (back down) with the head hanging off the end of the examination table. While an individual's head is hanging off the table the clinician watches for any nystagmus to appear (Dix & Hallpike, 1952). If after approximately 40 seconds no nystagmus is present then the individual is brought to a seated position and is considered negative for BPPV in that ear (Herdman & Tusa, 2004). If nystagmus does occur, it is monitored for at least 60 seconds, after which the individual is brought back to a seated position. In this case an individual would be considered positive for BPPV in the right ear. Upon the completion of the maneuver in the right ear, the clinician performs the same procedure on the left side (Herdman & Tusa, 2004).

Bithermal Caloric Irrigation.

The final portion of the ENG/VNG test battery is bithermal caloric testing (Baloh & Furman, 1989). Caloric testing evaluates the integrity of the horizontal SCCs (Goebel, 2001). There are four different test conditions employed in caloric testing: right cool, left cool, right warm, and left warm. In each test condition the individual's head is raised 30 degrees and vision is denied while their ear canal is either heated or cooled by air or water irrigation (Barin, 2009b). The temperature of the water or air stimuli is set 7 degrees above normal body temperature for the cool condition and 7 degrees below normal body temperature for the warm condition (Baloh & Furman, 1989). The air or water stimulation lasts for approximately 30 to 40 seconds (Goebel, 2001). This stimulation within the ear canal evokes a feeling of dizziness and nystagmus generally appears in the recordings (Baloh & Furman, 1989). To reduce the possibility of the individual suppressing the response, the clinician will administer a series of mental alerting tasks (Resnick, 1977). These tasks are generally simple questions and can include asking the patient to name various things with different letters of the alphabet, naming states, or recalling a variety of things from memory. When the slow component of the response has reached maximum velocity the patient is instructed to open their eyes and fixate on a light target (Jacobson & Shepard, 2008; Resnick, 1977).

If the horizontal SCCs and the afferent nerve pathways are functioning normally, the cool caloric stimulation produces a nystagmus that beats in the opposite direction of the ear that is stimulated (Barin, 2009b). In contrast, the warm caloric stimulation will produce nystagmus that beats in the direction of the stimulated ear. For example, if the clinician is presenting cool caloric stimulation to the client's right ear, then left beating nystagmus should occur in a normal functioning system. In contrast, if the clinician presents warm caloric stimulation to the right ear, then right beating nystagmus should appear.

Three primary measurements are calculated in the analysis of caloric responses. These are: unilateral weakness, directional preponderance, and fixation suppression. Unilateral weakness (UW) is a measurement of the difference in the strength of the caloric responses between the ears. The formula to derive unilateral weakness is as follows: $\frac{\mathbf{(LC+LW)-\ (RC+RW)}}{\mathbf{LC+LW+RC+RW}} \times \mathbf{100}$.

A normal functioning vestibular system should have symmetric responses between ears. Exact difference values for abnormality should be determined by age appropriate data obtained at each facility, but typically a UW of ≥ 20-30% is considered significant or abnormal (Jacobson & Shepard, 2008; Resnick, 1977). A significant unilateral weakness is indicative of a peripheral finding on the side with the reduced response (Jacobson & Shepard, 2008).

In contrast, Directional Preponderance (DP) is defined as the difference in the strength of nystagmus that beats to the right in comparison to the strength of nystagmus that beats to the left. The formula for directional preponderance is as follows:

$$\frac{(\mathbf{RC+LW}) - (\mathbf{RW+LC})}{\mathbf{LC+LW+RC+RW}} \times \mathbf{100.}$$

Similar to unilateral weakness, a normal functioning vestibular system should have symmetric responses in regard to the strength of the nystagmus in each direction. This measurement of the strength of the nystagmus is termed directional preponderance. Again, to determine abnormality these results should be compared to age appropriate normative data collected with a facility's specific equipment. The criterion for abnormal directional preponderance generally falls in the range of 30-50% difference (Jacobsen & Shepard, 2008; Resnick, 1977). A significant directional preponderance indicates the presence of an asymmetry between the horizontal SCC systems, but does not provide information related to the site of lesion, peripheral or central (Jacobson & Shepard, 2008).

Ocular fixation is a measurement of the individual's ability to suppress the vestibular response (Jacobson & Shepard, 2008). This is generally evaluated in two of the caloric conditions, one with left beating nystagmus and the other with right beating nystagmus. The formula to calculate the ratio of fixation suppression in each caloric condition is given in Table 1, below.

Table 1.

Formulas for calculating fixation suppression.

$$FI_{rb}\% = \frac{\text{Fix RW}}{\text{NoFixRW}} \times 100 \quad \text{or} \quad \frac{\text{Fix LC}}{\text{NoFixLC}} \times 100$$

$$FI_{lb}\% = \frac{\text{Fix RC}}{\text{NoFixRC}} \times 100 \quad \text{or} \quad \frac{\text{FixLW}}{\text{NoFixLW}} \times 100$$

Note. Formula for fixation suppression in the four caloric conditions. Clockwise from top left is right warm, left cool, left warm, right cool. RW = Right Warm, RC = Right Cool, LW = Left Warm, LC = Left Cool.

An individual with a typically functioning system should be able to reduce the strength of the nystagmus by 50%-70% (Jacobson & Shepard, 2008). An inability to suppress the nystagmus by this amount, or if the nystagmus grows in intensity, is a finding highly correlated with a central system dysfunction (Resnick, 1977; Jacobson & Shepard, 2008).

Caloric testing can assist in determining which ear, if any, is weaker in function and how well each vestibular system has compensated from any dysfunction (Baloh & Furman, 1989). The ENG/VNG test battery provides a good deal of information regarding the potential cause of dizziness as well as providing a baseline of function that may be needed to monitor the progression of the disease (Goebel, 2001; Jacobson & Shepard, 2008). The ENG/VNG test battery provides much information in regard to the vestibular labyrinth, especially in determining unilateral differences. However, it has a major limitation in that it only tests head motions at very low frequencies, approximately 0.003 Hz (Jacobson & Shepard, 2008). The human vestibular system is particularly sensitive to head motions in the range of 0.01 to 3 Hz. Thus, caloric testing only gives information regarding the integrity of a very small portion of the system. This limitation is addressed by the usage of rotary chair testing (Goebel, 2001; Jacobson & Shepard, 2008).

Rotary Chair.

Rotary chair testing is used to evaluate the function of an individual's VOR (Goebel, 2001; Jacobson & Shepard, 2008; Shepard & Telian, 1996). It supplements the information obtained from ENG/VNG testing in that it allows for testing across a broader range of frequencies extending from 0.01 to 1 Hz. These frequencies are outside the range of ENG/VNG testing. Additionally, rotary chair testing can be performed in cases of occluding wax, tympanic membrane perforations, or various surgical treatments that contraindicate caloric testing.

Rotary chair testing involves an individual sitting in a chair with his/her head motion restricted by a specially designed headpiece (Goebel, 2001). This test is typically performed in a dark booth or under goggles in an otherwise dark room. The client's eye movements are recorded and compared to their head movements in response to movements of the chair. Generally there are two types of rotary chair evaluations (Goebel, 2001; Jacobson & Shepard, 2008; Shepard & Telian, 1996). The first is called sinusoidal harmonic acceleration (SHA). In this technique the patient is rotated back and forth at a maximum speed of 50-60 degrees/second and at frequencies ranging from 0.01 to 0.64 Hz. Typically the order of testing is 0.08 Hz, 0.04 Hz, 0.02 Hz, 0.01 Hz, 0.16 Hz, 0.32 Hz, and 0.64 Hz (Goebel, 2001; Jacobson & Shepard, 2008). The duration of testing in the SHA method typically lasts at least 2-3 cycles per frequency that is being evaluated. A typical result of the SHA test is shown in Figure 10 below. The dotted line represents the slow component eye velocity and the solid line shows the head or chair motion throughout the test. Results of sinusoidal rotation for the SHA test are calculated in terms of the response phase, gain, and symmetry. These three terms are described below.

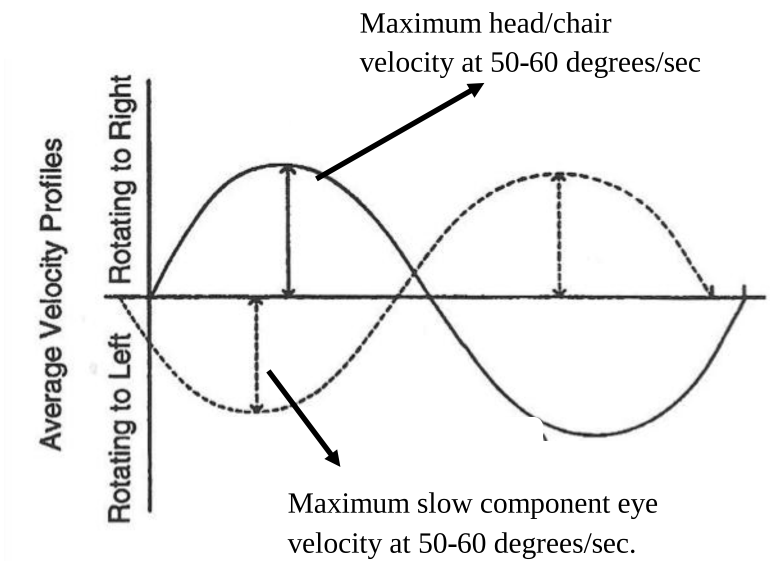

Figure 10. Illustration of a typical result of the SHA rotary chair testing. Maximums for both the slow component eye movements an the head/chair motion are labeled. Modified from “Practical Management of the Dizzy Patient” by N. Shepard & S. Telian, 1996

Phase measurements of the response quantify the timing relationship of the head motion and the conjugate eye movement. In a typically functioning vestibular system, the patient’s eye movements will have a slight phase lead in relation to the their head movement, as shown by the dark circle in Figure 11 (Shepard & Telian, 1996). This phase lead pattern is particularly true for the lower test frequencies (i.e., ≤ 0.16 Hz). Abnormalities in response phase, reported in terms of either a phase lead or a phase lag, can assist the audiologist in determining the site of lesion. A significant phase lead is typically indicative of a peripheral dysfunction whereas, a phase lag may suggest a cerebellar lesion (Shepard & Telian, 1996).

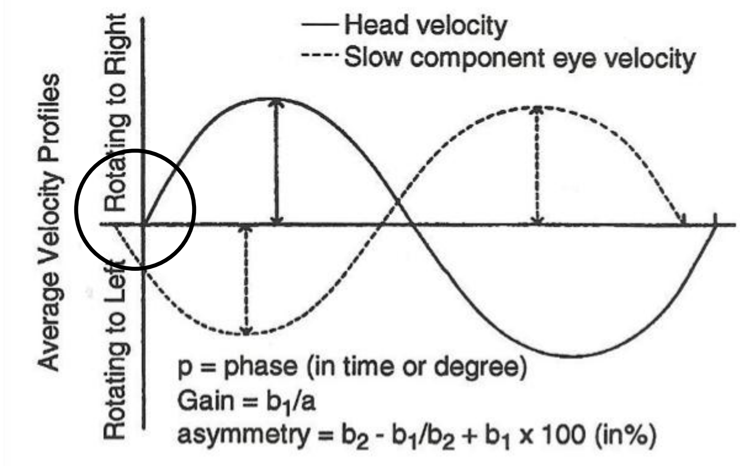

Figure 11. Calculation of phase in response to SHA rotary chair testing. A normal phase lead is approximately one-quarter of a cycle and is illustrated by the dark circle. Modified from "Practical Management of the Dizzy Patient" by N. Shepard & S. Telian, 1996.

In contrast, gain measurements are sensitive to the overall strength of the response. Gain is calculated as a ratio of the average slow phase velocity of eye movement to the velocity of the head (chair movement). It is calculated separately for each test frequency. Therefore for any given frequency, the system calculates the maximum slow component velocity (SCV) of the eye and divides it by the maximum chair velocity, which is either 50-60 degrees/sec. This is shown in Figure 12 below, with the maximum SCV labeled b1 and the maximum chair or head velocity labeled a.

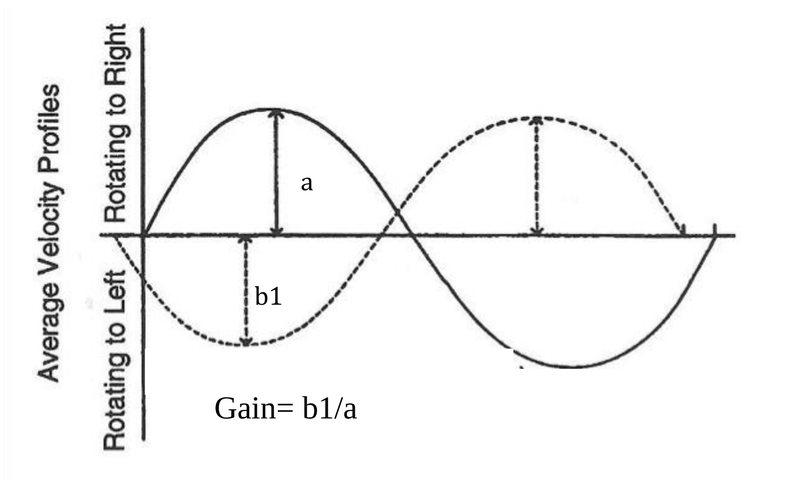

Figure 12. Calculation of gain in response to SHA rotary chair testing. Modified from “Practical Management of the Dizzy Patient” by N. Shepard & S. Telian, 1996.

A finding of reduced gain is seen in cases of bilateral vestibular weakness. One may also see decreased gain values at low test frequencies in cases or a poorly compensated unilateral vestibular dysfunction. In these cases, gain values should return to normal as central compensation occurs. Lastly, Symmetry can be described as similar to directional preponderance in caloric testing in that it is a Measure of the ease with which nystagmus can be produced when spinning to the right vs. spinning to the left. Specifically, it is a measurement of the velocity of the slow component of nystagmus when rotating to the right versus rotating to the left. An illustration of the calculation of response symmetry is shown in Figure 13, below. Abnormalities related to the symmetry of the response are generally associated with non-compensated peripheral lesions (Goebel, 2001; Shepard & Telian, 1996).

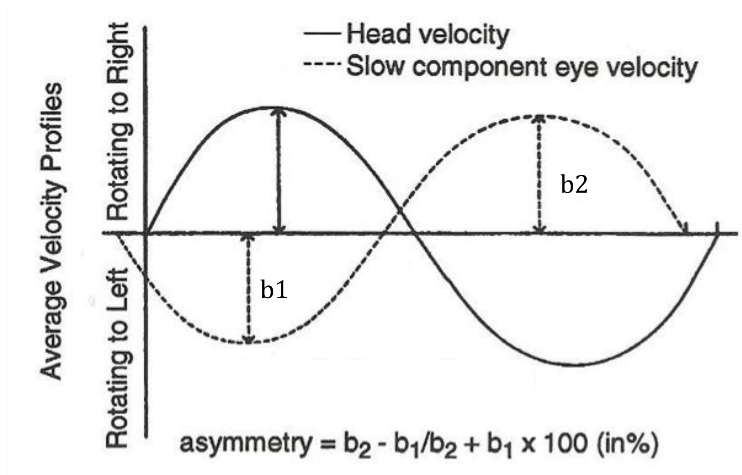

Figure 13. Calculation of symmetry in response to SHA rotary chair testing. Modified from "Practical Management of the Dizzy Patient" by N. Shepard & S. Telian, 1996.

The second portion of rotary chair testing is the step test. In the step test the individual is subjected to rotation with much higher acceleration and deceleration speeds in both a CW and CCW direction. The individual is accelerated at 100 degrees/second until they reach their fixed velocity. Once at fixed velocity, the patient maintains this acceleration for 45 – 60 seconds. Then the patient is decelerated. Because of this sudden stop, the patient has the sensation of being in motion even though the rotary chair is not moving. The step test is conducted at two set velocities, which are 60 degrees/second (low peak velocity) and 240 degrees/second (high peak velocity) (Jacobson & Shepard, 2008; Janky, 2010). The step test is performed four times. These are clockwise and counter clockwise rotation at the high peak velocity as well as clockwise and counter clockwise rotation at the low peak velocity. The responses are then averaged across all four conditions.

The most useful data obtained from step testing are the time constants. The time constant is defined as the time, in seconds, it takes for the nystagmus to reduce to 37% of the maximum SCV (Jacobson & Shepard, 2008). The normal range for step test time constant is from 10-24 seconds. An abnormally short time constant, less than 10 seconds, is suggestive of peripheral vestibular dysfunction. Whereas, an abnormally long time constant, greater than 24 seconds, is indicative of cerebellar involvement (Janky, 2010).

In combination with other portions of a complete vestibular evaluation, such as case history, responses to caloric testing, and other information gained from ENG/VNG testing, rotational testing can be beneficial in assisting the audiologist in determining site of lesion (Goebel, 2001; Jacobson & Shepard, 2008). Another helpful diagnostic tool that is used to assess the integrity of the vestibular system is Computerized Dynamic Posturography. This technique is described below.

Computerized Dynamic Posturography.

Computerized dynamic posturography is a diagnostic tool that is used to quantify several aspects of an individual's ability to maintain equilibrium (Goebel, 2001; Jacobson & Shepard, 2008; Shepard & Telian, 1996). It is most commonly used as part of a vestibular test battery in order to develop a rehabilitation plan and monitor progress throughout treatment. There are two main sections within the posturography evaluation, sensory organization testing (SOT) and motor control testing (MCT). The computerized dynamic posturography test involves the patient standing on a moveable platform with a visual scene that can be manipulated in front of them. During the testing, the individual is attached to a harness for safety should they lose balance. The SOT test has six conditions that systematically restrict input from each body system that contributes to overall equilibrium, the visual, somatosensory, and vestibular systems. The six conditions are shown in Figure 14 below and are listed by number. In condition 1, the patient is standing in a fixed position on the platform with their eyes open. Whereas, in condition 2 the patient is standing in a fixed position, but they have their eyes closed. In condition 3 the individual is standing in a fixed position, but the visual scene presents misleading cues.

Condition 4 involves the individual standing with eyes open on the platform, but the somatosensory input is reduced due to movement of a platform under the feet. Condition 5 has the same characteristics as condition 4, but the individual's eyes are closed. In condition 6 the individual is presented with conflicting visual cues and reduced somatosensory input. Conditions 5 and 6 are the most difficult, and provide the most information on the function of the vestibular system, because the inputs from the other two sensory systems are disrupted. Individuals with vestibular disorders typically score within the normal range on SOT conditions 1-4 and score very low on SOT conditions 5 and 6 (Goebel, 2001).

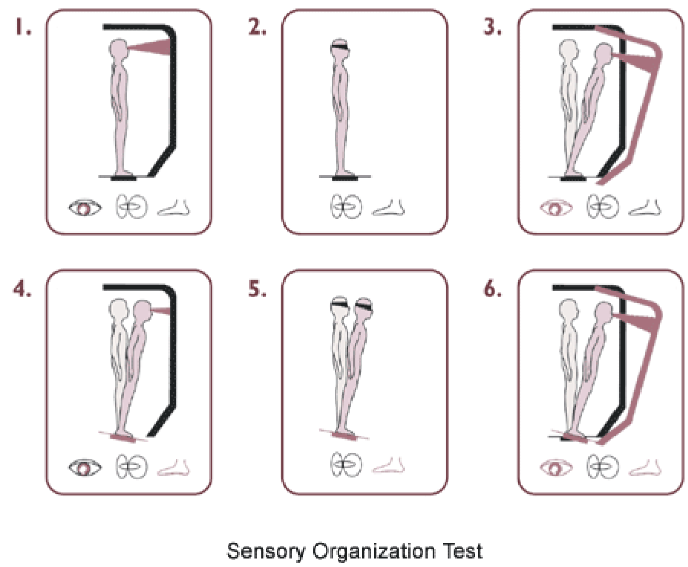

Figure 14. The six different conditions of sensory organization testing. Reprinted from “Practical Management of the Dizzy Patient” Goebel, 2001.

This organized evaluation of each sensory system during posturography allows the clinician to determine appropriate rehabilitation strategies to strengthen the affected systems and to monitor the progress of an individual that is performing vestibular rehabilitation exercises (Goebel, 2001; Jacobson & Shepard, 2008). The MCT portion of the posturography evaluation consists of the evaluation of patient responses in reaction to manipulations of the visual field or the platform they are standing on. The platform records an individual's weight shifts and records reactions to the perceived movements.

This portion of the exam is analyzed in terms of reaction time, symmetry, and strength of the responses. Again, the computerized dynamic posturography evaluation does not necessarily assist in determining site of lesion, but it can provide information important in creating an appropriate rehabilitation procedure and monitoring progress in these situations VOR (Goebel, 2001; Jacobson & Shepard, 2008).

Vestibular Evoked Myogenic Potential.

The vestibular evoked myogenic potential or VEMP assesses the integrity of the saccule and the inferior portion of the vestibular nerve (Goebel, 2001; Jacobson & Shepard, 2008; Rauch, 2006; Zhou & Cox; 2004). The VEMP is a myogenic potential that is recorded from electrodes placed on one sternocleidomastoid (SCM) muscle in response to a suprathreshold stimulus. The stimulus is typically presented at 90-100 dB nHL and can be either click or tonal stimulation. Three electrodes are involved in the recording of this potential, the inverting electrode is located near the clavicle at the base of the SCM, the non-inverting electrode is on the upper third of the SCM, and a ground electrode is located on the individual’s forehead. During VEMP testing the individual must maintain muscle contraction of the SCM for the duration of the test. This task is typically accomplished by asking the patient to raise their head and look toward the non-test ear.

A typical VEMP recorded from an adult with a normal functioning vestibular system consists of a waveform with a positive peak occurring at approximately 13 ms, known as P13, and a negative peak occurring at 23 ms, known as N23, shown in figure 15 (Rauch, 2006).

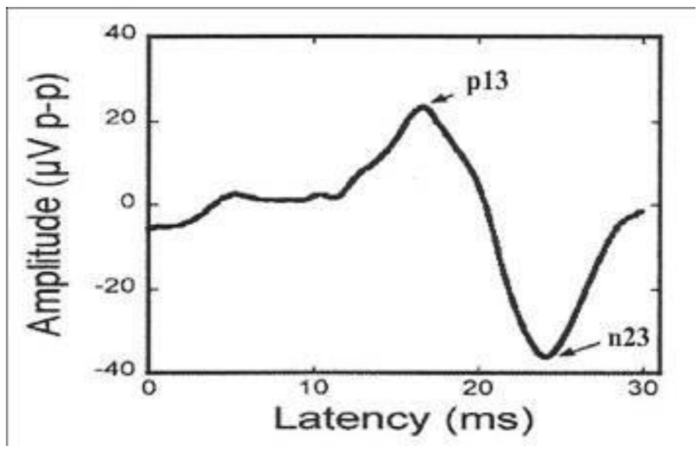

Figure 15. Example of a VEMP response to a high intensity stimulus in an adult with a normally functioning vestibular system. Reprinted from Zhou & Cox, 2004, with permission.

The VEMP waveform is analyzed in terms of latency, P1-N1 amplitude, threshold, and an asymmetry ratio between ears. Absolute P1-N1 amplitudes are extremely variable between individuals (Akin et al., 2004; Jacobson & Shepard, 2008). Therefore an asymmetry amplitude ratio between ears is used to determine whether the function of one side is weaker than the other. The asymmetry ratio is given as a percentage and calculated as the amplitude difference between ears divided by the total amplitude of both ears (Akin et al., 2004). An asymmetry ratio less than or equal to 40% is considered within the normal range (Akin et al., 2004). Individuals with normal functioning vestibular systems typically have VEMP thresholds within the range of 75-100 dB nHL (Rauch, 2006; Zhou & Cox, 2004). VEMP latency, amplitude, threshold and asymmetry values are then compared to age matched normative data to determine any abnormalities within the response. VEMP abnormalities, such as low VEMP thresholds, can be indicative of third window disorders such as Meniere's disease and superior canal dehiscence syndrome (Jacobson & Shepard, 2008; Rauch, 2006; Zhou & Cox; 2004).

Treatment Procedures

Another area in which audiologists are actively involved is the rehabilitation of some of the vestibular disorders diagnosed by these evaluations. Rehabilitation exercises can typically be administered in an audiologist's or physician's office. It is likely that the training of audiologists in these rehabilitation exercises typically occurs in vestibular courses or clinical experiences provided in graduate school for Au.D. students or by attending courses in vestibular management for practicing clinicians.

This literature review will focus on the vestibular rehabilitation exercises that are used clinically by audiologists. The three most common rehabilitation exercises that will be discussed in this literature review are Vestibular Rehabilitation Therapy (VRT), the Semont/Liberatory or Epley Maneuvers, and Brandt-Daroff exercises. Discussion of these rehabilitative procedures will include a brief description of the specific technique followed by a review of which individuals are candidates for the exercise and the frequency of which these exercises should be performed.

Vestibular Rehabilitation Therapy.

The goal of vestibular rehabilitation therapy (VRT) is to reduce an individual's motion related dizziness symptoms and promote overall equilibrium (Gans, 2002; Goebel, 2001; Funk, 2008; Shepard & Telian, 1996). There are three main aspects of VRT; these are: adaptation, substitution, and habituation (Gans, 2002; Funk, 2008; Shepard & Telian, 1996). Adaptation is essentially an attempt to reset the VOR and promote the central nervous system to compensate for asymmetric inputs from each ear. Substitution exercises assist in strengthening a weakened system in the presence of reduced input from the other systems. Habituation exercises evoke symptoms of dizziness in hopes of increasing the tolerance to those symptoms, eventually reducing the body's response to them all together (Gans, 2002; Funk, 2008). The VRT plan that the clinician develops is specific to the individual and their presentation of dizziness. VRT has been shown to be effective in up to 85% of these individuals (Gans, 2002). While many individuals who attempt VRT see significant improvement in their perception of symptoms not all individuals with vestibular related dizziness are candidates for VRT. VRT is most effective for those individuals with non-compensated asymmetric vestibular function. It is important that the individual's condition has stabilized prior to VRT and they are no longer experiencing severe symptoms such as nausea, emesis, or severe vertigo when exercises begin (Gans, 2002; Funk, 2008, Jacobson & Shepard, 2008).

Canalith Repositioning Maneuvers (Semont/Libertory or Epley).

Canalith repositioning maneuvers (Semont/Liberatory and Epley) are treatments for benign paroxysmal positional vertigo (BPPV) (Desmond, 2004; Jacobson & Shepard, 2008). These procedures are performed in a physician or audiologist's office. The Semont/Liberatory maneuver begins with the individual lying on one side and is quickly shifted to lying on the other side. The Epley maneuver, also called the canalith repositioning maneuver, involves moving an individual's head into four sequential positions. These four positions are: a right/left head hanging position, a right or leftward roll, further right or leftward roll, and the return to a seated position (Herdman & Tusa, 2004). These four positions are illustrated in Figure 16 below.

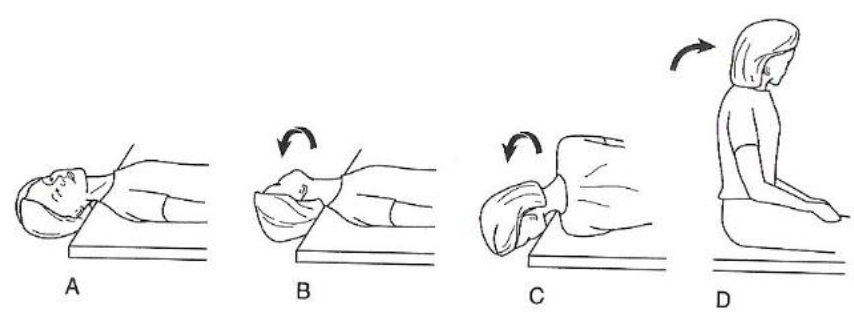

Figure 16. Order of the steps of the canalith repositioning maneuver. Reprinted from “Benign Paroxysmal Positional Vertigo” by S. Herdman & R. Tusa, 2004.

The individual's head is then held in each position for 30 seconds. Both of these procedures assist in returning the displaced otoconia to the vestibule and out of the affected semicircular canal. Occasionally BPPV will re-occur in approximately one-third of patients within five years of initial treatment (Desmond, 2004; Jacobson & Shepard, 2008). If symptoms of BPPV persist these canalith repositioning procedures can be performed weekly until the symptoms decrease (Epley, 1992). These procedures have been found to be effective in up to 90% of cases of BPPV (Gans & Harrington-Gans, 2002).

Brandt-Daroff Exercises.

Brandt-Daroff exercises are also used to treat BPPV (Desmond, 2004; Jacobson & Shepard, 2008). The difference between these exercises and the Semont/Liberatory or Epley maneuvers is who performs the task. The individual suffering from BPPV typically completes the Brandt-Daroff exercises at home. These are used if other treatments are ineffective. To perform the Brandt-Daroff exercises an individual is required to move into four positions. The first position is simply sitting on a couch or bed. In the second position the individual lays on one side and looks up at a 45 degree angle, focusing on the wall for 30 seconds, or until dizziness subsides. The third step is returning to a seated position for another 30 seconds and the fourth is lying on the opposite side as listed in step two. It is suggested that an individual performs this exercise five times per set with three sets a day for two weeks (Desmond, 2004; Jacobson & Shepard, 2008).

Education

Interest in vestibular assessment and management is a quickly growing across many areas of health care, including audiology. In a survey of 268 audiologists in the New England area a large portion of respondents cited interest in vestibular assessment and rehabilitation, 44% and 35%, respectively (Helfer, 1999). In recent years many graduate programs have incorporated an increased number of courses related to vestibular assessment and rehabilitation in their audiology training program (Nemes, 2000). The American Academy of Audiology has established a task force with a major goal of promoting vestibular topics to be included in graduate degree programs in audiology. Both AAA and ASHA position statements include vestibular assessment and management within the scope of practice of audiologists (American Academy of Audiology, 2011; American Speech Language Hearing Association, 1999). However, due to the complexity of the various sensory systems involved in maintaining an individual’s equilibrium and their interactions with other body systems more education is needed to perform these tasks adequately (Helfer, 1999). To obtain more information regarding current academic programs in audiology a review of 72 ASHA accredited Au.D. programs was conducted. Of these 72 academic programs, information regarding students’ program of study was readily available from 59. More specific information on each program is available in Appendix C of this document. Information from this preliminary review revealed that all of the programs included at least one course that covered vestibular topic areas. This finding is encouraging, but the majority of those programs (n=37) only offered one course to cover all the information related to the vestibular system and its function. Thus it appears that Au.D. students are not receiving a thorough coverage of the vestibular area during their degree program. A further break down of this information is provided in the discussion section of this document.

In order to maintain vestibular assessment and management as an area within the scope of practice of audiologists it appears that more academic and clinical training is needed (Nemes, 2000). For audiologists that are already practicing, CEUs, seminars, and workshops, as well as online courses are available to enhance training and work experience in these areas (Helfer, 1999).

Aims of this Study

To date, little research has been conducted in the areas of vestibular assessment and treatment that specifically relate to audiologists' education and/or training in these areas. The purpose of this study was to obtain information regarding the current status of vestibular assessment and management techniques in order to isolate areas where more comprehensive training is needed.

Specifically there were three goals of this study:

- To obtain more information regarding the current low tech and high tech assessment procedures as well as vestibular treatment procedures being used regularly in audiology practices.

- To obtain information regarding the audiologists' education and training in both the diagnosis and management of individuals with vestibular pathologies.
- To investigate the level of comfort experienced by practitioners in administering and interpreting the data from assessment procedures as well as performing the treatment exercises for individuals with vestibular pathologies as a function of their highest level of education.
- To investigate the level of comfort experienced by practitioners in administering and interpreting the data from assessment procedures as well as performing the treatment exercises for individuals with vestibular pathologies as a function of their years of experience in conducting vestibular assessments and treatments.

Chapter 3

Method

A survey titled "A Survey of Audiologists' Clinical Practices in the Assessment and Management of Adults with Vestibular Pathologies and their Education and Training in These Areas." was developed (see Appendix A below). The first pilot survey was sent electronically to three individuals with extensive clinical and research expertise in the field of vestibular assessment and rehabilitation (i.e., Dr. Neil Shepard, Dr. Kristen Janky, and Dr. Richard Gans). These individuals were asked to review the questions in terms of both content and clarity. These surveys were sent on September 18, 2011 (Dr. Shepard and Dr. Janky) and October 3, 2011 (Dr. Gans). Feedback was received by two of these individuals. The majority of the comments on the content of the survey were related to using more general terminology for specific test procedures. An example of this is using bedside assessment of postural control instead of the Gans SOP. Another comment noted by both individuals was regarding the checklist of equipment that is available at each respondent's practice. Again, this comment was related to using more general terminology that would be applicable to more individuals responding to the survey. These comments were incorporated into a revised version that was sent to a second group of audiologists.

This revised survey was sent to approximately 10-15 audiologists practicing in the Maryland area. These individuals were suggested by clinical faculty in the audiology program at Towson University and are known to provide vestibular services regularly.

Those who were willing to make comments on the survey at this stage in its development were asked to provide feedback on the content, clarity, and structure of the revised survey. This was the second pilot survey and was sent to these individuals by October 19, 2011. Individuals included in the second pilot of the survey were asked to return comments within a ten-day time frame (October 29, 2011). There were very few comments made regarding the structure, content, or clarity of the survey in the second pilot survey.

The final survey incorporated the suggestions made in each of the previous versions of the survey and was sent to a group of 900 practicing audiologists. These audiologists were identified through the American Academy of Audiology (AAA) as clinicians who noted vestibular assessment and management as areas of interest or expertise. There are approximately 1600 AAA members in the United States that mark these topics as specialties (AAA, personal communication, October 5, 2011). In order to determine an appropriate number of surveys for this population an online sample size calculator was used (Creative Research Systems, 2011). This calculation determined that to obtain a 95% confidence level for a population of 1600, an acceptable sample size is 310. Because a low response rate is often reported in surveys an estimate of three times the necessary amount, or 900, was selected. A mailing list was purchased through AAA that provided the contact information necessary to deliver the survey to this group of audiologists. Individuals were given the option to complete an electronic version of the survey, hosted on the website Survey Monkey, through a URL address provided on the paper copy of the survey. The final survey was distributed on November 9, 2011 and it was requested that they were returned within two weeks of their receipt. Individuals who chose to complete the online version had access to the link until November 22, 2011.

Survey

The survey included three sections: demographics, assessment, and treatment. The survey questions are included in Appendix A of this document. The survey consisted of 41 questions. There were six “additional comments” boxes following questions that required any further explanation. Additionally, any question that might not have had all the potential responses listed had the option to check “other” and list an individual’s specific response.

The demographics section of the survey included eight questions. These questions were focused on information related to the education and the current setting in which the respondent was practicing. Information regarding the amount of time he/she had spent performing both vestibular assessment and treatment procedures as well as how often he/she performed these evaluations in their clinical practice (i.e. how many vestibular evaluations he/she performed weekly) are included in the demographic section of the survey.

The assessment section included 23 questions. Three were related to the test battery used for vestibular evaluation and whom the respondent believed to be qualified to perform these tasks. Ten questions focused on the bedside assessment procedures that the individual performed in a balance evaluation. The remaining ten questions were in relation to the high tech evaluations that the respondent administers.

The treatment section of the survey consisted of ten questions. These questions were related to the types of vestibular treatment procedures that the clinician performed, who he/she believed should be performing these exercises, and the respondent's comfort level with each treatment procedure.

This survey was submitted to and reviewed by the Towson University Institutional Review Board for the Protection of Human Subjects and was classified as exempt (Appendix D).

Analyses

Data obtained from surveys returned, both electronically and in print, were inputted and stored into Microsoft Excel spreadsheets. These data were coded to remove any identifying information. Statistical analysis of the data was performed using the statistics software package, SPSS version 19.0.0. Data analysis primarily included the use of descriptive statistics and non-parametric analyses (i.e., Kruskal-Wallis one way analysis of variance and Mann-Whitney U tests). Descriptive statistics included reporting the percentage of the respondents that provided data on each question. Non-parametric statistics were calculated using cross-tabulation and a series of Kruskal-Wallis one way analysis of variance (i.e., ANOVA) statistics. The alpha level for all of the ANOVA results was $p \leq 0.05$. If significant main effects were found for the ANOVAs, then post hoc testing, using the Mann-Whitney U test statistic, were performed. The alpha level used for all of the *post hoc* Mann-Whitney U tests was adjusted to account for the possibility of a Type I error. This value was determined by dividing the original alpha level of $p \leq 0.05$ by the number of categories being evaluated. There were three categories of educational levels (i.e., Master's, clinical doctorate, and research doctorate) and three categories of experience levels (i.e., 0-5 years, 6-10 years, and 10+ years) that were evaluated in these analyses. Thus, the Bonferroni-corrected p-value for all of these *post hoc* analyses was $p \leq 0.0167$ (0.05/3) (Rosenthal & Rosnow, 1991).

Chapter 4

Results

A total of 900 written surveys were mailed to AAA members who listed vestibular assessment or treatment as an area of specialty. Of these 900 surveys, 334 of them were returned, yielding an overall response rate of 37.11%. The recipients of the survey had the option to return the surveys by mail, in a pre-paid envelope, or online through the host website SurveyMonkey.com. Of the 334 surveys returned, 301 (90.12%) were returned in the mail and 33 (9.88%) were submitted online. When each survey was sent out it was given a unique identification number. To ensure that there were no duplicate surveys received participants were required to provide this number if they chose to submit the survey online.

The results and discussion sections are organized based on the various sections of the survey. First, the questions related to the demographics of the participants are discussed. Secondly, the responses to the questions related to vestibular assessment techniques are summarized. Lastly, the questions regarding vestibular treatment protocols are discussed. It should be noted that not every participant answered every question on the survey. Therefore, we will be presenting data relative to the number of subjects who responded to each question. Lastly, we will also be discussing the numbers of no responses and/or non-applicable responses, as needed.

Demographics

There were specific questions on the survey related to the demographic information of the participants. These questions addressed the following topics: gender, highest level of education, and practice setting (specific wording of these questions can be found in Appendix A under questions 1, 2, and 7).

A total of 326 individuals responded to the question of gender, for a total response rate of 97.6%. The results of this question indicated that 248 (76.07%) of these individuals were female and the remaining 78 (23.93%) were male. There were 334 individuals who responded to the question regarding the participant’s highest level of education, for an overall response rate of 100%. The vast majority of these responses (n=259; 77.54%) indicated that they had earned a clinical doctorate in audiology (e.g., Au.D.). In contrast, 55 individuals (16.47%) indicated they had earned a Master’s Degree in audiology and 14 individuals (4.19%) reported earning a research doctorate in a field related to audiology (e.g., Ph.D. in hearing science).

Six participants responded “other” to the question regarding their highest level of education. Of these individuals, five reported having multiple degrees. Two of these individuals had both clinical and research doctorates in audiology; two had clinical and research doctorates in audiology and a degree in an additional field; and one reported a clinical doctorate in audiology and an MBA. One individual indicated that they had taken some doctoral level courses in audiology; however, he/she had not completed the requirements for the degree.

Three hundred thirty four participants responded to the question regarding the type of work setting in which they practice, yielding a response rate of 100%. The three most common settings that were reported were ENT practice (n=123; 36.83%), private practice (n= 85; 25.45%), and hospital/medical center/clinic (n=83; 24.85%). The percentage rates for each response are summarized in Figure 17, below.

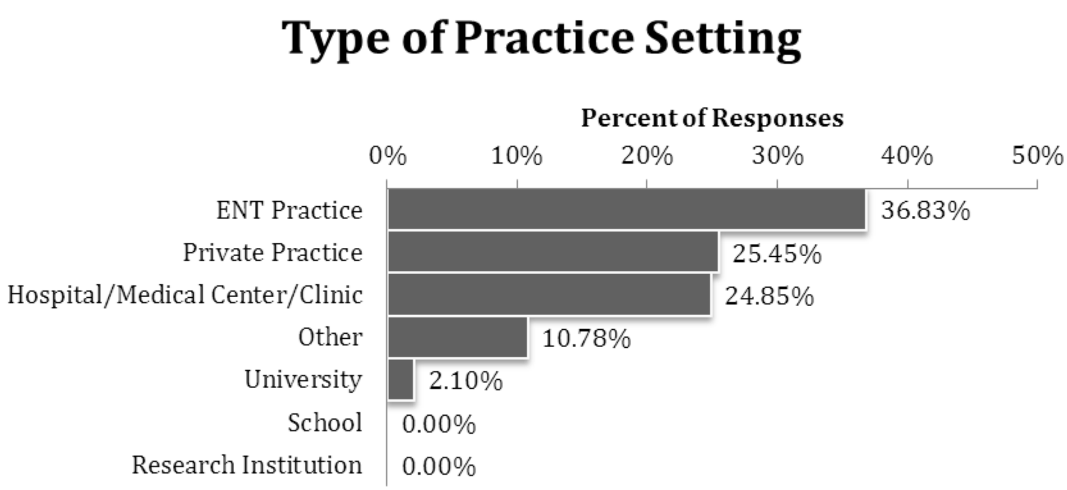

Figure 17. The distribution of reported settings in which survey participants practice. Percentages calculated from 334 responses.

Thirty-six participants (10.87%) responded “other” to the question related to type of practice. Within this “other” category, the majority of individuals indicated that they worked in multiple work settings. For example, 13 individuals reported working in both an ENT and private practice setting, four in a combination of an ENT practice and a hospital/medical center/clinic; and four in both a hospital/medical center/clinic and a university setting.

Assessment

Questions related to vestibular assessment were found in three different sections of the survey. These sections were: demographics, low-tech assessments, and high-tech assessments. In this sub-section of the results, the findings from assessment questions, which provide demographic information about the participants, are discussed first. This is followed by the results gleaned from the low tech and high tech assessment questions.

In the demographic section of the survey, there were five questions related to vestibular assessment. These questions included topics such as: the number of years each participant had been conducting vestibular assessments, their formal education in conducting vestibular assessments, how many vestibular evaluations they administer weekly, what types of tests are in those evaluations, their typical vestibular test battery, and what groups of professionals they believe are qualified to perform vestibular assessments.

Each participant was asked how many years he or she had been conducting vestibular assessment (Question 3 in Appendix A). All 334 participants responded to this question for a total response rate of 100%. The results of this question indicated that the most common response was that 27.54% of the participants (n=92) had administered vestibular assessments for a range of 6-10 years. Secondly, there were 85 individuals (25.45%) who reported only having 0-5 years of experience administering these types of assessments. Lastly, the third most common response was in the category of 21+ years, to which 75 individuals (22.46%) responded. More specific values for each experience group are listed in Figure 18 below.

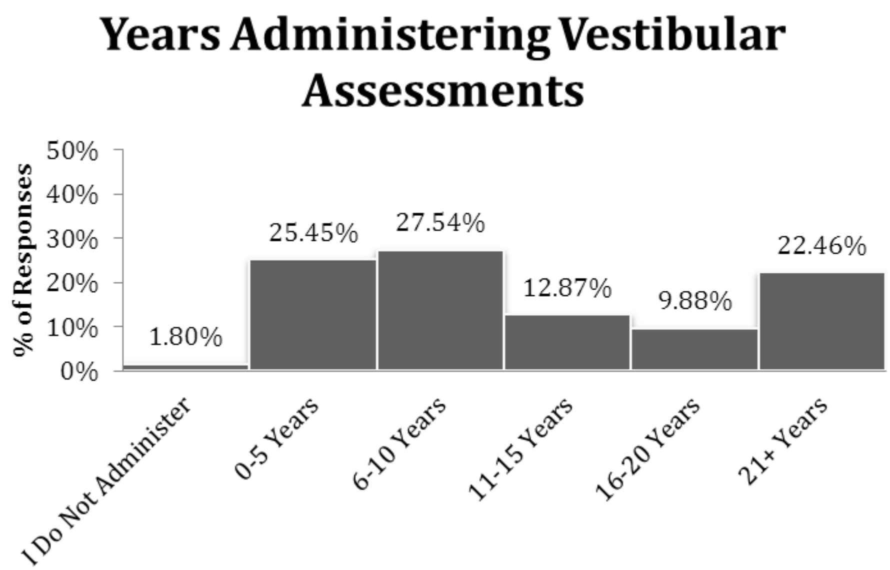

Figure 18. The number of years each participant reported to be involved in administering vestibular assessments. Percentages calculated from 334 responses.

There were 327 individuals who responded to the question related to the types of formal education that they had received in the area of vestibular assessment, yielding an overall response rate of 97.9% (Question 5 in appendix A). It should be noted that participants were able to mark all types of formal education that applied to their experience. The vast majority of individuals (n=304; 92.97%) indicated that they had successfully completed a lecture course related to vestibular assessment at some point within their degree program. Two other common types of formal education included: (1) a focused specialty training course(s) offered specifically on vestibular topics that they had taken following their degree program (n=229; 70.03%); (2) a hands-on lab course(s) associated with the vestibular lecture course that they had taken within their degree program (n=220; 67.28%). An interesting finding that was discovered in the responses from this question was at least half of the participants reported receiving training in vestibular assessment through clinical rotations, supervised training, or individual break-out sessions at professional conferences. Only a small percentage of individuals (n=18; 5.5%) reported receiving vestibular assessment training through their research projects, such as Au.D. theses. A summary of the percent of responses that occurred relative to the different types of formal education these individuals received in vestibular assessment is presented in Figure 19, below.

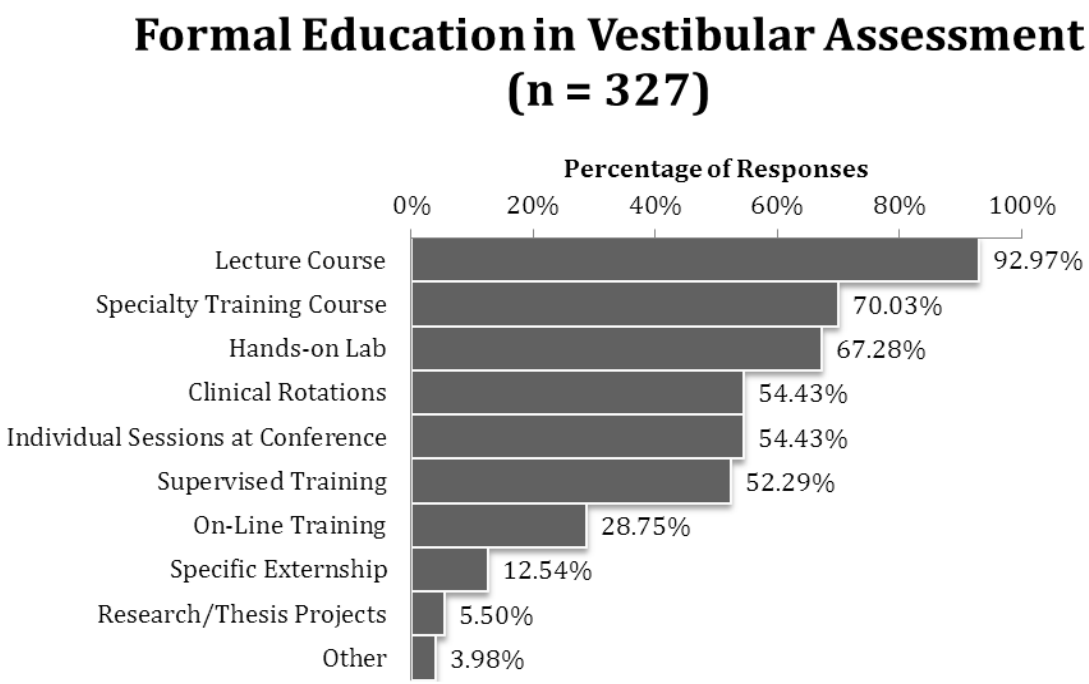

Figure 19. Types of formal education participants have completed related to vestibular assessment. Percentages calculated from 327 total responses.

A third vestibular assessment question located in the demographic portion of the survey was: On average, how many vestibular evaluations does the participant typically perform in a week (Question 8 in Appendix A). Three hundred twenty four individuals responded to this question for an overall response rate of 97%. Most individuals (n=112; 34.57%) reported performing 2-4 vestibular evaluations per week. There was a similar response rate of ~ 25% for the “4-6 per week” and “1-2 per week” categories as shown in Figure 23 below. Thirdly, there were 39 individuals (12.04%) who responded “other” to this question. Of those 39 participants, 24 individuals (61.54%) reported completing more than six evaluations per week and 15 individuals (38.46%) noted completing less than one evaluation per week. Therefore it appears that the audiologists who responded to this survey are actively involved in conducting vestibular assessments in their work environments on a weekly basis.

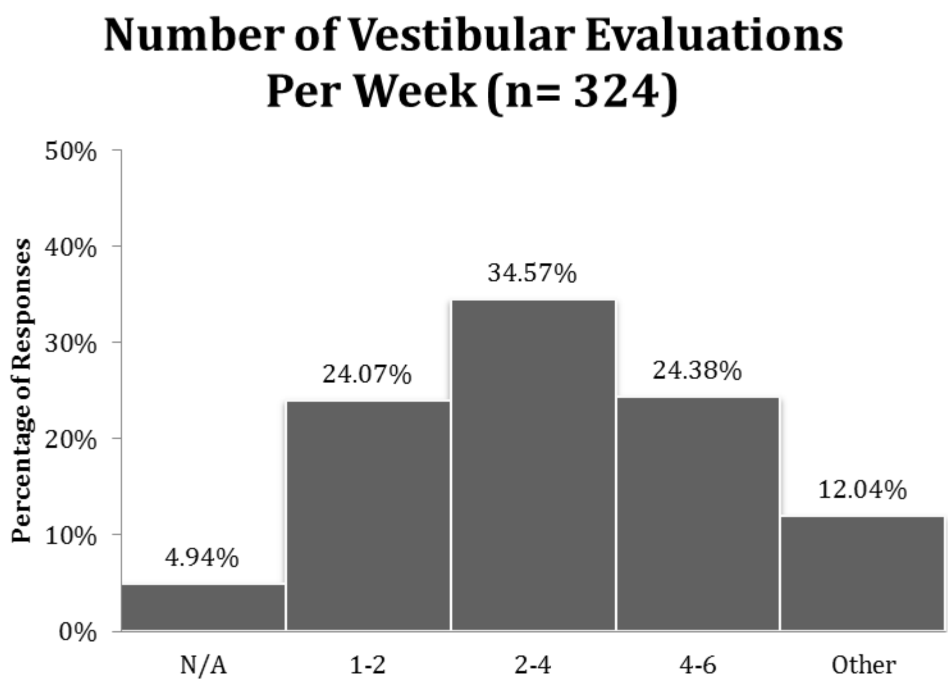

Figure 20. The number of times per week each participant reported administering vestibular assessments. Percentages calculated from 324 total responses.

Each participant was also asked to describe what assessments they typically include in their vestibular evaluations (Question 9 in Appendix A). There were 293 individuals that responded to this question providing a total response rate of 87.72%. This question was worded in an open format and therefore allowed participants to write in the names of the tests they typically include. Because this question was open ended, there was an extremely wide variety of responses. It should be noted that only tests that were listed by five or more individuals were included in this analysis. By far, the most common test reported was the ENG/VNG, with 92.83% (n=272) of the participants listing it as part of their typical vestibular evaluation. The next most common test was the VEMP, with 76 individuals (25.94%) including this as part of their routine test procedures. The test with the third highest response (n=54; 18.43%) was the ECochG. Other frequently listed test procedures and their respective response rates are summarized Figure 21 below.

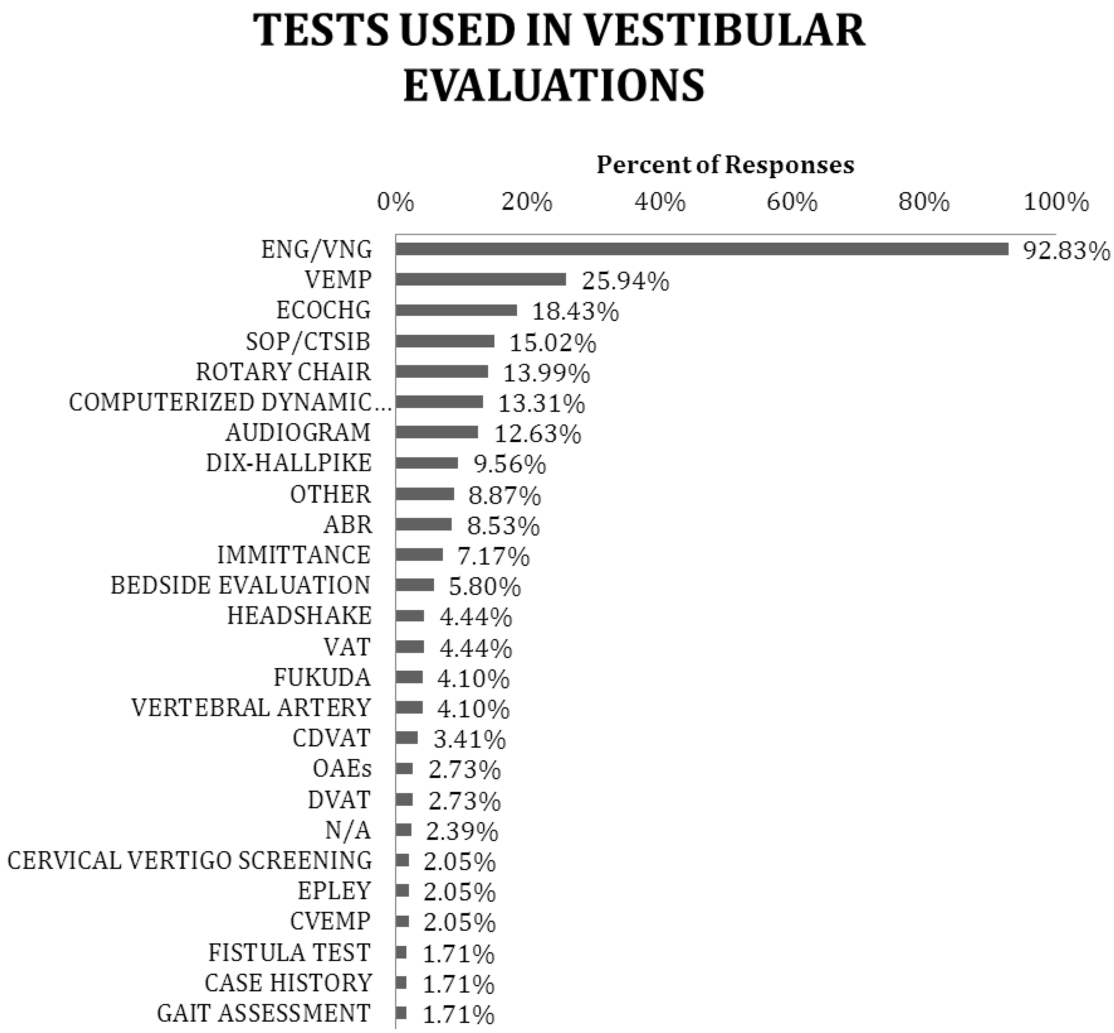

Figure 21. Common tests reported to be used in vestibular evaluations. Percentages calculated as the number of responses for a specific test divided by the total n (293).

The participants were also asked a question regarding the composition of the typical vestibular test battery they administer in their practice (Question 10 in Appendix A). There were 317 individuals that responded to this question, yielding an overall response rate of 94.91%. The results of this question, which are displayed in Figure 22, indicated that 176 (55.52%) of the participants used a standard test battery and added tests based on patient case history. There were 90 individuals (28.39%) who reported they use a standard vestibular test battery on all patients they evaluate. Thirdly, 25 participants (7.89%) listed “other” in response to this question. Most of the individuals indicated that their test battery was guided, at least in part, by the orders of the physician.

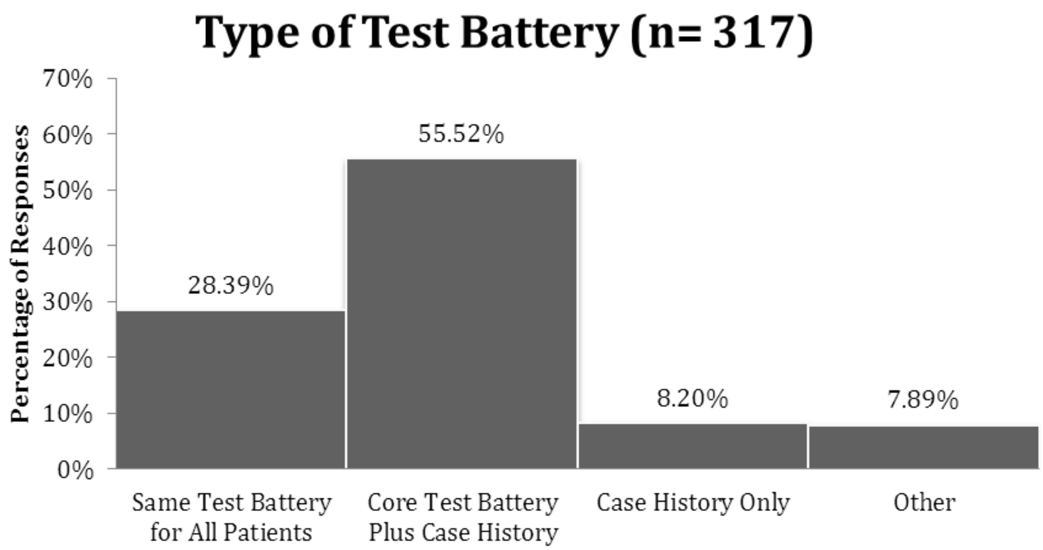

Figure 22. Factors that participants report influence how they choose the test battery for vestibular evaluations. Percentages are calculated from the total number of responses (n=317).

The final question related to demographic information on vestibular assessments asked the audiologists who they believed were qualified to perform vestibular assessment procedures (Question 13 in Appendix A). Similar to question 5, participants were able to check all of the professional groups they thought were qualified. Three hundred thirty individuals responded to this question for an overall response rate of 98.80%. One hundred percent of the respondents listed “audiologist” as being qualified to perform vestibular assessments. Approximately 40% of the respondents indicated that a “certified vestibular technician”, “otologist/neurologist”, or “otolaryngologist” were qualified to perform these assessments, as seen in Figure 23 below. The professional groups that received the lowest ratings (all less than 7%) were physician assistants, nurse practitioners, occupational therapists, general physicians, nurses and vestibular technicians without certification.

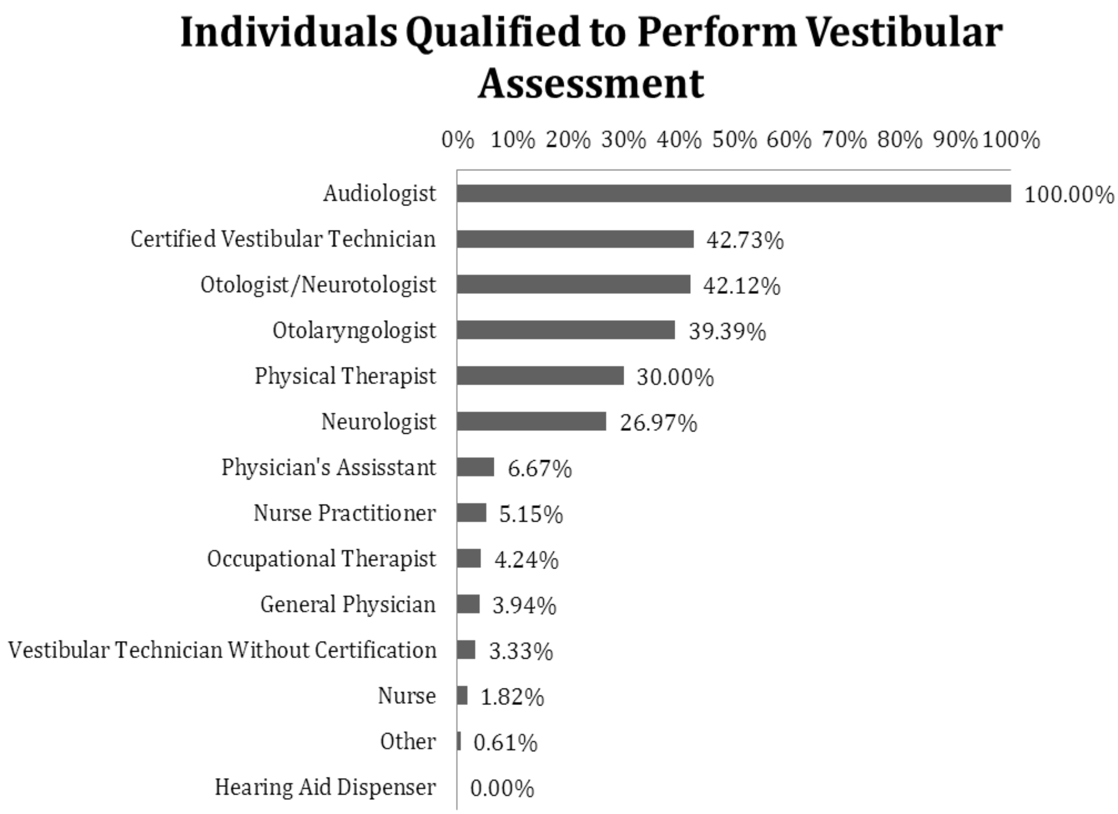

Figure 23. Distribution of participants' opinions in regard to professional groups qualified to perform vestibular assessment. Percentages are calculated from the total number of responses (n=330).

Low-tech vestibular assessments.

The next group of questions related to vestibular assessments focused specifically on low-tech vestibular assessments. These questions addressed the types of equipment the participants had available to them, the low-tech assessments they typically use, and the audiologists' comfort levels in administering and interpreting four commonly used low-tech assessments. These four low tech assessments were: bedside assessment of postural control, the dynamic visual acuity test, the head shake test and the vertebral artery test.

Each participant was asked a question about the different pieces of low-tech equipment available at their workplace (Question 11 in Appendix A). It should be noted that respondents were again able to check multiple answers to this question. A total of 293 individuals responded to this question, for an overall response rate of 87.72%. The majority of the participants (n=263; 89.76%) indicated that they had access to an exam table, followed by "foam pad" (n=137; 46.76%) and "Frenzel goggles" (n=115; 39.25%), as shown in Figure 24 below. Less than 10% of the respondents had access to an optokinetic (OPK) drum or a static balance platform.

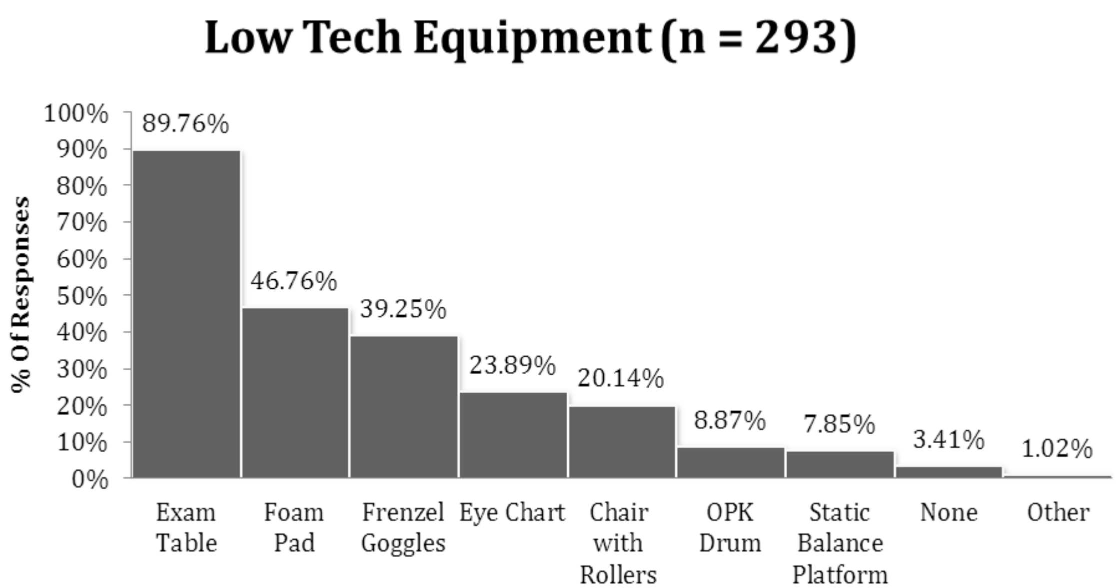

Figure 24. Low-tech equipment that is available at participants' worksites. OPK= optokinetic. Percentages are calculated based on the total number of responses (n=293).

Following this the participants were also asked to select which specific low-tech tests that they typically use (Question 14 in Appendix A). There were 297 individuals who responded to this question providing a response rate of 88.92%. Most of the participants (n=176; 59.26%) indicated that they used the head shake test and the vertebral artery test (n=148; 49.83%) as seen in Figure 25 below. Approximately one third (38.38%) of the participants reported using a bedside assessment of postural control, such as the Gan's SOP or the CTSIB evaluations. Ninety-four individuals (31.65%) checked the overall category of bedside vestibular assessment. In this question in the survey, we listed bedside assessment of vestibular assessment as one option, with several related procedures as sub-categories. These sub-categories included: ocular range of motion, bedside saccades, gaze stabilization, head thrust, and bedside pursuit procedures. However, only ~ 10-20% of these 94 individuals subsequently reported using these various sub-categories of the bedside vestibular assessment test battery, as seen in Figure 25 below. There were 27 individuals (9.09%) who reported "other" to this question. Of the responses in this "other" category, the majority (n=7; 25.93%) noted using the Dix-Hallpike.

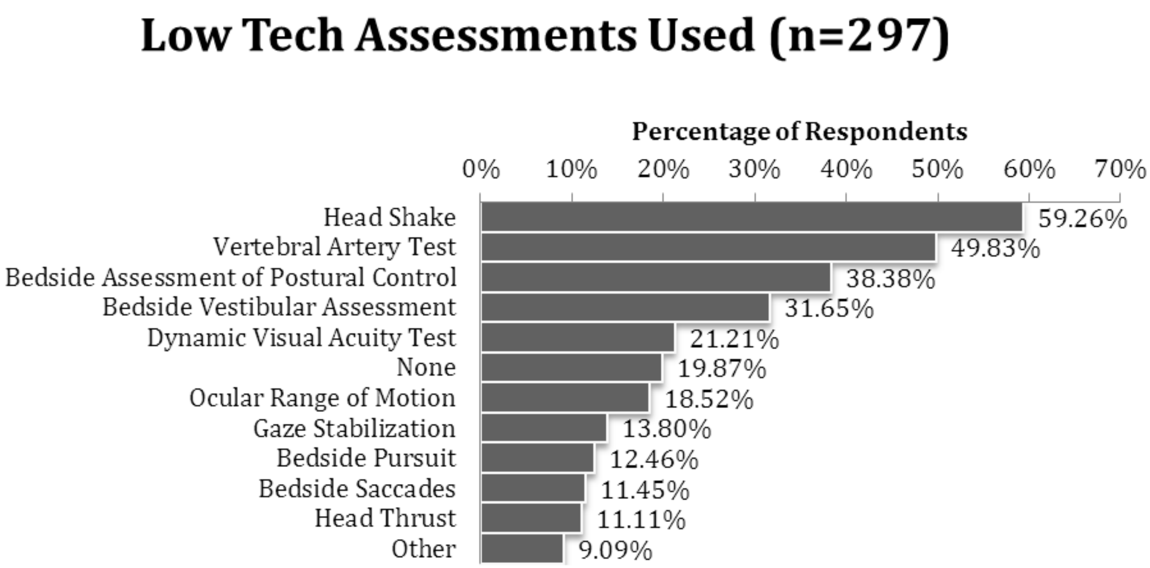

Figure 25. Distribution of various low-tech vestibular assessments that are being used clinically. Percentages are calculated based on the total number of responses (n=297).

A series of questions required the participants to note their comfort levels in administering and interpreting four specific low-tech assessments. Again these four low-tech assessments are: the bedside assessment of postural control, the dynamic visual acuity test, the head shake test, and the vertebral artery test (Questions 15-22 in Appendix A). For each of these low-tech tests, the participants rated their comfort levels in administering and interpreting these assessments according to the following categories: very comfortable, comfortable, uncomfortable, very uncomfortable, or not applicable. Table 2 displays a summary of the participants' comfort levels related to the administration of these four low-tech vestibular assessments. For each low-tech assessment, the actual number of respondents for each of the comfort level categories, as well as the number of respondents who checked "N/A" for these questions, is provided. The percentage of respondents for each comfort level category was calculated. This calculation is based on the total number of responses for that particular low-tech assessment. The comfort level category that received the largest number of responses is indicated by bold type. The use of this font style to indicate the category with the largest number of responses will be continued throughout the subsequent summary tables in the results section.

The data in Table 2 revealed several interesting patterns. First, it appears that the participants are most comfortable administering the head shake procedure followed by vertebral artery, bedside assessment of postural control, and DVAT. This pattern was evident given the number of respondents who have rated their comfort levels with administering these procedures as either “very comfortable” or “comfortable”. Secondly, it was surprising that the survey participants ranked their comfort levels in administering the head shake assessment considerably higher than the other three low-tech assessments. For example ~50% of the participants reported feeling “very comfortable” in administering the head shake test, in comparison to ~25%-35% of respondents who selected the same comfort level for the bedside assessment of postural control, DVAT, and vertebral artery tests. A third surprising pattern was that the DVAT assessment had the lowest ranking in terms of overall comfort (ratings of “very comfortable” and “comfortable”) given the similar nature of administering the DVAT and head shake assessments. A fourth interesting finding was that of the 334 participants who responded to the survey approximately 180-240 individuals (~54%-71%) are routinely using these low-tech assessment procedures in their workplace. It was hypothesized that the ~20%-35% “N/A” response rate had not used these low-tech procedures. Lastly, only a small percentage (12.86% or less) of the participants indicated that they were “uncomfortable” or “very uncomfortable” in the administration of any of these low-tech assessment procedures.

Table 2.

Summary of participants' comfort levels related to the administration of four low-tech vestibular assessment procedures.

	VC		C		U		VU		N/A		Total
Administration	N	%	N	%	N	%	N	%	N	%	N
Bedside Assessment of Postural Control	**90**	**30.61% (43.47%)**	80	27.21% (38.65%)	24	8.16% (11.59%)	13	4.42% (6.28%)	87	29.59%	294
Dynamic Visual Acuity	67	23.93% (36.81%)	**68**	**24.29% (37.36%)**	36	12.86% (19.78%)	11	3.93% (6.04%)	98	35%	280
Head Shake	**142**	**47.49% (59.66%)**	79	26.42% (33.19%)	10	3.34% (4.20%)	7	2.34% (2.94%)	61	20.40%	299
Vertebral Artery	**99**	**34.02% (46.92%)**	83	28.52% (39.34%)	21	7.22% (9.95%)	8	2.75% (3.79%)	80	27.49%	291

Note. The four specific low-tech assessments that were evaluated in the survey were Bedside Assessment of Postural Control, Dynamic Visual Acuity, Head Shake, and Vertebral Artery tests. The actual numbers of responses for each comfort level category are reported, as well as the percentage based on the total number of responses for that low-tech assessment. The values in parentheses are percentages calculated from the total of only the VC, C, U, and VU ratings. For each of these low-tech assessments the comfort level category with the largest number of responses has been bolded. VC= Very Comfortable, C= Comfortable, U= Uncomfortable, VU= Very Uncomfortable, N/A= Not Applicable.

Table 3 is organized in the same format as Table 2, however, the findings are related to the participants' comfort level categories in interpreting the findings for each low-tech assessment procedure. A few interesting patterns were noted from the responses to these interpretation questions. First, approximately 50%-75% of the participants stated that they were either "very comfortable" or "comfortable" in correctly interpreting the results of these four low-tech assessments. Secondly, there was a fairly even distribution of responses across the "very comfortable" and "comfortable" comfort level categories for each of the four low-tech assessments. This finding is in contrast to the results related to the administration of these low-tech procedures as discussed above. Thirdly, there were extremely low response rates (≤ 12.46%) in the comfort level categories of "uncomfortable" and "very uncomfortable" for these low-tech procedures. This finding is in agreement with the findings reported for the administration of these procedures. Again, it should be noted that there was a significant amount of respondents (~19%-33%) who noted "N/A" in response to interpreting each of these low-tech assessment procedures.

Table 3.

Summary of participants' comfort levels related to the interpretation of four low-tech vestibular assessment procedures.

	VC		C		U		VU		N/A		Total
Interpretation	N	%	N	%	N	%	N	%	N	%	N
Bedside Assessment of Postural Control	92	**30.36% (43.40%)**	**92**	**30.36% (43.40%)**	15	4.95% (7.08%)	13	4.29% (6.10%)	91	30.03%	303
Dynamic Visual Acuity	71	24.57% (36.79%)	**73**	**25.26% (37.82%)**	36	12.46% (18.65%)	13	4.50% (6.74%)	96	33.22%	289
Head Shake	**128**	**41.42% (51.61%)**	101	32.69% (40.73%)	14	4.53% (5.65%)	5	1.62% (2.02%)	61	19.74%	309
Vertebral Artery	86	28.57% (39.09%)	**95**	**31.56% (43.18%)**	28	9.30% (12.73%)	11	3.65% (5.00%)	81	26.91%	301

Note. The four specific low-tech assessments that were evaluated in the survey were Bedside Assessment of Postural Control, Dynamic Visual Acuity, Head Shake, and Vertebral Artery tests. The actual numbers of responses for each comfort level category are reported, as well as the percentage based on the total number of responses for that low-tech assessment. The values in parentheses are percentages calculated from the total of only the VC, C, U, and VU ratings. For each of these low-tech assessments the comfort level category with the largest number of responses has been bolded. VC= Very Comfortable, C= Comfortable, U= Uncomfortable, VU= Very

A series (n=8) of Kruskal–Wallis one-way analysis of variance (ANOVA) statistics were conducted to determine if there was a significant difference in the participants' mean comfort level rating as a function of their highest level of education. The independent factor in all of these analyses was the participants' highest level of education. The three levels analyzed for the participant level of education were: (1) Master's Degree (2) Clinical Doctorate (e.g., Au.D.) and (3) Research Doctorate (e.g., Ph.D.). The dependent factor in these all of these analyses was the participants' comfort level categories which were: "very comfortable", "comfortable", "uncomfortable", and "very uncomfortable". This series of one-way ANOVAs was completed independently for each low-tech test. Of these eight ANOVAs, four were completed on participants' comfort levels in administering the four low-tech assessments. The remaining four were completed on the participants' comfort levels in interpreting these four low-tech assessments. The alpha level used to indicate significance for all ANOVAs was $p \leq 0.05$. If a significant main effect was obtained for any of the ANOVAs, additional *post hoc* Mann-Whitney U tests were completed to investigate the pattern of these effects. The Bonferroni-corrected p value for these *post hoc* analyses was $p \leq 0.0167$. This value was determined by dividing the original alpha level 0.05 by the three possible education levels (0.05/3).

The results of the Kruskal-Wallis ANOVAs for the participants' comfort levels in administering the four low-tech assessment procedures as a function of their level of education is summarized in top portion of Table 4. Examination of Table 4 indicates there were no significant main effects for the any of the four low-tech assessments as all calculated probabilities were greater than 0.05. This finding implies that the level of education (i.e., Master's, Au.D., or Ph.D.) had no direct effect on the participants' comfort levels in administering any of these low-tech assessment procedures.

Similarly, the results of the next set of ANOVAs (seen in the bottom portion of Table 4) revealed that there were no significant main effects of the level of education on the participants' comfort levels in interpreting three of these low-tech assessments. These assessments were: the DVAT, the head shake, and the vertebral artery tests. In contrast to these results, there was a significant main effect of education level on the participants' comfort level in interpreting the bedside assessment of postural control (p = 0.013). *Post hoc* Mann-Whitney U tests were conducted to determine the pattern of this main effect. The results of the U tests revealed a significant difference between the "clinical doctorate" and the "research doctorate" groups (p = .003). All of the individuals who held a research doctorate indicated feeling "very comfortable" or "comfortable" in interpreting the bedside assessment of postural control; however only 86.8% of the participants with clinical doctorate degrees responded with these same two comfort level categories. This finding should be interpreted with caution given the difference in distribution of subjects in these two groups.

Table 4.

Summary of the results of a series of Kruskal-Wallis one-way ANOVAs related to participants' mean comfort levels in the administration and interpretation of four low-tech assessments as a function of their highest level of education.

ADMINISTRATION	Highest Level of Education
Bedside Assessment of Postural Control	P = 0.4
Dynamic Visual Acuity Test	P = 0.127
Head Shake	P= 0.688
Vertebral Artery	P = 0.778
INTERPRETATION	
Bedside Assessment of Postural Control	P = 0.013*
Dynamic Visual Acuity Test	P = 0.317
Head Shake	P = 0.556
Vertebral Artery	P = 0.223

Note. An * indicates statistical significance.

A similar series (n=8) of Kruskal-Wallis one-way ANOVAs was conducted to determine if there were any significant differences in the participants' mean comfort level categories as a function of the years of experience in conducting vestibular assessments. The independent factor in these analyses was the number of years of experience in conducting vestibular assessments. There were three levels analyzed within the levels of years of experience, which were: 0-5 years, 6-10 years, and 10+ years. The dependent factors in these analyses were the comfort level categories, which again, were: "very comfortable", "comfortable", "uncomfortable", and "very uncomfortable". Similar to the ANOVAs discussed previously, four of the eight ANOVAs were completed on participants' comfort levels in administering the four low-tech assessments. The remaining four were completed on the participants' comfort levels in interpreting these four low-tech assessments.

The results of the Kruskal-Wallis ANOVAs for the participants' comfort levels in administering the four low-tech assessment procedures as a function of their years of experience conducting vestibular assessments is summarized in top portion of Table 5. Examination of Table 5 indicates there were significant main effects of the participants' years of experience conducting vestibular assessments on the administration of two of these low-tech assessments. First, there was a significant main effect of years of clinical experience on the administration of the bedside assessment of postural control (p=0.008). *Post hoc* Mann-Whitney U tests revealed that there was a significant difference between the "6-10 years" and "10+ years" experience categories (p=0.003). Approximately 87% of the participants who had selected having "10+ years" of experience reported feeling at least "comfortable" in administering the bedside assessment of postural control. In contrast, only ~70% of the participants that were in the "6-10 years" of experience group reported having the same comfort levels. Thus, it appears that a higher number of individuals with more years of experience conducting vestibular assessments reported feeling at least comfortable in administering bedside assessment of postural control compared to individuals with fewer years of experience. The second significant main effect was on participants' mean comfort levels in administering the DVAT as a function of years of experience conducting vestibular assessment (p = 0.012). Mann-Whitney U tests indicated a significant difference between the respondents who marked "6-10 years" and those who selected the "10+ years" group (p=0.004). Again, the higher mean comfort level responses were associated with the respondents in the "10+ years" group with 81% feeling at least "comfortable" compared to ~61% of the "6-10 years" group reporting the same comfort levels. Again, it appears that more individuals with more years of clinical experience conducting vestibular assessments reported feeling at least comfortable in administering the DVAT compared to participants who reported having "6-10" years of clinical experience.

The results of the next series of ANOVAs (seen in the bottom potion of Table 5) revealed a similar pattern of main effects of participants' comfort levels interpreting these low-tech assessments as a function of their years of experience conducting these low-tech assessments. First, there was a significant main effect seen related to the participants' comfort levels associated with the interpretation of the bedside assessment of postural control (p = 0.008). *Post hoc* Mann-Whitney U tests revealed that there was a significant difference between the "0-5 years" and the "10+ years" categories (p=0.001). Significance was also found between the "6-10 years" and "10+ years" experience categories. Approximately 92% of respondents who selected having "10+ years" experience reported comfort levels of at least "comfortable" compared to ~80% of the participants in the "0-5 years" and "6-10 years" groups who selected the same comfort levels. Another significant main effect was found in the participants' comfort levels interpreting the DVAT as a function of their years of experience conducting vestibular assessment ($p = 0.029$). *Post hoc* Mann-Whitney U tests indicated that there was a significant difference between the "6-10 years" and "10+ years" groups. Further investigation revealed that ~80% of the participants who had more than ten years of experience conducting vestibular assessments felt at least comfortable as opposed to ~62% of the participants in the "6-10 years" group. This finding suggests again, that more participants with a higher number of years of experience reported feeling at least comfortable in interpreting these low-tech assessments than individuals with fewer years of experience who reported similar comfort levels.

Table 5.

Summary of the results of a series of Kruskal-Wallis one-way ANOVAs related to participants' mean comfort levels in the administration and interpretation of four low-tech assessments as a function of their years of experience conducting vestibular assessments.

ADMINISTRATION	Years of Experience Conducting Vestibular Assessments
Bedside Assessment of Postural Control	P = 0.008*
Dynamic Visual Acuity Test	P = 0.012*
Head Shake	P= 0.18
Vertebral Artery	P = 0.981
INTERPRETATION	
Bedside Assessment of Postural Control	P = 0.008*
Dynamic Visual Acuity Test	P = 0.029*
Head Shake	P = 0.079
Vertebral Artery	P = 0.165

Note. An * indicates statistical significance.

High-tech vestibular assessments.

The last group of questions on the assessment section of the survey focused specifically on high tech tests. The participants were asked to provide information about the types of high tech equipment they had available to them, high tech assessments they use, and comfort levels in administering and interpreting the data from four commonly used high tech assessments.

The first question was in regard to the types of high tech equipment that was available to each participant (Question 12 in Appendix A). There were a total of 329 individuals that answered this question, yielding a 98.5% response rate. Participants were asked to mark all pieces of equipment that applied to their work situation. The majority of individuals (n=320; 97.26%) indicated that they had access to an air/water caloric irrigator. Other responses that received response rates of approximately 70 to 80% included: Immittance Bridge, light bar, infrared goggles, and electrode equipment as seen in Figure 26 below. As expected only a small percentage of respondents had access to computerized dynamic posturography (21.88%) and rotary chair systems (16.11%), likely due in part to the cost of this equipment.

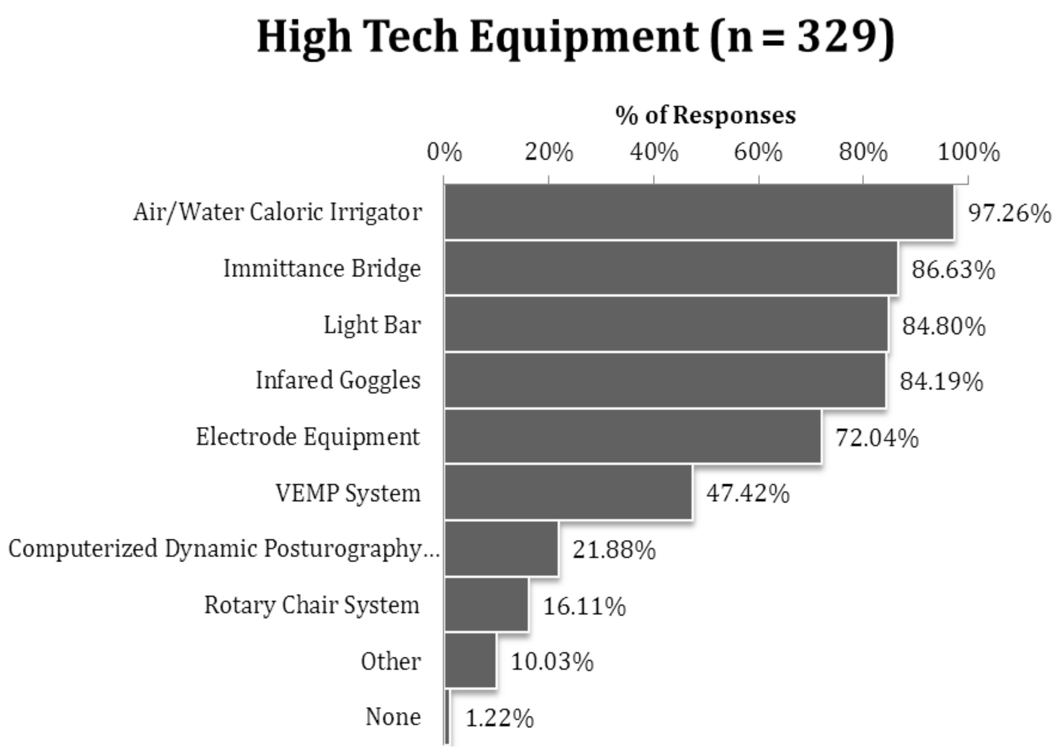

Figure 26. High-tech equipment that is reported to be available at participants' worksites. Percentages are calculated based on the total number of responses (n=329). VEMP= Vestibular Evoked Myogenic Potential.

Participants were asked to provide information on which high tech assessments they typically use. The options were: “ENG/VNG”, “Rotary Chair”, “Computerized Dynamic Posturography”, and “Vestibular Evoked Myogenic Potential (VEMP)” (Question 23 in Appendix A). The participants were able to mark all tests that they used. The vast majority of individuals (n=319; 99.38%) responded “ENG/VNG” to this question. The second most common test reported was the VEMP with 38.94% (n=125) of the participants indicating that they use this high tech assessment. A summary of the response rates to the other assessments on this question can be found in the Figure 27, below.

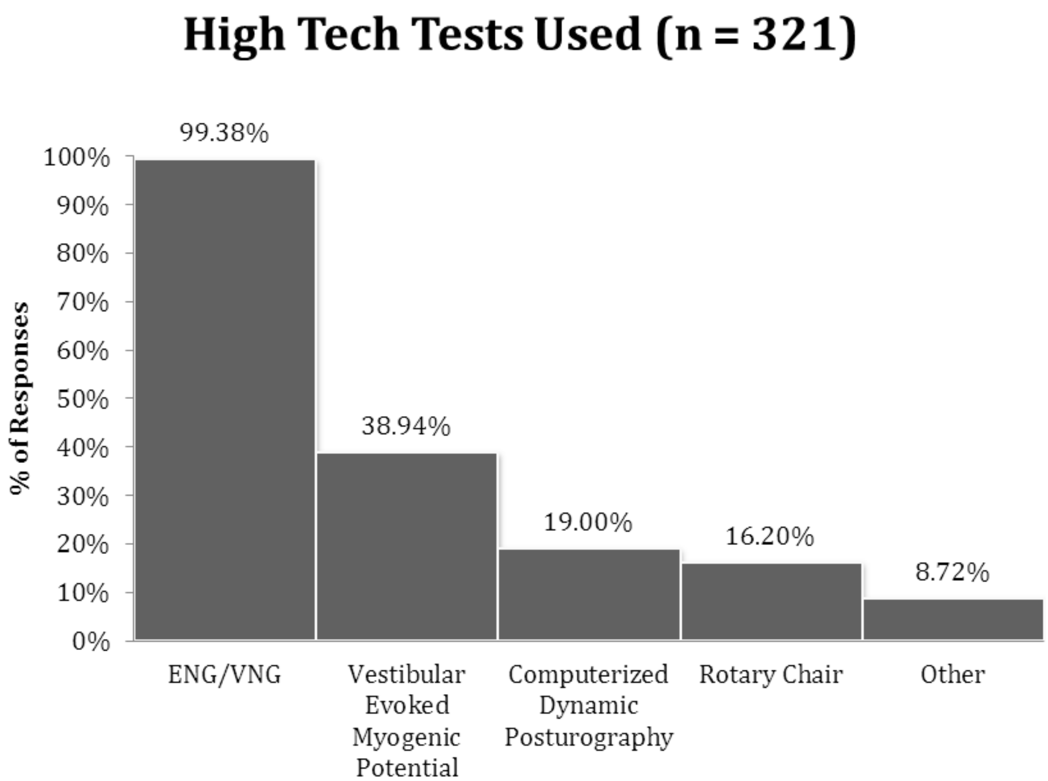

Figure 27. Distribution of various high-tech vestibular assessments that are being used clinically. Percentages are calculated based on the total number of responses (n=321). ENG/VNG= Electronystagmography/Vidonystagmography.

Similar to the low-tech assessments, the participants were asked to rate their comfort levels in administering and interpreting four high tech assessments employing the same rating scale (Questions 24-31 in Appendix A).

Table 6 displays a summary of the participants' comfort levels related to the administration of these four high-tech vestibular assessments. For each high-tech assessment the actual number of respondents for each of the comfort level categories, as well as the number of respondents who checked "N/A" for these questions, is provided. Also, the percentage of respondents who reported each of these comfort level categories is displayed for each high-tech assessment procedure.

There are several interesting patterns that were apparent from these results. First, participants were clearly more comfortable in administering the ENG/VNG assessment over any other high-tech procedure. This is supported by the high response rate to the question (97.3%) as well as the fact that 92% of respondents reported feeling "very comfortable" in the administration of the ENG/VNG. A second interesting finding was the extremely large "N/A" rates for the Computerized Dynamic Posturography, Rotary Chair, and VEMP assessments (~ 35%-58%). This finding suggests that only a half to two-thirds of the respondents were even attempting to perform these types of evaluations. It is also important to note that the participants' comfort levels were more evenly distributed between "very comfortable" and "comfortable" in relation to the administration of VEMP testing than any other high-tech assessment that was evaluated. Lastly, there were very a very small number of participants (less than 10%) who indicated feeling uncomfortable administering any of these four high-tech assessment procedures.

Table 6.

Summary of participants' comfort levels related to the administration of four high-tech vestibular assessment procedures.

	VC		C		U		VU		N/A		Total
Administration	N	%	N	%	N	%	N	%	N	%	N
ENG/VNG	**299**	**92% (92.28%)**	25	7.69% (7.72%)	0	0% (0%)	0	0% (0%)	1	0.30%	325
Computerized Dynamic Posturography	**70**	**23.73% (52.24%)**	27	9.15% (20.15%)	20	6.78% (14.93%)	17	5.76% (12.69%)	161	54.58%	295
Rotary Chair	**56**	**18.98% (45.53%)**	28	9.49% (22.76%)	22	7.46% (17.89%)	17	5.76% (13.82%)	172	58.31%	295
VEMP	**86**	**28.38% (44.33%)**	63	20.79% (32.47%)	30	9.90% (15.46%)	15	4.95% (7.73%)	109	35.97%	303

Note. The four specific low-tech assessments that were evaluated in the survey were ENG/VNG, Computerized Dynamic Posturography, Rotary Chair, and VEMP tests. The actual numbers of responses for each comfort level category are reported, as well as the percentage based on the total number of responses for that low-tech assessment. The values in parentheses are percentages calculated from the total of only the VC, C, U, and VU ratings. For each of these low-tech assessments the comfort level category with the largest number of responses has been bolded. VC= Very Comfortable, C= Comfortable, U= Uncomfortable, VU= Very Uncomfortable, N/A= Not Applicable. ENG/VNG = Electronystagmography/Videonystagmography, VEMP = Vestibular Evoked Myogenic Potential.

Table 7 shows the same information as discussed for Table 6, but the comfort level categories are related to the interpretation of the findings for each high-tech assessment procedure. A few interesting patterns were noted from the responses to these questions. First, approximately 75%-98% of the participants who reported a comfort level (i.e. “very comfortable”, “comfortable”, “uncomfortable”, and “very uncomfortable”) noted feeling at least “comfortable” in correctly interpreting the data from these four high-tech assessments. In contrast to the administration results discussed from Table 4, here there was generally a more even distribution of responses across the “very comfortable” and “comfortable” comfort level categories for each of the four low-tech assessments. Although participants were still clearly more comfortable in interpreting ENG/VNG results given the high “very comfortable” rate. Like the data in Table 6, these results indicated the vast majority of participants felt at least comfortable interpreting these low-tech assessments, given the extremely low response rates in the comfort level categories of “uncomfortable” and “very uncomfortable” (less than 8.7%). Again, it should be noted that there were a significant amount of respondents who noted “N/A” in response to interpreting each of these high-tech assessment procedures (~34%-58%).The exception to this is the extremely low “N/A” rate associated with the ENG/VNG test protocol (0.63%).

Table 7.

Summary of participants' comfort levels related to the interpretation of four high-tech vestibular assessment procedures.

	VC		C		U		VU		N/A		Total
Interpretation	N	%	N	%	N	%	N	%	N	%	N
ENG/VNG	**255**	**79.94% (80.44%)**	58	18.18% (18.30%)	4	1.25% (1.26%)	0	0% (0%)	2	0.63%	319
Computerized Dynamic Posturography	**68**	**23.37% (50.00%)**	38	13.06% (27.94%)	17	5.84% (12.50%)	13	4.47% (9.56%)	155	53.26%	291
Rotary Chair	**55**	**18.90% (44.72%)**	35	12.03% (28.46%)	17	5.54% (13.82%)	16	5.50% (13.00%)	168	57.73%	291
VEMP	**79**	**26.42% (40.53%)**	69	23.08% (35.38%)	26	8.70% (13.33%)	21	7.02% (10.77%)	104	34.78%	299

Note. The four specific low-tech assessments that were evaluated in the survey were ENG/VNG, Computerized Dynamic Posturography, Rotary Chair, and VEMP tests. The actual numbers of responses for each comfort level category are reported, as well as the percentage based on the total number of responses for that low-tech assessment. The values in parentheses are percentages calculated from the total of only the VC, C, U, and VU ratings. For each of these low-tech assessments the comfort level category with the largest number of responses has been bolded. VC= Very Comfortable, C= Comfortable, U= Uncomfortable, VU= Very Uncomfortable, N/A= Not Applicable. ENG/VNG = Electronystagmography/Videonystagmography, VEMP = Vestibular Evoked Myogenic Potential.

Similar to the analyses conducted on the low-tech assessments described above, a series (n=8) of Kruskal–Wallis one-way ANOVAs were conducted to determine if there was a significant difference in the participants' mean comfort level categories in administering and interpreting four high-tech assessments as a function of their highest level of education. Again, the three levels analyzed for the participant level of education were: (1) Master's Degree (2) Clinical Doctorate (e.g., Au.D.) and (3) Research Doctorate (e.g., Ph.D.). The same comfort level categories were used for all the ANOVAs, which were: "very comfortable", "comfortable", "uncomfortable", and "very uncomfortable". These series of one-way ANOVAs were completed independently for each high-tech test. Of these eight ANOVAs, four were completed on participants' comfort levels in administering the four high-tech assessments. The remaining four ANOVAs were completed on the participants' comfort levels in interpreting these four high-tech assessments. The alpha level used to indicate significance for all ANOVAs was $p \leq 0.05$. Consistent with the analyses of the low-tech procedures, if a significant main effect was obtained, additional *post hoc* Mann-Whitney U tests were completed to investigate the pattern of those effects. The Bonferroni-corrected p value for these *post hoc* analyses was $p \leq 0.0167$ (0.05/3).

The results of the Kruskal-Wallis ANOVAs for the participants' comfort levels in administering the four high-tech assessment procedures as a function of their highest level of education are summarized in top portion of Table 8. There were significant main effects of educational level on the participants' comfort levels in administering two high-tech procedures. The first main effect was seen in the administration of the computerized dynamic posturography assessment ($p = 0.008$). To evaluate the pattern of this main effect, *post hoc* U tests were conducted. These results indicated that there was a significant difference in the mean comfort levels of participants in the “Master’s degree” and “clinical doctorate” groups ($p = 0.012$). When investigated further, it appears that approximately 93% of the participants in the “master’s degree” group reported feeling at least “comfortable” in the administration of CDP in contrast to ~67% of the participants with a “clinical doctorate” who reported similar comfort level rating for this test. Again, these results should be interpreted with caution due to the unequal distribution of subjects in these two educational categories (i.e., 259 in the clinical doctorate group and 55 in the Master’s degree group). There was also a significant main effect of educational level on the participants’ mean comfort levels for the administration of the rotary chair test ($p = 0.020$). *Post hoc* measures revealed that there were no significant differences in the mean comfort levels for administering the rotary chair test across these three educational groups. The lack of a significant effect for these post hoc analyses was likely due to the use of a more strict alpha level of $p \leq 0.0167$ which was applied to these analyses.

The next set of ANOVAs evaluated the participants’ mean comfort levels in the interpretation of these four high-tech assessments as a function of their level of education. A summary of these ANOVAs can be seen in the bottom portion of Table 8. There were significant main effects were only found in relation to the interpretation of the CDP and rotary chair tests ($p = 0.008$ and $p = 0.021$, respectively). The pattern of these main effects was evaluated further by several *post hoc* Mann-Whitney U tests. However, it was revealed that level of education did not have a significant effect on the participants' comfort levels in interpreting these two high-tech assessments at this more conservative alpha level.

Table 8.

Summary of the results of a series of Kruskal-Wallis one-way ANOVAs related to participants' mean comfort levels in the administration and interpretation of four high-tech assessments as a function of their highest level of education.

ADMINISTRATION	Highest Level of Education
ENG/VNG	P = 0.993
CDP	P = 0.008*
Rotary Chair	P= 0.020*
VEMP	P = 0.706
INTERPRETATION	
ENG/VNG	P = 0.147
CDP	P = 0.008*
Rotary Chair	P = 0.021*
VEMP	P = 0.6

Note. An * indicates statistical significance. ENG/VNG= Electronystagmography/Videonystagmography, CDP = computerized dynamic posturography, and VEMP= vestibular evoked myogenic potential.

Another series of Kruskal-Wallis one-way ANOVAs was conducted to determine if there were any significant differences in the participants' mean comfort level categories as a function of their years of experience conducting vestibular assessments. The results of these ANOVAs related to administering the four high-tech assessments are summarized in the top portion of Table 9. The results do not indicate significant main effects for the administration of any of the four high-tech assessments as all alpha levels are greater than the 0.05 significance level. This finding suggests that the participants' years of experience in conducting vestibular assessments had no direct effect on their comfort levels in administering any of these high-tech assessment procedures.

Similarly, the results of the next set of ANOVAs (seen in the bottom portion of Table 9) revealed that there were no significant main effects of the years of experience on the participants' comfort levels in interpreting three of these high-tech assessments. These assessments were: the CDP, the rotary chair, and the VEMP tests. However, a significant main effect on the participants' comfort level as a function of their years of experience conducting vestibular assessments was revealed in interpreting the ENG/VNG ($p = 0.003$). *Post hoc* Mann-Whitney U tests were conducted to determine the pattern of this main effect. The results of the *post hoc* U tests revealed a significant difference between the "0-5 years" and the "6-10 years" groups as well as between the "0-5 years" and "10+ years" groups ($p = 0.014$ and $p = 0.001$, respectively). It seems that years of experience conducting vestibular assessment has a direct impact on participants' mean comfort levels in correctly interpreting the ENG/VNG results. This is surmised because

96.34% of those who marked “0-5 years” reported feeling at "comfortable" or "very comfortable" compared with 99.3% and 100% of participants who were in the “6-10 years” and “10+ years” groups who reported the same comfort level ratings.

Table 9.

Summary of the results of a series of Kruskal-Wallis one-way ANOVAs related to participants' mean comfort levels in the administration and interpretation of four high-tech assessments as a function of their years of experience conducting vestibular assessments.

ADMINISTRATION	Years of Experience Conducting Vestibular Assessments
ENG/VNG	P = 0.186
CDP	P = 0.419
Rotary Chair	P= 0.350
VEMP	P = 0.126
INTERPRETATION	
ENG/VNG	P = 0.003*
CDP	P = 0.345
Rotary Chair	P = 0.183
VEMP	P = 0.331

Note. An * indicates statistical significance. ENG/VNG= Electronystagmography/Videonystagmography, CDP = computerized dynamic posturography, and VEMP= vestibular evoked myogenic potential.

Treatment

The final section of the survey consisted of several questions regarding vestibular treatment. Within the treatment section, there were questions related to the demographics of the respondents as well as questions related to their experience in providing vestibular treatments. The results from these two sections will be discussed in that sequence.

The demographic treatment questions addressed how long the individual had been performing vestibular treatment, the participants' formal education in vestibular treatment, how many vestibular treatment sessions the individual completed weekly, and what groups of professionals he/she believed to be qualified to perform vestibular treatment.

Each participant was asked to report how many years he or she had been performing vestibular treatment procedures, if at all (Question 4 in Appendix A). Three hundred thirty four individuals responded to this question, yielding a response rate of 100%. A surprising 29.64% of the participants (n=99) noted that they did not administer any type of vestibular treatment. Of the individuals who did report providing vestibular treatment, approximately 25% indicated that they had been administering these treatments for 0-5 years and a similar amount reported providing treatment for 6-10 years. There was only a small amount of individual (2.99%) who reported administering vestibular treatment for greater than 20 years. A summary of the response rates to each treatment category is shown in Figure 28 below.

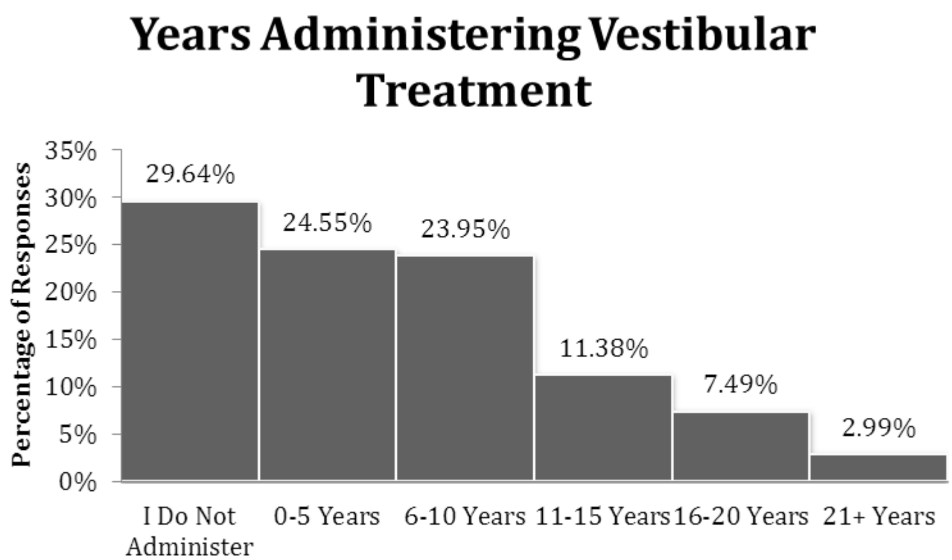

Figure 28. The number of years each participant reported to be involved in administering vestibular treatments. Percentages calculated from 334 total responses.

The participants were also asked what types of formal education they had received in the area of vestibular treatment (Question 6 in Appendix A). There were a total of 312 individuals who responded to this question for a response rate of 93.41%. Each participant was able to mark multiple answers. The vast majority of participants (n=245; 78.53%) noted that they had attended lecture course(s) in their degree program specifically related to vestibular treatment. Another 56.09% (n=175) reported attending a focused specialty-training course post-degree. The third most common response was "hands-on lab" with 41.67% (n=144) participants choosing this option. An interesting finding for this question was only about one third of the respondents received education regarding vestibular treatments in their clinical rotations or had direct supervised training in this area. Figure 29 summarizes the response rate for each of these options.

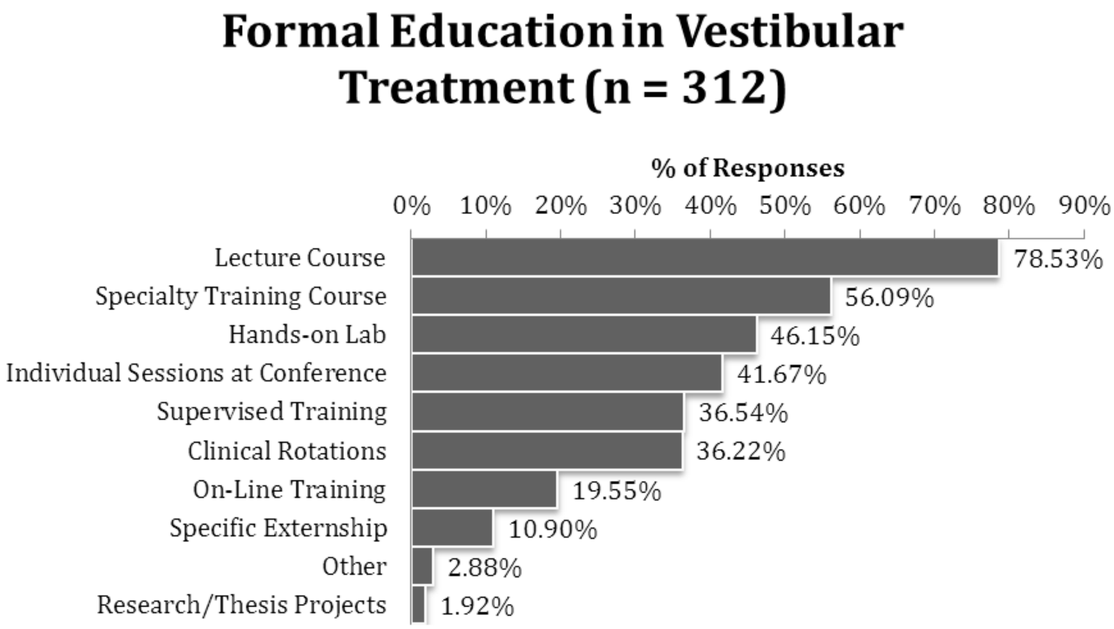

Figure 29. Types of formal education participants have completed related to vestibular assessment. Percentages calculated from 312 total responses.

Another question within the demographics section of the survey asked the participants how many vestibular treatment sessions they provide on a weekly basis. This question was divided into two parts, one portion dealing with the canalith repositioning maneuvers and the section portion dealing with vestibular rehabilitation therapy (Questions 32 and 33 in Appendix A). There were 312 individuals who responded to the question regarding canalith repositioning maneuvers, yielding a response rate of 93.41%. The majority of participants (n=101; 32.27%) responded “1-2” to this question. It should be noted that there were a significant number (n=95; 30.45%) of participants that reported “N/A”. A summary of response rates of each value category is presented in the Figure 30, below.

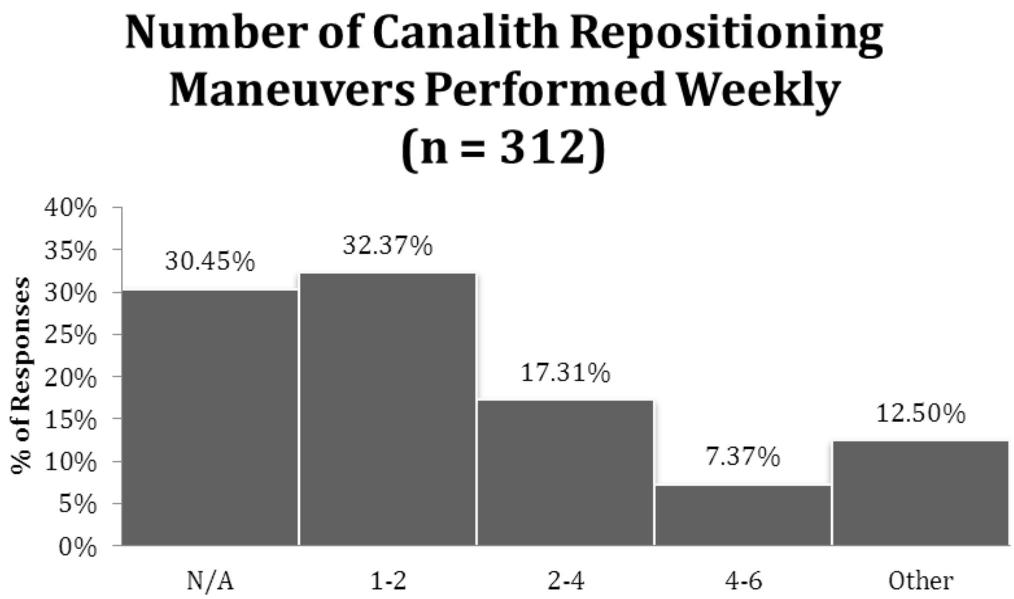

Figure 30. The number of times per week each participant reported performing canalith repositioning maneuvers. Percentages calculated from 312 total responses.

The second part to this question involved the number of vestibular rehabilitation therapy sessions performed weekly, as seen in Figure 31. By far the most common response was “N/A” with 234 individuals (79.86%) selecting this option. Of the individuals who noted performing any amount of VRT sessions 26 individuals (8.87%) reported providing “1-2” sessions weekly.

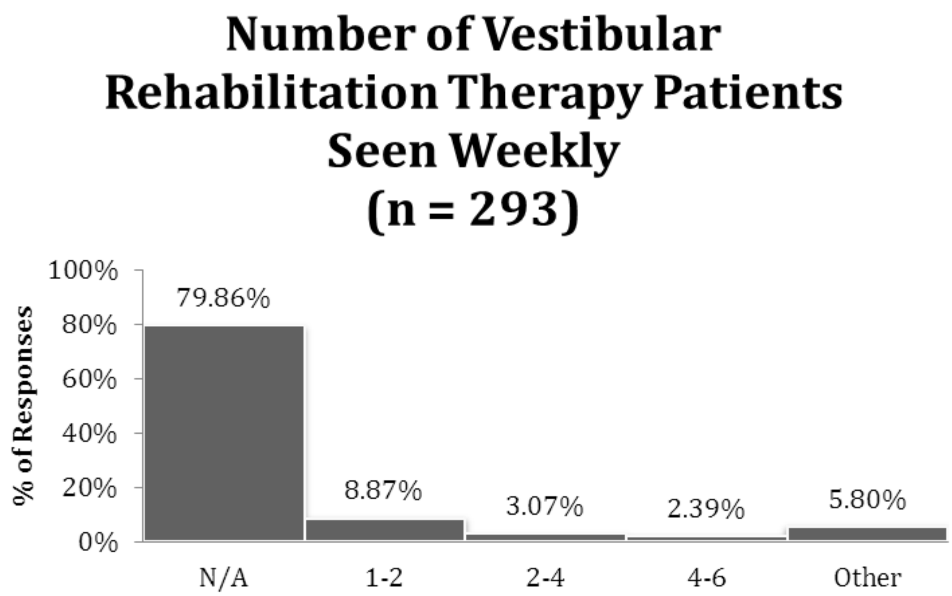

Figure 31. The number of times per week each participant reported providing a vestibular rehabilitation therapy session. Percentages calculated from 293 total responses.

The last question in this section of the survey addressed which groups of professionals the participants believed were qualified to perform vestibular treatment procedures (Question 34 in Appendix A). Three hundred twenty individuals responded to this question yielding a response rate of 95.81%. Participants were able to choose multiple answers to this question. The distribution of these responses is shown in Figure 32 below. The majority of participants (n=289; 90.31%) selected “Audiologist” as the professional group as being most qualified to perform vestibular treatment. A close second was “Physical Therapist” who were selected by nearly the same amount of participants (n=286; 89.38%). Other commonly selected groups were “Otolaryngologist” and “Otologist/Neurotologist” with 46.56% (n=149) and 44.38% (n=142) of participants, respectively. Similar to the responses for the question related to qualifications for administering vestibular assessments, very few participants (< 6%) believed that general physicians, nurses or hearing aid dispensers were qualified to administer vestibular treatment procedures.

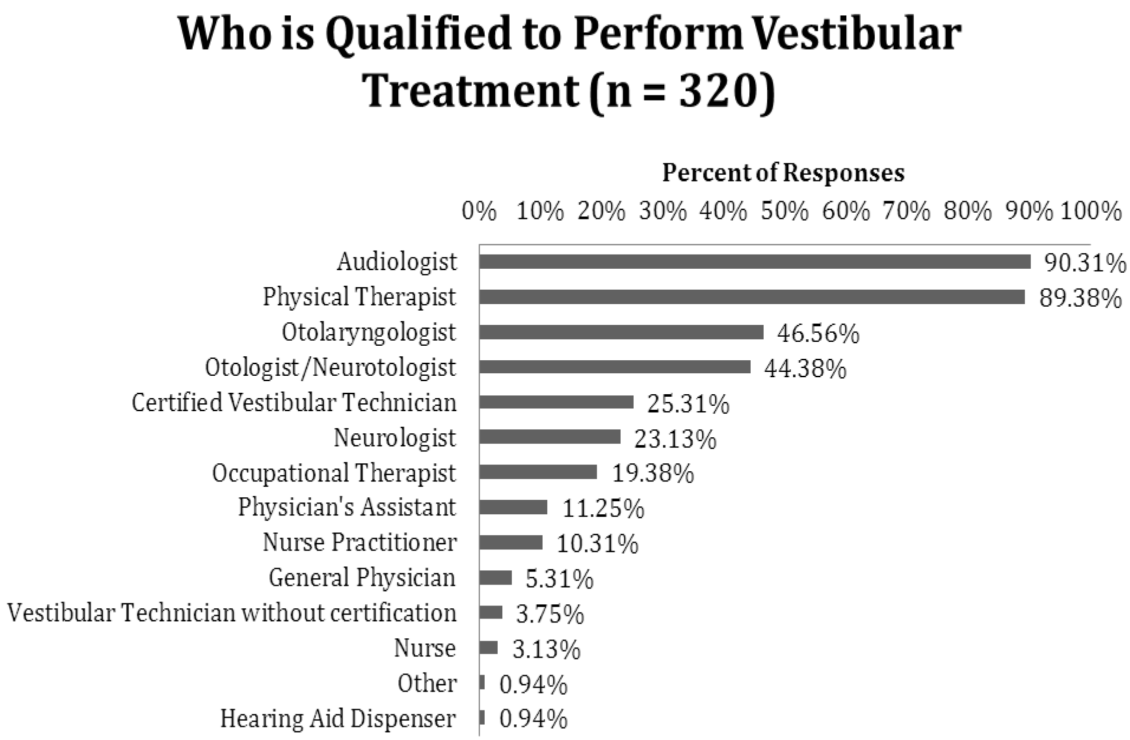

Figure 32. Distribution of participants' opinions in regard to professional groups qualified to perform vestibular treatment. Percentages are calculated from the total number of responses (n=320).

The last section of the survey addressed questions regarding whether vestibular treatment is available at each participants' workplace, who performs the treatment procedures, if they personally provide treatment, and what types of vestibular treatment are provided. This portion also included questions regarding the participants' reported comfort levels in administering three common types of vestibular treatment exercise.

The first question in this section addressed whether vestibular treatment was available at the participants workplace (Question 35 in Appendix A). Three hundred twenty nine individuals responded to this question for an overall response rate of 98.5%. Data from this question indicated that 76.9% (n=253) of participants had vestibular treatment available at their workplace. In contrast, 22.49% (n=74) reported that no vestibular treatment was given at their worksite. It should be noted that five individuals (1.52%) responded both "yes" and "no" to this question.

Those participants who answered yes to the question of whether vestibular treatment was available at his/her workplace were then asked who typically performs the treatment procedures (Question 36 in Appendix A). There were 267 individuals who responded to this question for an overall response rate of 79.94%. The vast majority of individuals (n=185; 69.29%) responded "Audiologist" to this question. "Physical Therapist" was the second most common response to this question with 93 individuals (34.83%) choosing this option. Another 22.1% (n=59) of the participants indicated "Otolaryngologist" was the typical vestibular treatment provider in his/her practice. A summary of response rates to all categories of professionals is listed in Figure 33 below.

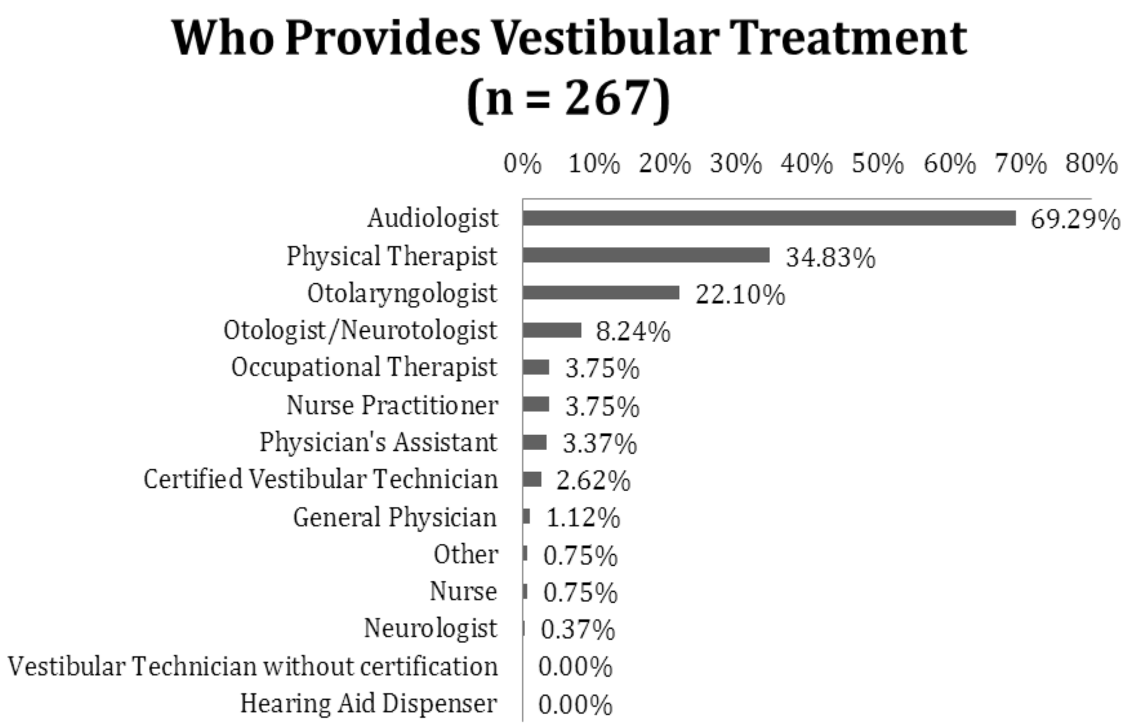

Figure 33. Distribution of participants' experience in regard to which professional within their practice typically provides vestibular treatment. Percentages are calculated from the total number of responses (n=267).

The participants were also asked whether they, personally, provided vestibular treatment procedures or not (Question 37 in Appendix A). A total of 323 individuals responded to this question yielding a response rate of 96.71%. The majority of participants (n=149; 46.13%) noted that they do provide vestibular treatment services. Other common responses were "No, but I refer to another center" with 20.74% (n=67) and "No, but I refer in the same facility" with 19.81% (n=64) of the participants selecting these options, respectively. A summary of the response rates to other categories is given in Figure 34 below.

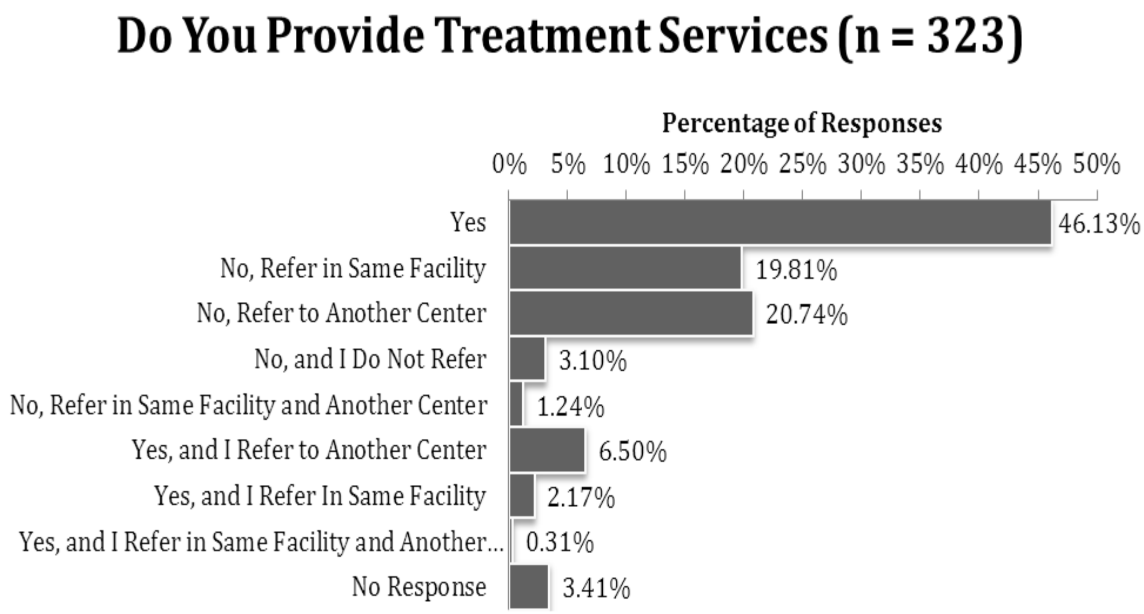

Figure 34. Distribution of who provides or is referred to for vestibular treatment. Percentages are calculated from the total number of responses (n=323).

The participants were then asked to provide information regarding the types of vestibular treatment procedures they offer (Question 38 in Appendix A). There were 317 individuals who responded to this question for a response rate of 94.91%. Most of the respondents (n=264; 83.28%) indicated that they performed canalith repositioning maneuvers. Other common responses were “Brandt-Daroff Exercises” with 44.48% (n=141) and “Vestibular Rehabilitation Therapy” with 27.76% (n=88) of participants selecting these treatment options. A summary of the response rates to this question can be found in Figure 35 below.

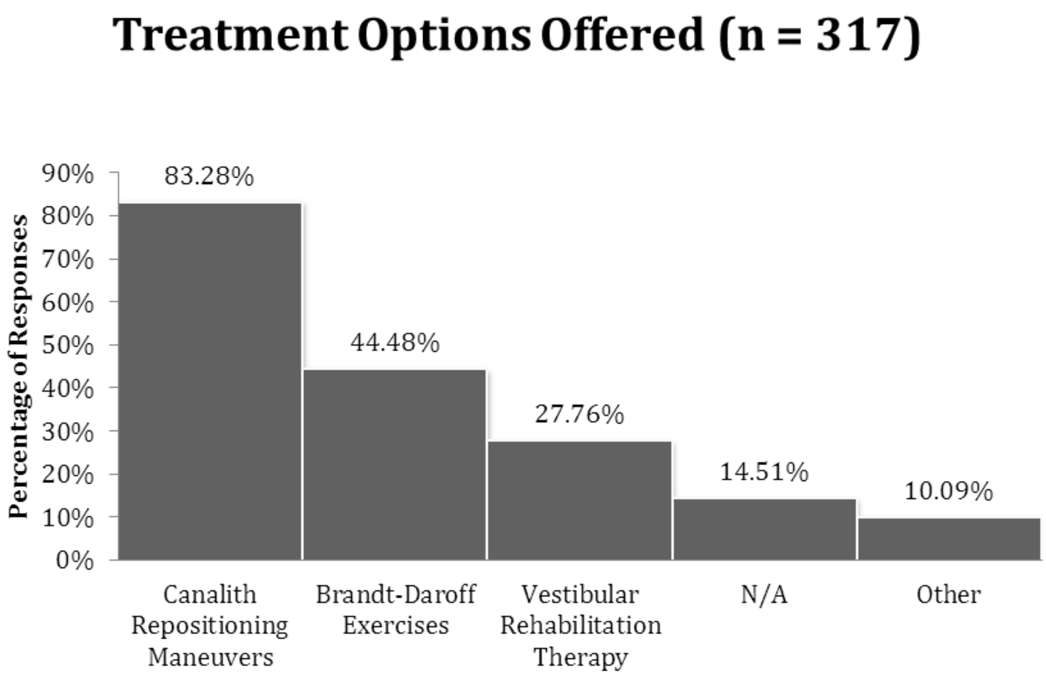

Figure 35. Distribution of various treatment procedures that are being used clinically. Percentages are calculated based on the total number of responses (n=317).

The last set of questions on the survey asked the participants' comfort levels in administering three specific types of treatment procedures. These procedures were vestibular rehabilitation therapy, Brandt-Daroff exercises, and canalith repositioning maneuvers. For each of these treatment procedures the participants rated their comfort levels as very comfortable, comfortable, uncomfortable, very uncomfortable, or not applicable. Table 10, below, shows the number of responses and the corresponding percentage for each question of comfort (which was calculated by the response number divided by the total of responses for that question). These descriptive statistics (number and percentage values) were calculated for each comfort level across all three treatment procedures. The most commonly reported comfort level for each procedure is indicated by bold type. Responses to the questions regarding the comfort levels in administering these treatment procedures revealed that of the respondents who indicated a comfort level the majority felt at least "comfortable" performing vestibular rehabilitation therapy, Brandt-Daroff exercises, and canalith repositioning maneuvers. Of these procedures canalith repositioning maneuvers had the largest difference between reported comfort levels with 62.09% (n=190) of the participants indicating "very comfortable" as their response. The distribution of responses was more even between "very comfortable" and "comfortable" in regard to vestibular rehabilitation therapy and Brandt-Daroff exercises. Again, it should be noted that the "N/A" rate to these questions reached from ~17%-53% of the sample population. Individual comments indicated that these results might have been affected by other professionals (Physical therapists and/or Ear, Nose, and Throat physicians) completing these procedures or reimbursement issues related to audiologists.

Table 10.

Summary of participants’ comfort levels related to providing vestibular treatments.

	VC		C		U		VU		N/A		Total
Administration	N	%	N	%	N	%	N	%	N	%	N
Vestibular Rehabilitation Therapy	**40**	**13.65% (28.78%)**	**40**	**13.65% (28.78%)**	38	12.97% (27.34%)	21	7.17% (15.12%)	154	52.56%	293
Brandt-Daroff Exercises	**87**	**29.19% (47.54%)**	70	23.49% (38.25%)	21	7.05% (11.48%)	5	1.68% (2.73%)	115	38.59%	298
Canalith Repositioning Maneuvers	**190**	**62.09% (75.40%)**	50	16.34% (19.84%)	10	3.27% (3.97%)	2	0.65% (0.79%)	54	17.65%	306

Note. The three specific treatment procedures that were evaluated in the survey were Vestibular Rehabilitation Therapy, Brandt-Daroff Exercises, and Canalith Repositioning Maneuvers. The actual numbers of responses for each comfort level category are reported, as well as the percentage based on the total number of responses for that low-tech assessment. The values in parentheses are percentages calculated from the total of only the VC, C, U, and VU ratings. For each of these low-tech assessments the comfort level category with the largest number of responses has been bolded. VC= Very Comfortable, C= Comfortable, U= Uncomfortable, VU= Very Uncomfortable, N/A= Not Applicable

The comfort levels performing the above treatment procedures were analyzed in a similar fashion as the comfort levels administering and interpreting the assessments described above. A series of Kruskal–Wallis one-way ANOVAs were conducted to determine if there was a significant difference in the participants' mean comfort levels in providing three vestibular treatment procedures as a function of the participant's highest level of education. These three procedures were: (1) vestibular rehabilitation therapy, (2) Brandt-Daroff exercises, and (3) canalith repositioning maneuvers. An alpha level of $p \leq .05$ was used to indicate significance. Again, if a significant effect was obtained additional *post hoc* Mann-Whitney U tests were completed, as needed. Again, the alpha level used for the *post hoc* Mann-Whitney U tests was adjusted to a Bonferroni-corrected value of $p \leq .0167$ (0.05/3). As seen in Table 11 below, the results of these ANOVAs indicated that there were no significant main effects on participants' mean comfort levels as a function of their highest education level (i.e. Master's degree, clinical doctorate, or research doctorate),

Table 11.

Summary of the results of a series of Kruskal-Wallis one-way ANOVAs related to participants' mean comfort levels in providing three vestibular treatment procedures as a function of their highest level of education.

ADMINISTRATION	Highest Level of Education
Vestibular Rehabilitation Therapy	P = 0.072
Brandt-Daroff Exercises	P = 0.065
Canalith Repositioning Maneuvers	P= 0.066

Note. An * indicates statistical significance.

A final series of Kruskal-Wallis one-way ANOVAs was completed to determine if there were any significant differences in the participants' mean comfort levels as a function of their years of experience providing vestibular treatment procedures. The results of these ANOVAs can be seen in Table 12 below. These findings revealed a significant main effect of years of experience on the participants' mean comfort levels in providing vestibular rehabilitation therapy (p=0.013). When *post hoc* Mann-Whitney U tests were calculated a significant difference was found between the "0-5 years" and "10+ years" groups (p=0.003). Further investigation regarding this finding revealed that more individuals with 10 or more years of experience felt at least "comfortable" providing this type of treatment exercise than individuals with fewer years of experience that reported similar comfort levels. There were no significant main effects of years of experience conducting vestibular treatments on the other two treatment options (i.e., Brandt-Daroff exercises and canalith repositioning maneuvers).

Table 12.

Summary of the results of a series of Kruskal-Wallis one-way ANOVAs related to participants' mean comfort levels in providing three vestibular treatment procedures as a function of their years of experience conducting vestibular assessments.

ADMINISTRATION	Years of Experience Providing Vestibular Treatments
Vestibular Rehabilitation Therapy	P = 0.013*
Brandt-Daroff Exercises	P = 0.148
Canalith Repositioning Maneuvers	P= 0.485

Note. An * indicates statistical significance.

Chapter 5

Discussion

A survey titled "A Survey of Audiologists' Clinical Practices in the Assessment and Management of Adults with Vestibular Pathologies and their Education and Training in These Areas" was mailed to 900 audiologists who listed vestibular interests on their AAA membership profile. Of these 900 surveys, 334 were returned (both online and in print). As expected, approximately two-thirds of the responses were obtained from female audiologists with the remaining one-third being submitted by male participants. Each participant was asked several questions which were specifically related to their formal education, work experience, vestibular procedures they typically provide, and comfort levels in completing these various types of vestibular procedures. There were several major goals of this study that merit restating. These goals were:

- To obtain information regarding the audiologists' education and training in both the diagnosis and management of individuals with vestibular pathologies.
- To investigate the level of comfort experienced by practitioners in administering and interpreting the data from assessment procedures as well as performing the treatment exercises for individuals with vestibular pathologies as a function of their highest level of education.
- To investigate the level of comfort experienced by practitioners in administering and interpreting the data from assessment procedures as well as

performing the treatment exercises for individuals with vestibular pathologies as a function of their years of experience in conducting vestibular assessments and treatments.

- To obtain more information regarding the current low tech and high tech assessment procedures as well as vestibular treatment procedures being used regularly in audiology practices.

These goals will be addressed in the various sections of the discussion. First, the potential effects of educational level will be covered in terms of its effect on participants' comfort levels in the assessment of vestibular disorders, followed by its impact on participants' responses to various vestibular treatment questions. Second, the effect of years of clinical experience in conducting vestibular procedures (assessment and treatment) on participants' comfort levels will be evaluated. Third, a summary of current practices and potential clinical and educational implications will be discussed. Lastly, the limitations of this current study and recommendations for further research in this area will be presented.

Education Level

There were 334 individuals who responded to this survey. Of these respondents, the vast majority, ~77%, reported having earned a clinical doctorate degree (e.g., an Au.D). Approximately 16% of the participants reported having earned a Master's degree and ~5% reported earning a research doctorate degree (e.g., a Ph.D. in hearing science). A direct question was included regarding the various types of formal education that a participant had received in vestibular assessment, in an attempt to clarify the type and extent of their education in this area. The respondents were instructed that they could check all of the options that applied to their type of education in this area. The results of this question indicated that approximately 93% of the participants successfully completed a vestibular lecture course within their degree program. Seventy percent of the survey respondents reported attending a focused specialty training course at a vestibular conference after completion of their degree program. A similar number of respondents (67.28%) reported that they had a hands-on lab related to vestibular assessment within their degree program. Roughly half of the respondents reported access to vestibular clinical rotations, individual vestibular sessions at a conference, and supervised training in vestibular topics at their worksite. It should be noted that several of these education options were pursued after the participant had successfully completed their degree program in audiology (i.e., online training, sessions at conferences, etc.). These findings reveal that the majority, at least ~93%, of the survey respondents had access to some form of formal education on vestibular topics. Because participants were asked to check all the options that applied, it is difficult to determine the proportion of the participants who selected multiple options. It is assumed that some participants likely selected more than one educational option. Lastly, it is important to note when reviewing the responses to this question, that the survey participants were all AAA members who listed vestibular topics as areas of interest or specialty. It is highly likely that this group of audiologists, in particular, have pursued a greater number of types of formal education in the vestibular area in comparison to the general population of audiologists, who may have a variety of areas of interest and/or specialty.

As previously stated, a major goal of this study was to evaluate the participants' comfort levels in administering and interpreting various vestibular assessments as a function of their education level, which was based on the highest degree they had earned (i.e., Master's degree, Au.D., or Ph.D.). First, the survey results related to the participants' comfort levels in administering and interpreting low-tech assessments, as a function of their highest level of education will be discussed. This will be followed by a discussion of the influence, if any, of their highest level of education on their comfort levels in administering and interpreting high-tech assessment procedures.

Low-tech assessments.

There were several patterns revealed in the data obtained from questions related to the participants' comfort levels administering and interpreting the four low-tech assessment procedures evaluated in this study. These procedures were: the bedside assessment of postural control, the DVAT, the head shake test, and the vertebral artery test. It is important to note the pattern of results discussed below were consistent across the responses to the questions regarding both the assessment and interpretation of these four low-tech assessment procedures. First, the majority of participants reported feeling comfortable or very comfortable in both the administration and interpretation of these low-tech assessment procedures. The percent of individuals who marked "comfortable" or "very comfortable" ranged from ~48%-74% across all of the low-tech assessments. The second finding was that there was a relatively low number of individuals (~5%-17%) who reported feeling "uncomfortable" or "very uncomfortable" in the assessment and/or interpretation of these low-tech procedures. Third, there were relatively large "N/A" rates (~19%-35%) in both the assessment and interpretation of these assessment procedures. The current investigators speculated that participants' who responded with "N/A" to any low-tech assessment questions were likely not completing that specific procedure. If this assumption is correct, it appears that those participants who are conducting these four low-tech assessment procedures generally feel very comfortable in their administration and interpretation. It may be that participants who completed the survey were performing other types of low-tech assessments, which were not addressed in the current survey.

Next, in order to determine whether the participants' highest level of education in audiology had a significant influence on their comfort levels in administering and interpreting these four low-tech assessment procedures a series of one way ANOVAs were calculated. The results of a series of one way ANOVAs revealed that the participants' highest level of education in audiology did not have a significant influence on their comfort level in administering any of the four low tech assessment procedures. In contrast, the participants' highest level of education only had a significant effect on the participants' mean comfort levels in interpreting the bedside assessment of postural control (i.e., the Gan's SOP/CTSIB). *Post hoc* analyses, using the Mann-Whitney U tests, were conducted to investigate the patterns of this main effect for the bedside assessment of postural control. These results revealed that there were significantly more participants with a "research doctorate" who reported comfort level ratings of "comfortable" or "very comfortable" in interpreting this procedure in comparison to participants who earned a "clinical doctorate" degree that reported similar comfort levels. This finding should be interpreted with caution, however, as there was a considerably uneven distribution of subjects between these groups.

Overall these findings suggest that the participants' highest level of education in audiology had only a minimal impact on their self-reported comfort levels in either administering or interpreting these four low-tech vestibular assessment procedures. The only exception to this pattern was in the interpretation of the bedside assessment of postural control. Perhaps some other variable, such as the participants' years of clinical experience in administering/interpreting these low-tech assessments, is a more accurate predictor of their comfort levels in providing these assessments. This issue, as well as other potential variables, such as the frequency of administering this type of evaluation, is addressed later in this discussion.

High-tech assessments.

The data obtained from the comfort level questions related to the high-tech assessments also revealed several interesting patterns. Of ~320 respondents, 99% of them reported feeling either "very comfortable" or "comfortable" administering and interpreting the ENG/VNG test battery. Second, of approximately 300 participants who responded to the other three high-tech assessment questions, only approximately 50% reported feeling "very comfortable" or "comfortable" in administering and interpreting the VEMP. Of these

300 respondents, again only ~25%-30% reported feeling “very comfortable” or “comfortable" in administering and interpreting the CDP and rotary chair tests. An additional interesting pattern evident in this data was that there were considerably higher percentages of “N/A” rates for the high tech versus low-tech procedures. The “N/A” response rates were ~55% for the CDP and rotary chair assessments and ~35% for the VEMP in comparison to “N/A” rates of ~ 20% for the administration of the various low-tech procedures. These overall findings suggest that the respondents were clearly quite comfortable with the administration and interpretation of the ENG/VNG test. The lower comfort ratings for the other high-tech procedures as well as the high “N/A” rates could be due to a number of potential factors such as high equipment costs for certain types of high tech assessments (e.g., the CDP and rotary chair systems), the participants’ years of clinical experience, how consistently the participants performed any of these procedures, various worksite preferences, etc. These potential factors will be discussed more in-depth later in this section.

The participants’ comfort levels in the administration and interpretation of the four high-tech assessments as a function of their highest level of education in audiology were evaluated in a similar fashion as for the low-tech assessments. The results of the series of ANOVAs indicated that the participants’ level of education had a significant influence on their comfort level response for two of these high-tech procedures, which were the CDP and rotary chair tests. These significant main effects of education level were seen for both the administration and interpretation of these two high-tech procedures. A series of *Post* *hoc U* tests were conducted to investigate the pattern of these main effects for the administration and interpretation of the CDP and rotary chair tests. The results of the *post hoc* tests for the administration of the CDP and rotary chair tests are summarized first below, followed by the interpretation of these two high tech tests.

The results of these U-tests for the administration of the CDP revealed that 99.3% of the participants with a Master's degree reported feeling "very comfortable" or "comfortable" compared to ~67% of the participants with a clinical doctorate that reported similar comfort level ratings. This difference in comfort level rating between these subject groups reached statistical significance at the more strict alpha level of 0.0167. This finding could, in part, be related to the participants' years of clinical experience administering the CDP procedure. However, this issue was not directly evaluated in this study. Again, this current finding should be interpreted with caution due to the uneven number of individuals in each of the education level categories.

The results of the *post hoc* analyses for the administration of the rotary chair assessment indicated there were no significant differences in the mean comfort levels for administering this high-tech procedure across the three subject groups (i.e., Master's degree versus clinical doctorate; clinical doctorate versus research doctorate; Master's degree versus research doctorate). It is likely these post hoc comparisons did not reach statistical significance due to the stricter Bonferonni-corrected alpha level of $p \leq 0.0167$.

Lastly, the results of *post hoc* U-tests revealed that there were no significant differences in the comfort levels reported by participants in the interpretation of the CDP and rotary chair assessments across the three subject groups. The lack of significant effects across these three groups is likely due to our use of the more strict alpha level criteria of $p \leq 0.0167$ for the post hoc testing.

In agreement with the findings seen for the low-tech assessments, the participants' highest level of education had only a minimal impact on their self-reported comfort levels in either administering or interpreting these four high-tech assessments. The only exception to this pattern was seen in the administration of the CDP procedure. One possible issue that may have influenced participants' responses to these high-tech questions is the equipment cost for these high-tech tests. Much of the equipment necessary is highly sophisticated and quite expensive to acquire, especially the rotary chair and CDP systems. As previously mentioned, this factor may have resulted in the higher "N/A" rates for the high-tech versus low-tech questions.

Treatment.

The results of participants' mean comfort levels in providing various vestibular treatment techniques also showed some interesting patterns. First, out of approximately 300 participants, the majority (~80%) reported feeling either "very comfortable" or "comfortable" in providing the canalith repositioning maneuvers. This is in comparison to only ~50% of respondents for the Brandt-Daroff exercises and only ~27% for the VRT exercises who reported similar comfort levels for these two procedures. Second, there were very low response rates for the “uncomfortable” or “very uncomfortable” categories related to these repositioning maneuvers indicating that as a whole, the survey participants’ felt at least comfortable in providing these types of treatments. Another evident pattern was the relatively high “N/A” rates (~40-50%) on the Brandt-Daroff and VRT exercises. These high “N/A” rates seem to suggest that only about half of the respondents were actually providing these two types of treatment options to their patients. This finding may have been affected by insurance reimbursement issues associated with vestibular therapy being provided by audiologists. There were several comments made on the survey that suggested more audiologists would be open to providing these services, however other professionals within their workplace, such as physical therapists and/or ENTs were typically performing them due to these reimbursement policies.

A series of one-way ANOVAs were completed to determine if there were significant differences in participants’ mean comfort levels in providing/administering these vestibular treatment exercises as a function of their educational level. The results of these analyses revealed that there were no significant main effects for education level on the comfort levels regarding the administration of these three types of vestibular treatment procedures. This finding suggests that educational degree (i.e., Master’s degree, clinical doctorate, or research doctorate) has no direct impact on the comfort levels participants’ reported in administering these treatment procedures.

Years of Experience

A second major goal of this study was to evaluate the effects of years of clinical experience providing vestibular services on the participants' mean comfort levels in administering and interpreting various low-tech and high-tech vestibular assessments and their associated treatment procedures. In an attempt to get more information related to their work experience, participants' were asked to provide information about the number of years they had been providing these services, the type of worksite in which they practice, and the frequency of vestibular procedures they provide weekly. The majority of survey respondents reported working in an ENT setting at least part of their work week. Other common work settings were private practice and hospital/medical center/clinic settings. In this section, the effects of years of clinical experience in the assessment of vestibular disorders will be discussed first. These will be followed by the effects of experience treating these disorders.

The responses in regard to the participants' years of clinical experience were collapsed into three groups which were: 0-5 years, 6-10 years, and 10+ years of experience. The majority of the respondents (~45%) reported conducting vestibular assessments for 10 years or more, while the remaining participants were distributed fairly equally across the other two groups (i.e., ~26% in each group).

The majority of participants in this study reported that they typically administered 2-4 vestibular evaluations weekly, however, the responses to this question ranged from zero to more than 20. Nearly all the participants (92.83%) reported including an ENG/VNG test battery in their typical vestibular evaluations. Other common tests reported were the VEMP, EcochG, and variations of the Gan's SOP/CTSIB batteries.

As previously stated a goal of this study was to evaluate the participants' mean comfort levels administering and interpreting various vestibular assessments as well as providing several types of vestibular treatments as a function of their years of clinical experience in these areas. First, the survey results related to the low-tech assessments, as a function of the participants' years of experience will be discussed, followed by the effect of clinical experience on their comfort levels in administering and interpreting the high-tech assessment procedures. These will be followed by a discussion of the influence, if any, of the participants' years of clinical experience on providing various vestibular treatment procedures.

Low-tech assessments.

The effect of participants' years of experience on their mean comfort levels in administering the four low-tech assessments will be discussed first, followed by a description of the impact of this factor on their mean comfort levels in the interpretation of these same assessment procedures. Another series of one-way ANOVAs were calculated and the results of these analyses revealed significant main effects of comfort level for only the administration of the bedside assessment of postural control and the DVAT. Results of *post hoc* testing indicated approximately 87% of respondents in the "10+ years" group reported feeling “very comfortable” or “comfortable” in administering the bedside assessment of postural control compared to only ~70% of respondents in the group with “6-10 years” of clinical experience. This difference between these groups reached statistical significance. Similarly, results of *post hoc* testing for the administration of the DVAT revealed that approximately 80% of the participants’ who had ten or more years of clinical experience reported feeling “very comfortable” or “comfortable” as opposed to ~60% of participants who had “6-10 years” of clinical experience and listed the same comfort level categories for this test.

A similar pattern of findings was found for the influence of participants’ years of clinical experience on their mean comfort levels in the interpretation of the bedside assessment of postural control and the DVAT. For each of these tests, a significantly larger number of individuals in the group with “10+ years” of experience reported comfort levels of “very comfortable” or “comfortable” in comparison to a smaller number of participants in the group with “6-10 years” of experience who reported similar comfort levels.

Collectively, these *post hoc* results suggest that, as expected, the greater the number of years of clinical experience a participant reported, the more likely they were to report feeling comfortable or very comfortable in administering and interpreting these specific low-tech assessment procedures.

High-tech assessments.

A series of ANOVAs were then calculated to determine if there were any significant main effects of participants' mean comfort level categories in the administration and interpretation of these four high-tech assessments as a function of their years of clinical experience. The ANOVA results indicated that there were no significant main effects of years of clinical experience on the administration and interpretation of any of these high tech assessments. The only exception to this pattern was that a significant main effect was found in the interpretation of the ENG/VNG assessment. *Post hoc* results showed that, as expected, a significantly lower number of participants in the group with "0-5 years" of clinical experience reported comfort levels of "very comfortable" or "comfortable" in interpreting the ENG/VNG assessment in comparison to the larger number of participants in the "6-10 years" and the "10+ years" group who reported these same comfort level ratings.

Treatment.

The influence of the participants' years of clinical experience on their comfort levels in terms of providing three vestibular treatments were evaluated in a similar fashion as described above. Results of the ANOVAs revealed that participants' years of clinical experience only reached statistical significance for providing vestibular rehabilitation therapy. *Post hoc* results revealed a significant difference between the number of participants who reported "very comfortable" and "comfortable" to the administration of VRT in the "0-5 years" group versus the "10+ years" group. As expected, there was a higher number of individuals in the more experienced group. In contrast to the effects of participants' education levels, the current data suggests that the participants' years of clinical experience does have an impact on their self-reported comfort levels in administering and interpreting low-tech and high-tech assessment procedures as well as providing treatment procedures, such as VRT.

Potential Clinical and Educational Implications

One additional area that we investigated in this study was related to the number of participants who are conducting these specific low-tech and high-tech vestibular assessment procedures and vestibular treatment exercises as a part of their typical evaluations for patients with vestibular complaints. This information is summarized in Figure 36 below.

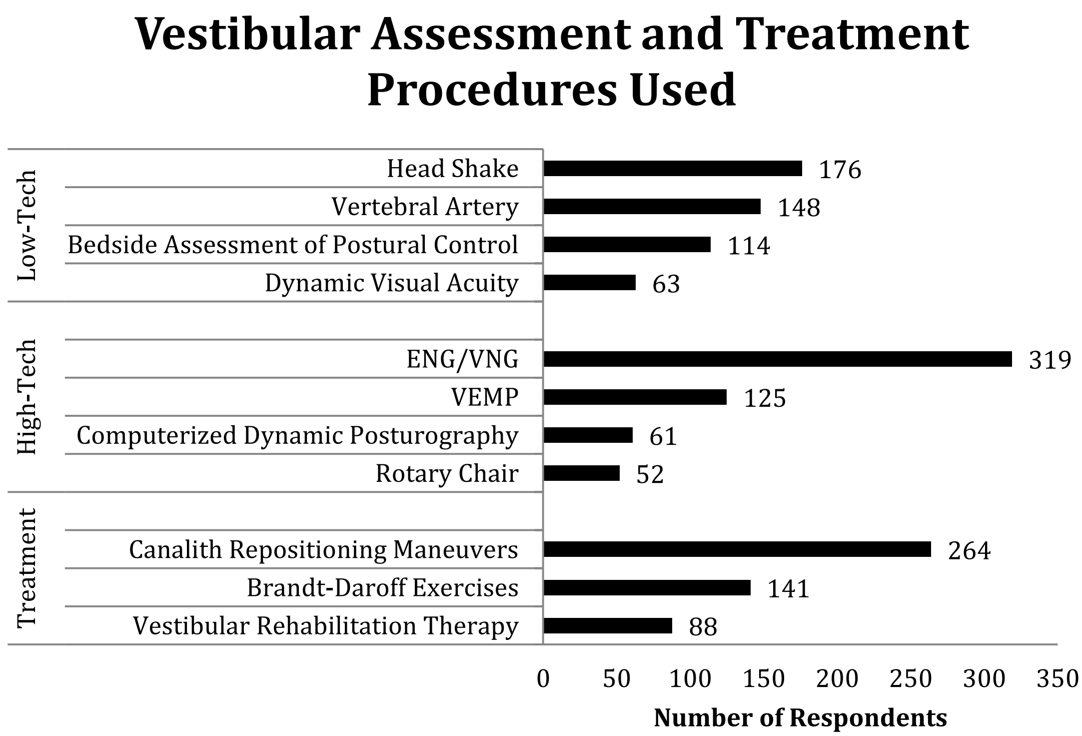

Figure 36. Distribution of vestibular assessment and treatment procedures typically used in participants' vestibular evaluations.

Several patterns are clearly evident related to the vestibular assessment procedures. First, the ENG/VNG test was very widely used across the survey participants (n=319 out of 334 total responses). Second, the head shake and the vertebral artery low-tech assessments and the VEMP high-tech assessment were routinely used by half of the respondents. Third, it appears that only about 20% of the participants are using the DVAT, CDP, and/or rotary chair assessments.

There are also several interesting findings related to the vestibular treatment procedures, as seen in Figure 36 above. The canalith repositioning maneuvers are used by approximately two-thirds of the survey participants. Whereas, only approximately half of the respondents are administering Brandt-Daroff exercises and only ~25% are providing VRT. As previously discussed these patterns are likely to be affected by a number of factors including: the type of work setting in which the participants practiced, the cost related to the high-tech vestibular assessment equipment, issues of insurance reimbursement for vestibular treatment procedures, participation of other professionals (i.e., physical therapists or ENT physicians) in either the vestibular assessment or treatment and treatment procedures, and the participants' knowledge regarding the foundational aspects involved in these vestibular assessment and treatment protocols.

For current Au.D. students basic knowledge and theoretical foundation in vestibular assessment and treatment procedures likely begins in their graduate degree program. Presently there are 72 ASHA accredited Au.D. programs across the United

States. In this current study information from 59 of these programs was reviewed to determine the extent of the students' education and training in the area of vestibular assessment and treatment. These programs had information regarding their academic curriculum available online, which permitted this review. An online review of the programs of study for these 59 clinical doctorate programs in audiology was conducted to determine: (1) the number of vestibular courses that were offered in their curriculum; (2) whether these didactic courses were related to vestibular assessment, treatment, or a combination of both in one course; and (3) if the program did not offer a class specifically related to vestibular topics, whether these topics were included in a diagnostic or medical audiology course. Specific data retrieved from each program can be found in Appendix C and will be summarized below. All 59 programs included at least one course that covered vestibular topic areas. Thirty-seven of the 59 Au.D. programs offered only one course that addressed vestibular topics. There were 19 programs that provided two courses in the vestibular area. Two Au.D. programs offered three classes in this area and only one program (Salus University) had four classes that covered vestibular topics. Some of these courses were described as covering only vestibular topics (n=68), whereas others were part of a diagnostic or medical audiology course (n=17). If these vestibular only courses are summarized, then a total of 68 classes are offered across these Au.D. programs. Of these 68 courses, 20 were specifically related to vestibular assessment, two were focused on vestibular treatment alone, and 29 were a combination of assessment and rehabilitation topics. The remaining 17 courses were described as being vestibular only, but their course descriptions did not further clarify the topics that were covered.

Overall, the results of this review were encouraging, in that the majority of Au.D. programs had at least one didactic course specifically related to vestibular topic areas. However, given the complexity of the anatomy and physiology of the vestibular system, as well as the numerous tests used to assess and treat vestibular disorders it is nearly impossible to cover all these topics in any level of appropriate detail in only one course. It is imperative that Au.D. students not only receive a thorough foundation in this area, but that they also receive hands-on experience in administering and interpreting these various assessment and treatment procedures. It can be speculated that the participants' highest educational level did not significantly affect their self-reported comfort levels because there is an enormous lack of education in these vestibular areas altogether, regardless of the academic degree achieved. It is also likely that this lack of formal education in vestibular topic areas is at the root of the survey participants' failure to provide several of these vestibular assessment and treatment procedures on a more regular basis, as reflected by the low response numbers shown in Figure 36 above (i.e., response rates for the DVAT, CDP, and rotary chair assessments).

Related questions addressed in the current survey asked participants to provide their opinion on which professional groups were qualified to perform these vestibular assessment and treatment procedures (Questions 13, 34, and 36 in Appendix A). All of the respondents indicated that audiologists should be the professional group that provides vestibular assessment procedures. The majority of respondents (90%) reported that both audiologists and physical therapists are qualified to provide vestibular treatment. However, approximately 70% of respondents indicated that audiologists were typically the professionals that provided these vestibular treatment services to their patients while only ~35% reported that the onsite physical therapist performs these vestibular treatment procedures. If the survey respondents believed that audiologists should be the professional group to provide these services and these same respondents, who are also audiologists, are not providing many of these services (given the results in Figure 36) there is likely to be a gross disconnect occurring in the services that are being provided to patients with vestibular disorders and what should be done as the best practice for these patients.

Given the fact that vestibular symptoms are the third most common reason for an adult to visit his/her physician, it is critical that audiologists have a strong theoretical foundation and clinical expertise in providing both vestibular assessment and treatment procedures (AAA, 2011; ASHA, 1999; Helfer, 1999; NIDCD, 2008; Nemes, 2000). In order to achieve this goal it appears that Au.D. programs need to provide a more complete educational foundation in vestibular anatomy and physiology as well as the assessment and treatment of vestibular pathologies. This educational foundation should be provided through a combination of didactic lectures, hands-on labs and clinic-related experiences, as well as research opportunities in vestibular topic areas. Once audiologists have completed their graduate work, if they have an interest in working with this patient population they should be strongly encouraged to pursue additional continuing education in these areas. These experiences can be attained at breakout groups during professional conferences, online lectures, various workshops that are related to vestibular assessment and treatment, etc.

Limitations/Future Directions

There are a number of limitations to this study. First, the sample size of the participants in the master's degree and research doctorate degree categories were small. Although this trend is consistent with the overall population of clinical audiologists; the smaller number of participants in these two groups may have affected results related to the effect of education on participants' comfort levels. Second, as this study was a survey it relied on participants' subjective responses. It is impossible to report the exact clinical practices that occurred or if there were major discrepancies in the comfort levels that were reported and what practicing audiologists actually felt. Third, the survey itself was quite long. The length of the survey may have deterred some participants' from responding altogether and/or reading and answering questions thoroughly and completely.

Given the fact that the clinical doctorate has become the entry level degree for the field of audiology, future studies may want to focus on only individuals with clinical doctorate degrees. If these individuals are targeted it may be possible to get a more complete picture about their knowledge base in vestibular areas by asking more specifically about didactic lecture courses and related clinical experience in their various practicums and external rotations. It is hoped that this information gained by this survey will be used by current Au.D. program directors that wish to re-evaluate the vestibular component of their current curriculum in order to provide a more complete education in these critical vestibular topic areas.

To summarize, there were several major points gained from this survey. These are:

- The highest level of education in audiology appears to have had a minimal impact on participants' mean comfort levels in administering and interpreting various low-tech and high-tech vestibular procedures as well as providing vestibular treatment services.
- In general, participants with 10 or more years of clinical experience were found to report comfort levels of "very comfortable" or "comfortable" in the administration and interpretation of these various vestibular assessment and treatment procedures more consistently than participants in other experience level groups.
- Overall, participants believe audiologists should be key professionals in providing vestibular services.
- It appears that the ENG/VNG is very widely used across the participants. In contrast, approximately 50% of the participants are using the head shake and

vertebral artery assessments, and only ~20% are routinely using the DVAT, computerized dynamic posturography and rotary chair assessments.

- Our review of the current Au.D. programs reveals that most students receive only 1-2 classes in vestibular areas during their graduate degree program. Given that the peripheral and central vestibular systems are very complex and also interact with many other sensory systems, it is unlikely that these one or two vestibular classes are enough to provide audiology graduate students with a thorough and solid understanding of the vestibular system and sufficient experience in the clinical assessment and rehabilitation of this system. Therefore, it is hoped that program directors for current AuD programs will use this information to re-evaluate the vestibular portion of their graduate curriculums.

APPENDIX A

A Survey of Audiologists' Clinical Practices in the Assessment and Management of Adults with Vestibular Pathologies and their Education and Training in These Areas

Demographics

What is your highest level of education?

- ☐ Masters Degree
- ☐ Clinical Doctorate Degree (e.g., Au.D.)
- ☐ Research Doctorate Degree (e.g., Ph.D.)
- ☐ Other (Please specify: ________________)

In what type of setting do you practice?

- ☐ Private Practice
- ☐ ENT Practice
- ☐ Hospital/Medical Center/Clinic
- ☐ School
- ☐ University
- ☐ Research Institution
- ☐ Other (Please specify: _________________)

How many years have you been conducting vestibular <u>assessment</u> (e.g., Bedside assessments, ENG/VNG, VEMP, Etc.)?

- ☐ I do not administer vestibular assessments
- ☐ 0-5 years
- ☐ 6-10 years
- ☐ 11-15 years
- ☐ 16-20 years
- ☐ 21+ years

How many years have you been conducting vestibular treatment (e.g., general vestibular rehabilitation, repositioning maneuvers for BPPV, Etc.)?

- ☐ I do not administer vestibular treatments
- ☐ 0-5 years
- ☐ 6-10 years
- ☐ 11-15 years
- ☐ 16-20 years
- ☐ 21+ years

What formal education have you received in vestibular assessment? (Check all that apply)

- ☐ Lecture course(s) in degree program (such as M.S., Au.D., Ph.D.)
- ☐ Hands-on lab course(s) in degree program
- ☐ Clinical rotation(s) in degree program
- ☐ Research/thesis project(s) in degree program
- ☐ Focused specialty training course(s) post-degree (e.g., conference only on vestibular topics)
- ☐ Individual sessions at professional conferences (e.g., Keynote at conference)
- ☐ Supervised training/mentoring by employment site
- ☐ On-line training
- ☐ Specific externship focused on vestibular evaluations (greater than 4 weeks)
- ☐ Other (Please specify: ________________________)

Additional Comments:

What formal education have you received in vestibular treatment? (Check all that apply)

- ☐ Lecture course(s) in degree program (such as Au.D.)
- ☐ Hands-on lab course(s) in degree program
- ☐ Clinical rotation(s) in degree program
- ☐ Research/thesis project(s) in degree program
- ☐ Focused specialty training course(s) post-degree (e.g., conference only on vestibular topics)
- ☐ Individual sessions at professional conferences (e.g., Keynote at conference)
- ☐ Supervised training/mentoring by employment site
- ☐ On-line training
- ☐ Specific externship focused on vestibular evaluations (greater than 4 weeks)
- ☐ Other (Please specify: ________________________)

Additional Comments:

On average, how many vestibular evaluations do you administer weekly?

Additional Comments:

What is your gender?

- ☐ Male
- ☐ Female

Assessment

Which of the following best describes the vestibular test battery you administer in your practice:

- ☐ I use the same test battery for all patients
- ☐ I use a core test battery and add tests based on patient case history
- ☐ I base the entire test battery on patient case history
- ☐ Other (Please specify: ________________________)

Additional Comments:

What types of vestibular testing equipment are available at your workplace? (Check all that apply)

Low Technology

- ☐ None
- ☐ Exam table
- ☐ Eye chart
- ☐ Frenzel goggles
- ☐ Foam pad
- ☐ Static balance platform
- ☐ Chair with rollers for informal assessment
- ☐ Other (Please specify:________________________)

High Technology

- ☐ None
- ☐ Immittance bridge
- ☐ Light bar
- ☐ Infrared goggles
- ☐ Electrode equipment
- ☐ Air/water caloric irrigator
- ☐ Rotary chair system
- ☐ VEMP system
- ☐ Computerized Dynamic Posturography platform
- ☐ Other (Please specify:________________________)

In your opinion, who is qualified to perform vestibular <u>assessment</u>? (Check all that apply)

- ☐ Audiologist
- ☐ Otolaryngologist (ENT)
- ☐ Otologist/Neurotologist
- ☐ Neurologist
- ☐ General Physician
- ☐ Physical Therapist
- ☐ Occupational Therapist
- ☐ Certified vestibular technician
- ☐ Vestibular technician without certification
- ☐ Nurse
- ☐ Nurse Practitioner
- ☐ Physician's Assistant
- ☐ Hearing Aid dispenser
- ☐ Other (Please specify:__________________________)

Additional Comments:

Low Tech Assessments

Which low tech assessments do you typically use? (Check all that apply)

- ☐ None
- ☐ Bedside assessment of postural control (Gans SOP, CTSIB)
- ☐ Head shake
- ☐ Dynamic visual acuity test (DVAT)
- ☐ Vertebral Artery test
- ☐ Bedside vestibular assessment (Check all that apply)
  - o Ocular range of motion
  - o Bedside saccades
  - o Gaze stabilization
  - o Head thrust
  - o Bedside pursuit
- ☐ Other (Please specify:_______________________)

Please rate your comfort level in <u>administering</u> each low tech assessment.

Bedside Assessment of Postural Control

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Dynamic Visual Acuity

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Head Shake

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Vertebral Artery

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Please rate your comfort level in interpreting the results of each low tech assessment.

Bedside Assessment of Postural Control

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Dynamic Visual Acuity

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Head Shake

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Vertebral Artery

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

High Tech Assessments

Which high tech assessments do you typically use? (Check all that apply)

- ☐ ENG/VNG
- ☐ Rotary Chair
- ☐ Computerized Dynamic Posturography
- ☐ Vestibular Evoked Myogenic Potential (VEMP)
- ☐ Other (Please specify:________________________)

Please rate your comfort level in <u>administering</u> each high tech assessment.

ENG/VNG

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Computerized Posturography

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Rotary Chair

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

VEMP

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Please rate your comfort level in <u>interpreting</u> the results of each high tech assessment.

ENG/VNG

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Computerized Dynamic Posturography

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Rotary Chair

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

VEMP

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Treatment

In your opinion, who is qualified to perform vestibular treatment? (Check all that apply)

- ☐ Audiologist
- ☐ Otolaryngologist (ENT)
- ☐ Otologist/Neurotologist
- ☐ Neurologist
- ☐ General Physician
- ☐ Physical Therapist
- ☐ Occupational Therapist
- ☐ Certified vestibular technician
- ☐ Vestibular technician without certification
- ☐ Nurse
- ☐ Nurse Practitioner
- ☐ Physician's Assistant
- ☐ Hearing Aid dispenser
- ☐ Other (Please specify:__________________________)

Additional Comments:

Is vestibular treatment provided at your workplace?

- ☐ Yes
- ☐ No

If yes, who typically administers the vestibular treatment exercises?

- ☐ Audiologist
- ☐ Otolaryngologist (ENT)
- ☐ Otologist/Neurotologist
- ☐ Neurologist
- ☐ General Physician
- ☐ Physical Therapist
- ☐ Occupational Therapist
- ☐ Certified vestibular technician
- ☐ Vestibular technician without certification
- ☐ Nurse
- ☐ Nurse Practitioner
- ☐ Physician's Assistant
- ☐ Hearing Aid dispenser
- ☐ Other (Please specify:__________________________)

Do you provide vestibular treatment services?

- ☐ Yes, I provide treatment
- ☐ No, but I refer to someone in the same facility
- ☐ No, but I refer to another center
    - Please specify the type of facility: ____________________
- ☐ No and I do not refer for vestibular treatment

What types of treatment options do you offer?

- ☐ Vestibular Rehabilitation Therapy
- ☐ Canalith Repositioning Maneuvers (Semont/Liberatory or Epley)
- ☐ Brandt-Daroff Exercises
- ☐ Other (Please specify:____________________)
- ☐ N/A

Additional Comments:

Please rate your comfort level in administering each treatment.

Vestibular Rehabilitation Therapy

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Brandt-Daroff Exercises

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

Canalith Repositioning Maneuvers (Semont/Libertory or Epley)

- ☐ Very comfortable
- ☐ Comfortable
- ☐ Uncomfortable
- ☐ Very uncomfortable
- ☐ N/A

APPENDIX B

Demographics

1. What is your highest level of education?	N	%
Masters Degree	55	16.47%
Clinical Doctorate Degree (e.g., Au.D.)	259	77.54%
Research Doctorate Degree (e.g., Ph.D.)	14	4.19%
Other (Please specify: __________________)	6	1.8%
Total Response Rate	334	100%

2. In what type of setting do you practice?

Private Practice	85	25.45%
ENT Practice	123	36.83%
Hospital/Medical Center/Clinic	83	24.85%
School	0	0%
University	7	2.1%
Research Institution	0	0%
Other (Please specify: ___________________)	36	10.78%
Total Response Rate	334	100%

3. How many years have you been conducting vestibular <u>assessment</u> (e.g., Bedside assessments, ENG/VNG, VEMP, Etc.)?

I do not administer vestibular assessments	6	1.8%
0-5 years	85	25.45%
6-10 years	92	27.54%
11-15 years	43	12.87%
16-20 years	33	9.88%
21+ years	75	22.46%
Total Response Rate	334	100%

4. How many years have you been conducting vestibular <u>treatment</u>?

I do not administer vestibular treatments	99	29.64%
0-5 years	82	24.55%
6-10 years	80	23.95%
11-15 years	38	11.38%
16-20 years	25	7.49%
21+ years	10	2.99%
Total Response Rate	334	100%

5. What formal education have you received in vestibular <u>assessment</u>? (Check all that apply)

Lecture course(s) in degree program	304	92.97%
Hands-on lab course(s) in degree program	220	67.28%
Clinical rotation(s) in degree program	178	54.43%
Research/thesis project(s) in degree program	18	5.50%
Focused specialty training course(s) post-degree	229	70.03%
Individual sessions at professional conferences	178	54.43%
Supervised training/mentoring by employment site	171	52.29%
On-line training	94	28.75%
Specific externship focused on vestibular evaluations	41	12.54%
Other (Please specify: ______________________)	13	3.98%
Total Response Rate	327	97.90%

6. What formal education have you received in vestibular <u>treatment</u>? (Check all that apply)

Lecture course(s) in degree program	245	78.53%
Hands-on lab course(s) in degree program	144	46.15%
Clinical rotation(s) in degree program	113	36.22%
Research/thesis project(s) in degree program	6	1.92%
Focused specialty training course(s) post-degree	175	56.09%
Individual sessions at professional conferences	130	41.67%
Supervised training/mentoring by employment site	114	36.54%
On-line training	61	19.55%
Specific externship focused on vestibular evaluations	34	10.90%
Other (Please specify: ______________________)	9	2.88%
Total Response Rate	312	93.41%

7. What is your gender?

Male	78	23.93%
Female	248	76.07%
Total Response Rate	326	97.6%

Assessment

8. On average, how many vestibular evaluations do you administer weekly?

N/A	16	4.94%
1-2	78	24.07%
2-4	110	33.95%
4-6	79	24.38%
Other (Please specify: ________________________)	41	12.65%
Total Response Rate	324	97.01%

9. Which vestibular assessments are included in these evaluations?

Total Response Rate	293	87.72%

10. Which of the following best describes the vestibular test battery you administer in your practice:

I use the same test battery for all patients	90	28.39%
I use a core test battery and add tests based on patient case history	176	55.52%
I base the entire test battery on patient case history	26	8.20%
Other (Please specify: ________________________)	25	7.89%
Total Response Rate	317	94.9%

11. What types of vestibular testing equipment are available at your workplace? (Check all that apply)

Low Technology

None	10	3.41%
Exam table	263	89.76%
Eye chart	70	23.89%
Frenzel goggles	115	39.25%
Foam pad	137	46.76%
Static balance platform	23	7.85%
OPK drum	26	8.87%
Chair with rollers for informal assessment	59	20.14%
Other (Please specify:________________________)	3	1.02%
Total Response Rate	293	87.72%

12. High Technology

None	4	1.22%
Immittance bridge	285	86.63%
Light bar	279	84.80%
Infrared goggles	277	84.19%
Electrode equipment	237	72.04%
Air/water caloric irrigator	320	97.26%
Rotary chair system	53	16.11%
VEMP system	156	47.42%
Computerized Dynamic Posturography platform	72	21.88%
Other (Please specify:________________________)	33	10.03%
Total Response Rate	329	98.5%

13. In your opinion, who is qualified to perform vestibular <u>assessment</u>? (Check all that apply)

Audiologist	330	100%
Otolaryngologist (ENT)	130	39.39%
Otologist/Neurotologist	139	42.12%
Neurologist	89	26.97%
General Physician	13	3.94%

Physical Therapist	99	30.00%
Occupational Therapist	14	4.24%
Certified vestibular technician	141	42.73%
Vestibular technician without certification	11	3.33%
Nurse	6	1.82%
Nurse Practitioner	17	5.15%
Physician's Assistant	22	6.67%
Hearing Aid dispenser	0	0.00%
Other (Please specify:________________________)	2	0.61%
Total Response Rate	330	98.8%

Low Tech Assessments

14. Which low tech assessments do you typically use? (Check all that apply)

None	59	19.87
Bedside assessment of postural control	113	38.05%
Head shake	176	59.26%
Dynamic visual acuity test (DVAT)	63	21.21%
Vertebral Artery test	148	49.83%
Bedside vestibular assessment	94	31.65%
Ocular range of motion	55	18.52%
Bedside saccades	34	11.45%
Gaze stabilization	41	13.80%
Head thrust	33	11.11%
Bedside pursuit	37	12.46%
Other (Please specify:________________________)	28	9.43%
Total Response Rate	297	88.9%

Please rate your comfort level in administering each low tech <u>assessment</u>.

15. Bedside Assessment of Postural Control

Very comfortable	90	
Comfortable	80	
Uncomfortable	24	
Very uncomfortable	13	
N/A	87	
Total Response Rate	294	88.02%

16. Dynamic Visual Acuity

Very comfortable	67	
Comfortable	68	
Uncomfortable	36	
Very uncomfortable	11	
N/A	98	
Total Response Rate	280	83.83%

17. Head Shake

Very comfortable	142	
Comfortable	79	
Uncomfortable	10	
Very uncomfortable	7	
N/A	61	
Total Response Rate	299	89.52%

18. Vertebral Artery

Very comfortable	99	
Comfortable	83	
Uncomfortable	21	
Very uncomfortable	8	
N/A	80	
Total Response Rate	291	87.13%

Please rate your comfort level in interpreting the results of each low tech <u>assessment</u>.

19. Bedside Assessment of Postural Control

Very comfortable	92	
Comfortable	92	
Uncomfortable	15	
Very uncomfortable	13	
N/A	91	
Total Response Rate	303	90.72%

20. Dynamic Visual Acuity

Very comfortable	71	
Comfortable	73	
Uncomfortable	36	
Very uncomfortable	13	
N/A	96	
Total Response Rate	289	86.53%

21. Head Shake

Very comfortable	128	
Comfortable	101	
Uncomfortable	14	
Very uncomfortable	5	
N/A	61	
Total Response Rate	309	92.51%

22. Vertebral Artery

Very comfortable	86	
Comfortable	95	
Uncomfortable	28	
Very uncomfortable	11	
N/A	81	
Total Response Rate	301	90.12%

High Tech Assessments

23. Which high tech assessments do you typically use? (Check all that apply)

ENG/VNG	319	99.38%
Rotary Chair	52	16.20%
Computerized Dynamic Posturography	61	19.00%
Vestibular Evoked Myogenic Potential (VEMP)	125	38.94%
Other (Please specify:_________________________)	28	8.72%
Total Response Rate	321	96.12%

Please rate your comfort level in administering each high tech assessment.

24. ENG/VNG

Very comfortable	299	
Comfortable	25	
Uncomfortable	0	
Very uncomfortable	0	
N/A	1	
Total Response Rate	325	97.31%

25. Computerized Posturography

Very comfortable	70	
Comfortable	27	
Uncomfortable	20	
Very uncomfortable	17	
N/A	161	
Total Response Rate	295	88.32%

26. Rotary Chair

Very comfortable	56	
Comfortable	28	
Uncomfortable	22	
Very uncomfortable	17	
N/A	172	
Total Response Rate	295	88.32%

27. VEMP

Very comfortable	86	
Comfortable	63	
Uncomfortable	30	
Very uncomfortable	15	
N/A	109	
Total Response Rate	303	90.72%

Please rate your comfort level in interpreting the results of each high tech assessment.

28. ENG/VNG

Very comfortable	255	
Comfortable	58	
Uncomfortable	4	
Very uncomfortable	0	
N/A	2	
Total Response Rate	319	95.51%

29. Computerized Dynamic Posturography

Very comfortable	68	
Comfortable	38	
Uncomfortable	17	
Very uncomfortable	13	
N/A	155	
Total Response Rate	291	87.13%

30. Rotary Chair

Very comfortable	55	
Comfortable	35	
Uncomfortable	17	
Very uncomfortable	16	
N/A	168	
Total Response Rate	291	87.13%

31. VEMP

Very comfortable	79	
Comfortable	69	
Uncomfortable	26	
Very uncomfortable	21	
N/A	104	
Total Response Rate	299	89.52%

Treatment

On average, how many vestibular treatment sessions do you provide weekly?

32. Canalith Repositioning Maneuvers

N/A	95	30.45%
1-2	101	32.37%
2-4	54	17.31%
4-6	23	7.37%
Other (Please specify:__________)	39	12.50%
Total Response Rate	312	93.41%

33. Vestibular Rehabilitation Therapy

N/A	234	79.86%
1-2	26	8.87%
2-4	9	3.07%
4-6	7	2.39%
Other (Please specify: __________)	17	5.80%
Total Response Rate	293	87.72%

34. In your opinion, who is qualified to perform vestibular treatment?

Audiologist	289	90.31%
Otolaryngologist (ENT)	149	46.56%
Otologist/Neurotologist	142	44.38%
Neurologist	74	23.13%
General Physician	17	5.31%
Physical Therapist	286	89.38%
Occupational Therapist	62	19.38%
Certified vestibular technician	81	25.31%
Vestibular technician without certification	12	3.75%
Nurse	10	3.13%
Nurse Practitioner	33	10.31%
Physician's Assistant	36	11.25%
Hearing Aid dispenser	0	0.00%
Other (Please specify:___________________________)	3	0.94%
Total Response Rate	320	95.81%

35. Is vestibular treatment provided at your workplace?

Yes	253	76.90%
No	74	22.49%
Both	5	1.52%
Total Response Rate	329	98.50%

36. If yes, who typically administers the vestibular treatment exercises?

Audiologist	185	69.29%
Otolaryngologist (ENT)	59	22.10%
Otologist/Neurotologist	22	8.24%
Neurologist	1	0.37%
General Physician	3	1.12%
Physical Therapist	93	34.83%
Occupational Therapist	10	3.75%
Certified vestibular technician	7	2.62%

Vestibular technician without certification	0	0.00%
Nurse	2	0.75%
Nurse Practitioner	10	3.75%
Physician's Assistant	9	3.37%
Hearing Aid dispenser	0	0.00%
Other (Please specify:_________________________)	2	0.75%
Total Response Rate	267	79.94%

37. Do you provide vestibular <u>treatment</u> services?

Yes, I provide treatment	149	46.13%
No, but I refer to someone in the same facility	64	19.81%
No, but I refer to another center	67	20.74%
Please specify the type of facility: _____		
No and I do not refer for vestibular treatment	10	3.10%
No, and refer in same facility and another center	4	1.24%
Yes, and I refer to another center	21	6.50%
Yes, and I refer in same facility	7	2.17%
Yes, and I refer in same facility and another center	1	0.31%
Total Response Rate	323	96.71%

38. What types of <u>treatment</u> options do you offer?

Vestibular Rehabilitation Therapy	88	27.76%
Canalith Repositioning Maneuvers	264	83.28%
Brandt-Daroff Exercises	141	44.48%
Other (Please specify:_______________________)	32	10.09%
N/A	46	14.51%
Total Response Rate	317	94.91%

Please rate your comfort level in administering each <u>treatment</u> exercise

39. Vestibular Rehabilitation Therapy

Very comfortable	40	
Comfortable	40	
Uncomfortable	38	
Very uncomfortable	21	
N/A	154	
Total Response Rate	293	87.72%

40. Brandt-Daroff Exercises

Very comfortable	87	
Comfortable	70	
Uncomfortable	21	
Very uncomfortable	5	
N/A	115	
Total Response Rate	298	89.22%

41. Canalith Repositioning Maneuvers (Semont/Libertory or Epley)

Very comfortable	190	
Comfortable	50	
Uncomfortable	10	
Very uncomfortable	2	
N/A	54	
Total Response Rate	306	91.62%

APPENDIX C

Program	Vestibular Assessment Courses	Vestibular Management Courses	Other	Total
Arizona State	Balance Assessment			1
ATSU			1.Vestibular Assessment and Treatment I 2.Vestibular Assessment and Treatment II	2
Auburn University	Balance Assessment			1
Ball State	Balance Function and Assessment			1
Bloomburg University of PA			1.Evaluation and Management of Balance Disorders I 2. Evaluation and Management of Balance Disorders II	2
Central MI University			Evaluation & Management of Balance Disorders	1
East Tennessee State University			Vestibular Science I&II	2
Gallaudet University			Anatomy and Physiology of the Auditory & Vestibular System	1
Idaho State University	Advanced Vestibular Assessment			1
Illinois State University			1.Anatomy and Physiology of the Auditory Vestibular System 2.Vestibular Evaluation and Rehabilitation	2
Indiana University			Vestibular Diagnosis and Rehabilitation	1
James Madison University	Vestibular Physiology and Testing			1
Lamar University			1.Electrophysiology II 2.Medical Audiology	
Louisiana State University	Electronystagmography		Advanced Vestibular Testing and Rehabilitation	2
Louisiana Tech. University			Vestibular System Disorders	1
Missouri State University			Vestibular Assessment & Rehab.	1
Montclair State University			Advanced Medical Audiology	1
Northern Illinois University			1.Auditory and Vestibular Pathologies 2.Evaluation and Treatment for Balance Disorders	2
Northwestern University			Vestibular Disorders	1
Nova Southeastern University			1.Auditory and Vestibular Pathologies 2.Electrophysiology: Vestibular	2

Ohio State University	Assessment of Vestibular Function			1
Ohio University	Balance Function Assessment			1
Purdue			Vestibular Assessment and Rehabilitation	1
Rush University			1.Vestibular Assessment and Rehabilitation 2.Vestibular II	2
Salus University	1.Vestibular and Balance Evaluation 1 2.Vestibular and Balance Lab 3. Vestibular and Balance Evaluation 2	Vestibular Rehabilitation		4
SUNY	Vestibular Testing			1
Syracuse University			Vestibular Assessment & Management	1
Texas Tech			1.Balance Function 2.Balance Function Lab	2
Towson University			Vestibular Assessment and Rehabilitation	1
University of Arizona			1.Anatomy & Physiology of Auditory & Vestibular Systems 2.Disorders of Hearing & Balance 3.Assessment & Rehab of the Balance System/Lab	3
University of Arkansas, Little Rock			1.Anatomy and Physiology of the Auditory and Vestibular Systems 2.Anatomy and Physiology of the Auditory and Vestibular Systems II 3.Evaluation & Treatment of the Balance System	3
University of Cincinnati			1. Vestibular Assessment and Rehabilitation 2. Vestibular Assessment and Rehabilitation II	2
University of Connecticut			Vestibular System: Clinical Aspects	1
University of Florida			1. Anatomy and Physiology of Balance 2. Vestibular Disorders	2
University of Iowa			Vestibular Assessment & Rehabilitation	1
University of Kansas			1. Vestibular Systems/Rehabilitation 2. Anatomy and Physiology of the Hearing and Vestibular Mechanisms	2

University of MD, College Park	Vestibular-ocular Function and Assessment (Electrophysiologic Measures II)			1
University of Mass., Amherst			Assessment/Rehabilitation of Balance Disorders and Tinnitus	1
University of Memphis			Vestibular and Balance Function	1
University of Minnesota, Minneapolis			Anatomy and Physiology of Hearing and Balance	1
University of Nebraska, Lincoln	1.Vestibular Assessment I 2.Vestibular Assessment II			2
University of North Texas			Neuroanatomy and Neurophysiology of the Auditory and Vestibular System	1
University of Northern Colorado			1.Basic Audiology 2.Advanced Diagnosis of Auditory and Vestibular Disorders	2
University of Oklahoma	Balance Assessment			1
University of Pittsburgh			Vestibular Assessment and Rehabilitation	1
University of South Alabama			Vestibular Assessment and Treatment	1
University of South Dakota			Otoacoustic Emissions and Balance Function	1
University of South Florida			1.Vestibular Evaluation & Treatment 2.Advanced Vestibular Seminar	2
University of Tennessee, Knoxville			Vestibular Disorders	1
University of Texas at Dallas	Physiologic Assessment of Vestibular System			1
University of Utah			Vestibular Assessment and Rehab	1
University of Washington	Balance Assessment			1
Utah State University			Balance Evaluation and Management	1
Vanderbilt	Assessment of Vestibular Disorders	Management of Vestibular Disorders		2
Washington University			Assessment and Management of Vestibular Disorders	1

Wayne State University	Equilibrium/ Vestibular System Evaluation		Auditory and Vestibular Pathologies	2
West Virginia University			1.Vestibular Evaluation & Rehabilitation 2.Lab: Vestibular Evaluation & Rehabilitation	2
Western Michigan University			Anatomy of Audition & Balance	1
Wichita State University			Diagnosis & Management of Persons with Balance Disorders	1

APPENDIX D

TOWSON UNIVERSITY

EXEMPTION NUMBER: 12-0X38

To: Ashlee Blohm
From: Institutional Review Board for the Protection of Human Subjects, Melissa Osborne Groves, Member
Date: Tuesday, November 08, 2011
RE: Application for Approval of Research Involving the Use of Human Participants

Office of University Research Services
Towson University
8000 York Road
Towson, MD 21252-0001
t. 410 704-2236
f. 410 704-4494

Thank you for submitting an application for approval of the research titled, *A Survey of Audiologists' Clinical Practices in the Assessment and Management of Adults with Vestibular Pathologies and their Formal Education and Training in these Areas*

to the Institutional Review Board for the Protection of Human Participants (IRB) at Towson University.

Your research is exempt from general Human Participants requirements according to 45 CFR 46.101(b)(2). No further review of this project is required from year to year provided it does not deviate from the submitted research design.

If you substantially change your research project or your survey instrument, please notify the Board immediately.

We wish you every success in your research project.

CC: P. Korczak
File

References

Akin, F.W., Murnane, O.D., Panus, P.C., Caruthers, S.K., Wilkinson, A.E., & Proffit, T.M. (2004). The Influence of Voluntary Tonic EMG Level on the Vestibular Evoked Myogenic Potential. *Journal of Rehabilitation Research and Development, 41(3),* 473-480.

American Academy of Audiology. Position Statement on the Audiologist's Role in the Diagnosis & Treatment of Vestibular Disorders. (2011). *AAA Task Force Committee.* Retrieved from http://www.audiology.org/resources/documentlibrary/Pages/VestibularDisorders.aspx

American Speech-Language-Hearing Association. Balance System Assessment. (1992). *Ad Hoc Committee on Advances in Clinical Practice.* Retrieved from www.asha.org/policy

American Speech-Language-Hearing Association. Role of Audiologists in Vestibular and Balance Rehabilitation. (1999). *ASHA Ad Hoc Committee on Vestibular Rehabilitaion.* Retrieved from www.asha.org/policy

Baloh, R.W. & Furman, J.M.R. (1989). Modern Vestibular Function Testing. *The Western Journal of Medicine, 150(1),* 59-67.

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2001). *Neuroscience: Exploring the*

Brain. Baltimore: Lippincot, Williams and Wilkins.

Berne, R.M. & Levy, M.N. (1993). *Physiology: 2nd Edition.* Mosby-Year Book: Philadelphia

Barin, K. (2009a). Clinical Neurophysiology of the Vestibular System. In J. Katz (Ed). *Handbook of Clinical Audiology, 6th Edition.* (pp. 431-466). Baltimore: Lippincott Williams and Wilkins.

Barin, K. (2009b). *Intro to ENG/VNG*. GN Otometrics: Illinois

Central Michigan University. (Producer). (2009). *Vestibular Assessment: The Modified Vertebral Artery Test.* Available at http://webcast.cmich.edu/webcast/Viewer/?peid=27417a8796774161bed36cdbad84440b

Clarke, A.H. (2010). Laboratory Testing of the Vestibular System. *Current Opinion in Otolaryngology & Head and Neck Surgery, 18,* 425-430.

Creative Research Systems. (2011). Sample Size Calculator. Unpublished instrument. Retrieved from http://www.surveysystem.com/sscalc.htm

Desmond, A.L. (2004). *Vestibular Function: Evaluation and Treatment.* Thieme: New York

Dix, M.R. & Hallpike, C.S. (1952). The Pathology, Symptomatology, and Diagnosis of

Certain Common Disorders of the Vestibular System. *Proceedings of the Royal Society of Medicine, 45,* 341-354.

Fife, T.D, Tusa, R.J., & Furman, J.M., et al. (2000). Assessment: Vestibular Testing Techniques in Adults and Children. *Neurology, 55*, 1431-1442.

Froehling, D.A., Silverstein, M.D., Mohr, D.N., Beatty, C.W., Offord, K.P., & Ballard, D.J. (1991). Benign Positional Vertigo: Incidence and Prognosis in a Population-Based Study in Olmsted County, Minnesota. *Mayo Clinic Proceedings, 66(6),* 596-601.

Funk, K.P. (2008). Managing Vestibular Disorders. *American Occupational Therapy Association, 13,* 11-15.

Gans, R. (1999). The Hearing Review, 6(7), 32-36.

Gans, R. (2002). Professional Seminar.

Gans, R. (2002). Vestibular Rehabilitation: Critical Decision Analysis. *Seminars in Hearing, 23(2),* 149-159.

Gans, R.E. & Harrington-Gans, P.A. (2002). Treatment Efficacy of Benign Paroxysmal Positional Vertigo (BPPV) with Canalith Repositioning Maneuver and Semont Liberatory Maneuver in 376 Patients. *Seminars in Hearing, 23(2),* 129-142.

Goebel, J.A. (2001). *Practical Management of the Dizzy Patient.* Lippincott Williams &

Wilkins: Baltimore

Herdman, S.J. & Tusa, R.J. (2004). *Benign Paroxysmal Positional Vertigo*. GN Otometrics: Illinois

Helfer, K.S. (1999). Continuing Education in Audiology: What do We Want? *American Academy of Audiology, 8,* 6-12.

Hester, O.T. & Silverstein, H. (2002). Patient Interview: History of Symptoms and Definitions of Common Vestibular Disorders. *Seminars in Hearing, 23,* 107-111.

Janky, K. (2010). Professional Seminar.

Jacobson, G.P. & Shepard, N.T. (Eds.). (2008). *Balance Function Assessment and Management.* Plural Publishing: San Diego

Jacobson, G.P., Newman, C.W., & Kartush, J.M. (Eds.). (1997). *Handbook of Balance Function Testing.* Singular Publishing Group, Inc: San Diego

Kroenke, K., Lucas, C., Rosenberg, M., Scherokman, B., Herbers, J., Wehrle, P., et al., (1992). Causes of persistent dizziness: a prospective study of 100 patients in ambulatory care. *Ann Internal Med, 17(11)* 898-904.

Klumpp, M. (2010). The effects of aging and unilateral vestibular disorders on the kinematic performance of vestibular rehabilitation exercises and physical function. (Doctoral Dissertation: Louisiana State University) Louisiana.

Koch, H. & Smith, M.C. (1985). Office Based Ambulatory Care for Patients 75 Years Old and Over. *National Ambulatory Medical Care Survey, 1980 and 1981.* Retrieved from http://www.cdc.gov/nchs/data/ad/ad110acc.pdf

Lyaskowski, A. (2005). Anatomy of Vestibular End Organs and Neural Pathways. *Cummings Otolaryngology Head & Neck Surgery,* 3089-3114.

Nandi, R. & Luxon, L.M. (2008). Development and Assessment of the Vestibular System. *International Journal of Audiology*. *47.* 566-577.

National Institute on Deafness and Other Communication Disorders (NIDCD). *Strategic Plan.* (FY 2006-2008). Available online. Accessed May 8, 2011.

Nemes, J. (2002). An Opportunity for Audiologists. *The Hearing Journal, 53(7),* 21-25.

Pikus, A. (2002). Heritable Vestibular Disorders. *Seminars in Hearing*, *23,* 113-119.

Rauch, S.D. (2006). Vestibular Evoked Myogenic Potentials. *Current Opinion in Otolaryngology & Head and Neck Surgery, 14,* 299-304.

Resnick, D.M. (1977). The Vestibular System and its Assessment by Electronystagmography. *Ear, Nose, & Throat Journal, 56*, 38-44

Richter, R.R. & Reinking, M.F. (2005). Evidence in Practice: How Does Evidence on the Diagnostic Accuracy of the Vertebral Artery Test Influence Teaching of the Test in a Professional Physical Therapist Education Program? *Physical Therapy, 85(6),* 589-599.

Rosenthal, R., & Rosnow, R.L. (1991). *Essentials of Behavioral Research: Methods and Data Analysis* (2nd Ed.). McGraw-Hill: New York.

Sloane, P., Blazer, D., & George, L. (1989). Dizziness in a Community Elderly Population. *Journal of American Geriatric Society, 37(2),* 101-108.

Shepard, N.T. & Telian, S.A. (1996). *Practical Management of the Balance Disorder Patient.* Singular Publishing Group: San Diego.

Tusa, R.J., Saada, A.A., & Niparko, J.K. (1994). Dizziness in Childhood. *Journal of Child Neurology, 9(3),* 261-274.

Wall, C. & Vrabec, J.T. (2001). Vestibular Function and Anatomy. *Head and Neck Surgery*, 1641-1650.

Yardley, L., Owen, N., Nazareth, I., & Luxon, L. (1998). Prevalence and presentation of dizziness in a general practice community sample of working age people. *British Journal of General Practice, 48*, 1131-1135.

Zhou, G. & Cox, L.C. (2004). Vestibular Evoked Myogenic Potentials: History and Overview. *American Journal of Audiology*, *13*, 135-143.

CURRICULUM VITA

NAME: Ashlee Blohm

PERMANENT ADDRESS: 6181 Dry Creek Circle. Highland, UT 84003

PROGRAM OF STUDY: Audiology

DEGREE AND DATE TO BE CONFERRED: Doctor of Audiology, 2013

Secondary education: Lone Peak High School, Highland, UT May 2004

Collegiate institutions attended	Dates	Degree	Date of Degree
Utah State University	2004-2009	B.S.	May 2009
Towson University	2009-2013	Au.D.	May 2013

Major: Communicative Disorders and Deaf Education, Psychology
Audiology