The Science Journal of the Lander College of Arts and Sciences

Volume 12
Number 1 *Fall 2018*

Article 2

2018

The Relationship between Vertigo, Vestibular System Disorders, and Therapy

Etta Rubin
Touro College

The Relationship between Vertigo, Vestibular System Disorders, and Therapy

Etta Rubin

Etta Rubin graduated in june 2018 with a b.s. degree in biology and is currently attending the physical therapy program at Hunter College

Abstract

The relationship between vertigo and vestibular system disorders has been the subject of much research in recent years. The aim of this study is to review and analyze the relevant literature regarding this relationship, with emphasis on determining what causes the dizziness, how to test for vertigo, and specifically how to treat it. Additionally, while there may be many ways to prevent vertigo, the focus will be on how the role of therapy is vital in the future of healthcare, serving as prevention of anxiety and reoccurring vestibular disorders.

Introduction

About forty percent of Americans, will at some point of their lives have a balance problem that is disturbing enough that they consult a doctor, according to the National Institute of Health (Better Balance, 2017). Symptoms of dizziness from seasickness, fear of heights, or alcohol consumption were mentioned as early as 730 BC in Roman, Greek, and Chinese texts. However, due to the lack of scientific evidence at that time, an explanation for this dizziness was not present until mid-19th century scientists began to study the somewhat camouflaged vestibular system and research its possible correlations to vertigo. There are different forms of treatment available for vertigo and vestibular disorders. This review will investigate and determine which form of treatment is the most effective for treating vertigo and vestibular disorders.

Methods

The information gathered in this paper has been collected from numerous sources including databases such as PUBMED, Google Scholar, Touro Library, and Nature.com. The information was read, analyzed and compared to determine each study's validity and standpoint.

Discussion: Defining the Vestibular System

One's balance system helps one stand, walk, run, and move without falling. The eyes, inner ear, and body's muscles and tendons coordinate with the brain, which help one control balance (Tamaki, 2016). Together the organs that control or sense the signals throughout the body are known as the vestibular system. The vestibular apparatus found in the inner ear of humans, provides a sense of balance and awareness of spatial orientation. It is made up of three semicircular canals, anterior, posterior, and lateral, that are sensitive to angular accelerations (head rotations: up-down, side to side, and tilting movements). It also includes two labyrinth organs, the utricle and the saccule, that are sensitive to linear (or straight-line) accelerations by sensing gravity (Tamaki, 2016). Information from the vestibular organs of each ear, the eyes, and the rest of the body are then integrated in the brain.

The semicircular canals originate from the utricle and are positioned at a 90° angle from one another, with the horizontal canal tipped backwards 20-30 degrees (Figure 2). They are filled with endolymphatic fluid which exerts pressure against the 10–50 micrometer stereocilia, the canal's sensory hair cell receptors (Better Balance, 2017). Calcium carbonate crystals called otoconia are attached to both the medial wall of the saccule and floor of the utricle. Thus, under the influence of acceleration of a car, for example, it can cause stimulation of the hair cells by their movement relative to the endolymphatic fluid. The receptors respond by sending impulses to the brain about movement from the specific canal that was stimulated. When the vestibular organs on both sides of the head are functioning properly, they send symmetrical impulses to the brain and let the brain know that the car has accelerated.

Additionally, the Vestibulocochlear Nerve, also known as Cranial Nerve VIII, is responsible for a human's sense of hearing and equilibrium (Patel et. al., 2017). It transmits balance-related information from the semicircular canals and the labyrinth organs to the central nervous system. The superior portion of the nerve innervates anterior and horizontal canals and utricle, while the inferior portion innervates posterior canal and saccule. When, for example, a rotational head movement occurs, it causes the fluid in the semicircular canals to move which causes the stereocilia in the saccule, utricle, and the cristae of the semicircular canals to bend. When the hair cells bend, they exert a mechanical force into electrical nerve action potentials stimulating cranial nerve VIII. However, if one is jumping up and down, descending in an elevator, or accelerating on the highway, the two labyrinth organs of each ear are activated. Consequently, it causes the fluid in the labyrinth organs to move, while otoconia, the calcium carbonate crystals, lag behind. The lagging behind of the otoconia causes hair cells in the labyrinth organs to bend, and the bending of the hair cells stimulates cranial nerve VIII as well. Through the help of the cochlea and the vestibular apparatus, cranial nerve VIII sends messages from the inner ear to the central nervous system to empower the body's sensation of hearing and balance (Gill-Body, 2001).

History of Vertigo

Descriptions of vertigo and dizziness as a result of seasickness, fear of heights, and alcohol consumption were found in Roman, Greek, and Chinese texts as early as 730BC –600CE (Huppert et al, 2018). One of the earliest references to vertigo and the idea of dizziness in relation to fear of heights is found from the 5th century BC in the Hippocratic Corpus. In a collection of around 60 early Ancient Greek medical works strongly associated with the physician Hippocrates and his teachings, the

Hippocratic Corpus uses Latin keywords of vertigo such as caligo, caligare, altitudo, magnitudo, and celsitudo, describing relationship between heights and dizziness (Huppert et al, 2013).

During the sixteenth century the middle ear was described in detail and further progress was made between the sixteenth and eighteenth century in describing the inner ear.

Knowledge of the vestibular system and its functions began to grow with nineteenth century scientists such as Jan Evangelista Purkinje, Ernst Mach, Josef Breuer, Hermann Helmholtz, and Alexander Crum-Brown (Huppert et al, 2018). The first textbook on neurology (Lehrbuch der Nervenkrankheiten des Menschen, 1840) by Moritz Romberg contained general descriptions of signs and symptoms of various conditions with the key symptom of vertigo, but lacked a definition of vestibular disorders. However, in the nineteenth century technological advancement permitted a description of the cells and structures that constituted the cochlea. Von Helmholtz made progress in hearing physiology when he postulated his resonance theory, and later Von Békésy made progress as well when he observed a traveling wave within the cochlea of human cadavers. Brownell later made a major advance when he discovered that the ear has a mechanism for sound amplification, via outer hair cell electromotility (Hachmeister, 2003).

Vertigo as a Symptom

Vertigo and dizziness are among the most common complaints in neurology clinics. They account for about 13% of patients entering emergency units and are reported as the third most common major medical symptom in general medical clinics (Brandt, Dieterich, 2017).

Dizziness and vertigo are complex neurological symptoms, traditionally categorized as one of four "types" based on symptom quality: (1) vertigo, an illusion of spinning or motion, (2) presyncope, feeling faint, (3) disequilibrium, a loss of balance or equilibrium when walking, and (4) lightheadedness, wooziness, and giddiness, etc. (Newman-Toker, 2007).

Vertigo is a symptom, not necessarily a disease, but it is an outcome of a physiological or uncontrolled processes, characterized by sudden dizzy spells causing a lot of discomfort (Srinivasan, Jebasingh, 2007). Vertigo is often caused by an inner ear problem. The sensations from the inner ear, eyes, and throughout the body (somatosensory) are mismatched. Humans need the above three to regulate their balance (Better Balance, 2012). Any abnormality in one or more of these can trigger vertigo.

Vertigo can also be caused by decreased blood supply to certain areas of the brain. This can follow mini-strokes called transient ischemic attacks (TIAs) or can happen as a result of a permanent stroke (Seiden, 1989). Similarly, head trauma, even a minor blow to the head, is a risk factor to cause vertigo (Naguib et al, 2012).

There are different types of vertigo. Rotatory vertigo mimics the sensation of being on a merry-go-round, like in vestibular neuritis and other disorders, while postural vertigo resembles the sensation of riding in a boat. Yet many patients use the term "dizziness" for lightheadedness without any sensation of movement (e.g., in drug intoxication). Lightheadedness is the most common type of vertigo; it mainly affects older patients and it is characterized by brief attacks of rotational vertigo, accompanied by vertical positioning nystagmus that rotates toward the lower of the two ears and beats toward the forehead. The attacks are triggered by reclining the head, or by lateral positioning of the head or body, with the affected ear downward. After a change in position of one of these types, rotational vertigo and nystagmus arise after a latency of a few seconds and last a total of 30 to 60 seconds (Strupp, Brandt, 2008).

Importance of Treating Vertigo

According to news from Munich, Germany by NewsRx editors, research states, "Vertigo and dizziness are among the most common complaints in neurology clinics, and they account for about 13% of the patients entering emergency units (Nervous system diseases and conditions, 2017). "Some vertigo is so violent a person can't get out of bed, sometimes for several days at a time. They can't hold a job or take care of the family or just be with the family. Some balance problems can be very debilitating," says Browning, a certified clinical audiologist at Rocky Mountain Hearing and Balance in Salt Lake City (Collins, 2007)

The NIH also reports that balance-related falls cause more than half of the accidental deaths among the elderly. About forty percent of people over age sixty five fall each year, totaling more than thirteen million falls a year, resulting in at least 1,600 senior citizens' deaths as a direct or indirect result of falls (Collins, 2007).

Dysfunction of the vestibular system in humans can be severe and extremely debilitating, leading one to become housebound and lead a very restricted life, with high rates of anxiety disorders and depression. In the United States of America, approximately 35% of people aged 40 and over have suffered from some form of vestibular dysfunction [based on a sample of 5,086] (Smith, 2017).

Vestibular Disorders and Vertigo

Humans can become disoriented if different sensory input received from their eyes, muscles, tendons, or vestibular organs conflict (Brennan, 2012). For example, Physiological vertigo is Vertigo while in moving vehicles, colloquially known as motion sickness. This is due to a "sensory conflict" between one's vision and the actual movement sensation. In motion sickness, it is caused by multi-sensory motions that do not correlate to the expected pattern of movement. Many feel better sitting in the front seat of the car or bus as it gives them more visual input than at the back seat. These individuals are encouraged to keep their eyes open as this will let the brain gain more information of the movement of the vehicle and decrease the vertigo. Additionally, signal conflicts may occur when a person is standing next to a bus that is pulling away from the sidewalk. The visual image of the large moving bus may create an illusion for the pedestrian that he, rather than the bus, is moving. However, at the same time the information from his muscles and joints indicates that he is not actually moving. Sensory information provided by the vestibular organs helps override sensory conflicts (Bedford, 2012). In addition, higher level thinking and memory might suggest the person to glance away from the moving bus to look down in order to seek visual confirmation that his body is not moving relative to the pavement.

One of the most commonly diagnosed vestibular disorders is Benign Paroxysmal Positional Vertigo, also known as BPPV (Smith, 2017). BPPV is a mechanical problem in the inner ear that is the most frequent cause of dizziness. It occurs when a tiny crystal of calcium breaks free from the wall of one of the semi cicular canals and moves into the canal of the inner ear, causing disruptions in the inner ear signals that are eventually sent to the brain about head and body movements (Najeeb, 2016). Typically, the crystals fall into the posterior semicircular canal every time the patient lies down with the affected ear down. As a result, the crystals move the fluids of the inner ear, activating the sensor of the semicircular canal inappropriately. This is perceived as vertigo or spinning by the patient and lasts less than a minute until the crystals settle down and stop moving (Vestibular.org). It can occur suddenly while the sleeping person gets into a particular position, yet, the after effects of uneasiness and unsteadiness are even more disturbing than the original pain (Baloh, 1998). BPPV is called "benign" because it usually resolves spontaneously within a few weeks or months; in some cases, however, it can last for years. If left untreated, it persists in about 30% of patients (Strupp et al, 2008).

The treating physician will perform a simple maneuver called the Dix Hallpike to test for the condition. The doctor will ask the patient to sit on the exam table and he'll turn the patient's head 45 degrees to one side and then will help him or her lie back quickly so his or her head hangs slightly over the edge of the table. This movement may make the loose crystals move within the semicircular canals. The doctor will then ask if the patient feels symptoms of vertigo and watch his or her eyes to see how they move, checking for nystagmus, an involuntary movement of the eyeballs, which is a major symptom of vertigo.

Once vertigo is proven, the follow-through procedure would be either an Epley maneuver involving rotation of the patient in the reclining position with their head hanging down, or Semonts or Brandt Daroff maneuvers, which are all equally effective. The cure rate for these procedures is more than 95% within a few days, as shown by multiple controlled studies (Strupp et al, 2008). The purpose of these procedures is to displace abnormal calcium deposits within the inner ear to an area which prevents them from stimulating the nerve cells, which causes vertigo.

Canalith Repositioning Maneuvers, also known as Epley maneuvers, can be used to treat vertigo. It is a repositioning maneuver involving sequential movement of the head into four positions, staying in each position for approximately thirty seconds to subsequently move the displaced crystals out of the affected area (American-hearing.org).

With a series of specific head and body movements for BPPV recommended by the American Academy of Neurology, the movements are done to move the calcium deposits out of the canal into an inner ear chamber so they can be absorbed by the body. One will likely have vertigo symptoms during the procedure as the canaliths move. The movements are safe and often effective. Commonly, this will be followed by Brandt-Daroff exercises, which will consist of shaking the crystals within the fluids by alternating body positions and ultimately dissolving them.

The treatment of benign paroxysmal positioning vertigo with the Semont maneuver is as follows: In the initial sitting position, the head is turned forty five degrees to the side of the unaffected "healthy" ear. Then the patient is laid on the right side, i.e., on the side of the affected ear, while the head is kept in forty five degrees of rotation to the other side. This induces movement of the particulate matter in the posterior semicircular canal by gravity, leading to rotatory nystagmus toward the lower ear that stops after a brief interval. The patient should maintain this position for about one minute. While the head is still kept in forty five degree of rotation toward the side of the healthy ear, the patient is rapidly swung over to the side of the unaffected ear, so that the nose now points downward. The particulate matter in the semicircular canal now moves toward the exit from the canal. This position, too, should be maintained for at least one minute. The patient returns slowly to the initial, sitting position. The particles settle in the utricular space, where it can no longer induce rotatory vertigo. The above sequence should be performed three times in a row three times per day, in the morning, at noon, and at night. Most patients are free of symptoms after doing this for three days (Strupp et al, 2008).

If one is diagnosed with BPPV, one should get treatment from a physical therapist. Physical therapy has a success rate with the symptoms usually resolving within one or two treatments. The physical therapist guides the patient through a series of movements that will relocate the crystals to their place of origin or to an area of the ear that is not affected by their presence (Kelowna Capital News, 2008).

Another kind of vertigo is vestibular vertigo. Vestibular vertigo is the leaking of inner ear fluid, vestibular failure, infection of the vestibule, and tumors. Vestibules are sensitive to the movement of the head, and any type of irritation or damage to the vestibules can cause confusion in the brain, resulting in vertigo. Vestibular nerve inflammation, which is mostly viral in nature, is self- limiting and almost always resolves by itself.

Similarly, Labyrinthitis and Vestibular Neuritis are vestibular disorders resulting from an infection that inflames the inner ear or the nerves connecting the inner ear to the brain. This inflammation disrupts the transmission of sensory information from the ear to the brain. Vertigo, dizziness, and difficulties with balance, vision, or hearing may result. This is explained from the inner ear organs and the balance signals sent through the vestibulocochlear nerve. When one ear is infected, it sends faulty signals and thus the brain receives mismatched information, resulting in dizziness or vertigo.

Lastly, Meniere's disease is a chronic, incurable vestibular disorder defined in 1995 by the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology. It produces a recurring set of symptoms as a result of abnormally large amounts of endolymph fluid collecting in the inner ear. Meniere's disease can develop at any age, but it is more likely to happen to adults between 40 and 60 years of age (Agrup Et. Al., 2007).

Vertigo is often triggered by a change in the position of one's head. Within seconds, one can experience an awful sensation, as if the entire environment has begun to spin or that one is spinning against a stationary environment. One may feel nauseated, have a headache, and have abnormal jerky eye movements (Brandt, 2000). Ringing in the ears or hearing loss symptoms can last a few minutes to a few hours or more and may come and go. Another symptom may be nystagmus, which is involuntary movement of the eyeballs. One will not see it in the mirror because once one fixes their vision in the mirror, nystagmus disappears. Additionally, hemi spatial neglect (failure to be aware of one side of space), room tilt illusion, loss of spatial memory, and ultimately pusher syndrome, a loss of postural balance are all symptoms of vertigo. It is important to note that most of the peripheral vestibular disorders have a clinical diagnosis, and therefore medical history is important.

Testing for Vertigo

The Head Impulse Test (HIT) is one of the many tests to do to find the possible cause of vertigo. During the Head Impulse Test, the patient is asked to fix his or her eyes on a target (e.g. the examiner's nose). The examiner will then generate a rapid head impulse while monitoring the patient's eyes for a corrective or compensatory saccade (CS) response. Individuals with normal vestibular function should not generate a compensatory saccade after a head impulse, rather the eyes should stay fixed on the target.

Ocular Motor Testing looks at the systems responsible for integrating balance, vision, and movement. Four categories of ocular motor functions: stability of gaze; smooth pursuit eye movements,optokinetic nystagmus; and saccadic eye movements are used to determine spontaneous and gaze-evoked nystagmus. Nystagmus often results in reduced vision and depth perception and can affect balance and coordination. This testing can also be used to determine skew deviation- wherein the eyes move upward (hypertropia), but in opposite directions. Skew deviation is caused by abnormal prenuclear vestibular input to the ocular motor nuclei, most commonly due to brainstem or cerebellar stroke.

Frenzel goggles are extremely useful in evaluation of patients with vestibular disorders. They were termed by the German otolaryngologist Herman Frenzel from Gottingen, Germany in the 1950's, and have been used as an examination tool to disable the patient's ability to visually fixate on an object while at the same time allowing the examiner to adequately visualize the eye. In essence, they consist of the combination of magnifying glasses and a lighting system. When Frenzel goggles are placed on the patient and the room lights darkened, nystagmus can easily be seen because the patient's eyes are well illuminated and magnified, and because fixation is removed as the patient can hardly focus through magnifying glasses on a dark room. The Frenzel goggles reduce visual fixation by means of the magnification glasses of about sixteen diopters (a unit of measurement of the optical power of a lens or curved mirror), and also allow a better examination of the eye movements, specifically nystagmus (Strupp, et. Al., 2014).

Despite these tests, sometimes one may feel dizzy or light-headed but it's not truly vertigo. This is common in people with panic disorders or low blood sugar count, or when one suddenly stands up from a lying or seated position or is intoxicated with drugs or alcohol. Alcohol interferes with the communication between nerve cells and cell receptors that send messages between the body and the brain. As a result, the cerebellum, the part of the brain that usually creates nerve impulses that control an individual's balance and other fine movements for balance, cannot function properly due to the uncoordinated nerve signals. Ultimately, the muscle movements become uncoordinated and one can lose his or her balance (Susanto, 2014).

Treatment

Vertigo is a symptom, so finding its cause is the key to treating it. For some, treatment from an audiologist, physical therapist, or occupational therapist for balance treatment is needed. In many cases, vertigo goes away without any treatment. This is because one's brain is able to adapt, at least in part, to the inner ear changes, relying on other mechanisms (Phillips, 2011). For example, if one is at a very loud concert, the brain adapts and contracts the inner ear muscles to protect the inner ear from damage. Similarly, the brain relies on sight as well as the musculoskeletal system to help with balance when one is walking along a beach. Stepping on sand may not be as sturdy as pavement, but with the help of the eyes and muscles, one can maintain his or her balance even on uneven surfaces.

"Vestibular Rehabilitation" may be recommended if one has recurrent bouts of vertigo. This is a type of physical therapy aimed at helping strengthen the vestibular system. It helps train the other senses to compensate for vertigo or learn ways to turn one's head or move without getting dizzy. It includes improving balance and stability while in motion, improving neuromuscular coordination and decreasing anxiety due to vestibular disorientation, and minimizing falls (Merlingolda, 2013).

Medicine can be another treatment towards vertigo discomfort. In some cases, medication may be given to relieve symptoms such as nausea or motion sickness associated with vertigo. Antihistamines such as meclizine (Antivert) may offer short-term relief from vertigo in addition to anti-nausea medications (Donaldson et al, 2008). If vertigo is caused by an infection or inflammation, antibiotics or steroids may reduce swelling and cure the infection.

In a few cases when medical treatment is not effective in controlling vertigo, surgery may be considered to repair or stabilize the inner ear function (Strupp et al, 2008). There are destructive treatments that are designed to eliminate vertigo, possibly sacrificing hearing. These procedures are appropriate for consideration when medical treatment and vestibular rehabilitation has failed to control vertigo symptoms. For example, labyrinthectomy is a destructive procedure used for Ménière's disease. Labyrinthectomy is appropriate for patients in whom there is no hearing in the ear which is causing vertigo and thus offers excellent control of vertigo (Hain 2012). The balance end organs, namely the semicircular canals and two otolith organs, are removed so that the brain no longer receives signals from the parts of the inner ear that sense gravity and motion changes. It is important to note the hearing organ, the cochlea, is also sacrificed with this procedure. Ultrasound surgery at times may also be used to destroy the balance end organs so that the brain no longer receives signals from the parts of the ear that sense gravity and motion changes (vestibular.org).

After an estimated half a million people have received cochlear implants by 2016, several decades since the first cochlear implant was performed in 1961 (Smith, 2017), the success of cochlear implant technology has naturally encouraged researchers to consider other forms of bionic implants that can substitute for lost sensory function. The development of the 'vestibular implant or prosthesis', which aims to replace a missing or dysfunctional vestibular system, has been given to groups of patients since 2007 and considerable progress has been made in this area.

It is important to note, if vertigo is caused by a more serious underlying problem, such as a brain tumor or injury to the brain or neck, initial treatment for those conditions may help to alleviate its chain reaction vertigo as well.

Conclusion

Through the analysis and research shown throughout the paper, it leaves one empowered by what may be the best future healthcare treatment for one who has vertigo and other vestibular disorders. There are many types of treatment for vestibular disorders, but where does the future for best healthcare treatment of vertigo and vestibular disorders lie? According to the above research discussed, doctors and healthcare providers should be weary of surgery and medication as solutions to vertigo, for many times the vertigo symptoms may prove to be invalid or subside over time and these treatments are short term and destructive to nearby organs in the body. As a healthier and longer lasting alternative, Vestibular Rehabilitation via Epley, Sermont, or Brandt Daroff Maneuvers will not only help control the dizziness, but also strengthen other senses in the body to compensate for vertigo. As a result of the therapy, it will not only prove strengthening of the vestibular system, but will also decrease the anxiety and the symptoms of disorientation that occur as a result of vestibular disorders.

References

Agrup, C., Gleeson, M., & Rudge, P. (2007). The inner ear and the neurologist. Journal of Neurology, Neurosurgery and Psychiatry, 78(2), 114. doi:http://dx.doi.org/10.1136/jnnp.2006.092064

Baloh, R. W. (1998). Vertigo. The Lancet, 352(9143), 1841-6. Retrieved from https://search.proquest.com/docview/199022045

Bedford, F. L. (2012). A perception theory in mind-body medicine: Guided imagery and mindful meditation as cross-modal adaptation. Psychonomic Bulletin & Review, 19(1), 24-45. Retrieved from https://search.proquest.com/docview/1021977739

Brandt, T., & Dieterich, M. (2017). The dizzy patient: Don't forget disorders of the central vestibular system. Nature Reviews. Neurology, 13(6), 352-362. http://dx.doi.org/10.1038/nrneurol.2017.58 Retrieved from https://search.proquest.com/docview/1903441252

Brandt, T. (2000). Management of vestibular disorders. Journal of Neurology, 247(7), 491-9. http://dx.doi.org/10.1007/s004150070146

Brennan, M. (2012). Visual-vestibular interaction and treatment of dizziness: A case report. Journal of Behavioral Optometry, 23(3), 68-72. Retrieved from https://search.proquest.com/docview/1032813340

Collins LM. (Sep 24 2007) Balancing Act. Deseret News: C01. Available from: https://search.proquest.com/docview/351548677

Donaldson, Mark, BScPhm, R.Ph, PharmD., Gizzarelli, Gino, BScPhm, D.D.S., M.Sc, & Chanpong, Brian, D.D.S., M.Sc. (2008). Oral sedation: A primer on anxiolysis for the adult patient. Oral Health, 98(2), 11-14, 17-18, 21-22, 24, 82-83. Retrieved from https://search.proquest.com/docview/210822891

Gill-Body, K. (2001). Current concepts in the management of patients with vestibular dysfunction. Pt, 9(12), 40. Retrieved from https://search.proquest.com/docview/216835628

Hachmeister JE. An abbreviated history of the ear: from Renaissance to present. The Yale Journal of Biology and Medicine. 2003; 76(2):81-86

Hain, T.C. (2012) Surgical Treatments of Vertigo American-hearing.org/disorders/surgical-treatments-of-vertigo/

Huppert, D., & Brandt, T. (2018). Dizziness and vertigo syndromes viewed with a historical eye. Journal of Neurology, 1-7. doi:http://dx.doi.org/10.1007/s00415-018-8807-x

Huppert, D., Benson, J., Krammling, B., & Brandt, T. (2013). Fear of heights in roman antiquity and mythology. Journal of Neurology, 260(9), 2430-2. doi:http://dx.doi.org/10.1007/s00415-013-7073-1

Kelowna Capital News Vertigo responds well to physiotherapy treatments. (2008, Jan 27). Retrieved from https://search.proquest.com/docview/375944147

Merlingolda, V. (2013). Vestibular rehabilitation: Rehabilitation options for patients with dizziness and imbalance. Nursing Journal of India, 104(1), 18-20. Retrieved from https://search.proquest.com/docview/1536919971

Najeeb (2016, Apr 28). Vertigo can be daunting, but it often can be treated. Saudi Gazette Retrieved from https://search.proquest.com/docview/1784866004

Naguib, M. B., Madian, Y., Refaat, M., Mohsen, O., El Tabakh, M., & Abo-Setta, A. (2012). Characterization and objective monitoring of balance disorders following head trauma, using videonystagmography. The Journal of Laryngology and Otology, 126(1), 26-33. doi:http://dx.doi.org/10.1017/S002221511100291X

Newman-Toker, D. (2007). Diagnosing dizziness in the emergency department: Why "What do you mean by 'dizzy'?" should not be the first question you ask (Order No. 3267879). Available from ProQuest Central. (304856716). Retrieved from https://search.proquest.com/docview/304856716

Patel, V. A., Zacharia, T. T., Goldenberg, D., & McGinn, J. D. (2017). End-organ radiographic manifestations of cranial neuropathies: A concise review. Clinical Imaging, 44, 5-11. doi:http://dx.doi.org/10.1016/j.clinimag.2017.03.014

Phillips, J. O., PhD. (2011, fall). Find your balance. Deafness Research Foundation (U.S.).Hearing Health, 27, 20-20, 22. Retrieved from https://search.proquest.com/docview/906279595

Seiden, H. (1989, Aug 17). Causes of vertigo enough to leave your head spinning. Toronto Star Retrieved from https://search.proquest.com/docview/436012454

Smith, P. F. (2017). Bionic balance organs: Progress in the development of vestibular prostheses. The New Zealand Medical Journal (Online), 130(1461), 56-65. Retrieved from https://search.proquest.com/docview/1938125164

Srinivasan, A.V., Jebasingh, K. (2007, Dec 02). When your world spins. The Hindu Retrieved from https://search.proquest.com/docview/287326340

Strupp M, Fischer C, Hanß L, Bayer O. The takeaway Frenzel goggles: A Fresnel-based device. Neurology. 2014; 83(14):1241-1245. doi:10.1212/WNL.0000000000000838

Strupp M, Brandt T. Diagnosis and Treatment of Vertigo and Dizziness. Deutsches Ärzteblatt International. 2008; 105(10):173-180. doi:10.3238/arztebl.2008.0173.

Susanto, M. (2014). Dizziness: If not vertigo could it be cardiac disease? Australian Family Physician, 43(5), 264-9. Retrieved from https://search.proquest.com/docview/1528598666

Tamaki, C. (2016, Jan). Ears and balance. Hearing Loss Magazine, 37, 26-31. Retrieved from https://search.proquest.com/docview/1897260786

Better balance: Easy exercises to improve stability and prevent falls. (2012). Boston: Harvard Health Publications. Retrieved from ProQuest Central Retrieved from https://search.proquest.com/docview/1370724289

Better balance. (2017). Boston: Harvard Health Publications. Retrieved from ProQuest Central Retrieved from https://search.proquest.com/docview/1992936732

Nervous system diseases and conditions - vertigo; investigators from Ludwig Maximilian university report new data on vertigo (the dizzy patient: Don't forget disorders of the central vestibular system). Health & Medicine Week. Jun 23 2017:3036. Available from: https://search.proquest.com/docview/1910227481

www.american-hearing.org

www.vestibular.org