VESTIBULAR REHABILITATION SIG

APTA & Academy of Neurologic Physical Therapy

Message from the Chair

Anne K. Galgon, PT, PhD, NCS
Vestibular Rehab SIG Chair

This issue of the Newsletter presents information for our first International Conference for Vestibular Rehabilitation (ICVR) that took place in Chicago on August 17-19th, 2018.

The purpose of the ICVR was to bring together world renowned speakers to present various cutting-edge topics with the purpose of advancing the practice of vestibular rehabilitation (VR). Overall the conference was a success for the VR SIG and Academy of Neurologic Physical Therapy (ANPT). Post conference survey responses and personal communications from attendees were overwhelmingly positive. Personally, I was overjoyed to see so many long time VR SIG members and acquaintances who reveled in this groundbreaking event. There were so many clinicians and researchers at the ICVR who are committed to advance the practice of VR. Participating in this conference reminds me that it is truly an exciting time to be a vestibular rehabilitation therapist.

Who was there?

555 individuals including speakers and exhibitors participated in the conference. 373 attendees were ANPT members. Attendees came from 43 states in the US, 4 Canadian provinces, and 20 countries. The conference planners were excited by the world-wide participation. Although our original intention was to educate US trained physical therapists, it was evident that there is a global need for education in vestibular rehabilitation.

What was learned?

Over the 2 ½ days, twenty-seven speakers, international and national, gave 30 minute presentations that were grouped along 5 major themes in 5 sessions: 1) Differentiate Central from Peripheral Vestibular Dysfunction; 2) Motor Learning; 3) Benign Paroxysmal Positional Vertigo: New advances in science and treatment; 4) When Vestibular Rehabilitation Does Not Work or Provides Incomplete Recovery; 5) Future Directions/Where should the science go from here?

VESTIBULAR REHABILITATION SIG OFFICERS:

CHAIR	ANNE K. GALGON, PT, PHD, NCS GALGONANNE56@GMAIL.COM
VICE CHAIR	LEXI MILES, MPT ALEXIA.MILES@FROEDTERTHEALTH.ORG
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NEWSLETTER EDITORS	JASMINE JACKSON, PT, DPT, NCS JJACKSONDPT@GMAIL.COM DEBBIE STRUIKSMA PT, NCS DSTRUIKSMA77@AOL.COM
LIAISON TO ANPT PRACTICE COMMITTEE	ANNA DEJOYA, PT, DSC, NCS ANNA.DEJOYA@MEMORIALHERMANN.ORG
WEB COORDINATOR	MICHELLE GUTIERREZ, PT, DSC MGUTIERREZ28@UTEP.EDU
PODCAST COORDINATOR	MAUREEN CLANCY, PT, DPT MCLANCY1076@GMAIL.COM
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Message from the Chair (cont.)

Speaker panel discussions for questions and answers occurred at the end of each session to add relevancy. At the beginning of the conference, Patty Scheets, ANPT President, welcomed the attendees and Susan Herdman presented a brief Keynote address on the History of Vestibular Rehabilitation.

It is difficult to give enough recognition and praise to the program committee, Susan Whitney, Michael Schubert, and Janet Helminski, who created the program, attained world renown speakers, presented research and clinical experience, and moderated the speaker panels.

Additionally, 58 posters were presented in two evening poster sessions. Posters included original research and case study presentations. A list of speakers and poster presenters and abstracts are available on the VR SIG website, http://www.neuropt.org/special-interest-groups/vestibular-rehabilitation/intrernational-vestibular-rehabilitation-conference.

How can you get information from the conference?

We will disseminate information from the ICVR in several ways. In this newsletter issue some of the attendees of the conference have written summaries of select topics from the conference. Posters that received awards at the conference are also highlighted. We are planning podcasts for this fall and winter that will cover topics presented at the conference. At CSM 2019, Susan Whitney, Janet Helminski and Michael Schubert will present the clinical pearls gained from the conference in a 2-hour educational program. Lastly, topics from the conference will be published in a special supplement to the Journal of Neurologic Physical therapy in 2019.

Who helped to make the conference successful?

A successful conference cannot occur without the help of many individuals. I want to thank everyone who enthusiastically, gave their time and energy to make the conference a success. Without these volunteers the work of the VR SIG and specifically the ICVR would not have been accomplished. I have listed individuals by the activities that they contributed to.

Planning Committee: Anne Galgon, Susan Whitney and, Becky Olson Kellogg
Program Committee: Susan Whitney, Janet Helminski, Michael Schubert
Marketing Committee: Becky Olson Kellogg, Sara Oxborough, Chuck Plishka, April Hodge, Michele Gutierrez,
Poster Abstract Committee: Anne Galgon, Karen Skop, Becky Bliss, Linda D'Silva
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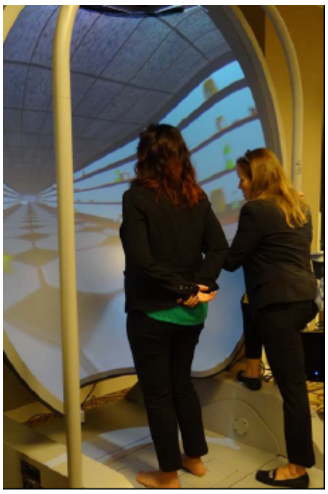
Message from the Chair (cont.)

This conference could also not have occurred without the support of the ANPT Board of Directors and the staff. I would like to thank Sandy (Rossi) Brooks, Lynette Uetz, Andrea Miller, Ali Carlson, and Joann Taie, who gave countless hours to handle the big and small details and assisted the planning committee. Their effective management and onsite presence allowed for the conference to run smoothly.

I would also like to thank the sponsors, exhibitors and advertisers who contributed to the conference experience. Eight companies sponsored the conference and there were 17 exhibitors in the exhibition hall. Fyzical Therapy and balance Centers, Libra Home, Bertec, Interacoustics, Mel-El, Micromedical Tech, Natus, Synapsys, Virtualis, Theraspecs, Perry Dynamics, Motion Guidance, Vestibular Disorders Association, Neuro-Kinetics, Vestibular First, Journal for Vestibular Research, and ANPT.

What is in the Future? Currently, the VR SIG is proposing to have a second ICVR in 2021. We strongly feel that there continues to be emerging knowledge and research that will inform the practice of vestibular rehabilitation. The practice of vestibular rehabilitation is also informing researchers on what needs to be studied. An international conference where researchers and clinicians interact is the ideal forum for this exchange.



Visual Desensitization: Assessment and Rehabilitation Methods for Persons with a Vestibular Disorder

Marousa Pavlou, PT, PhD, BA, MCSP
By: Eric Anson, PT, PhD

At the first International Vestibular Rehabilitation Conference a world class cohort of international experts wowed the audience with exciting and occasionally controversial presentations. All of the presentations had excellent content and the scientist in me appreciated them all. However, the clinician in me always asks "How can I use this to treat my patient on Monday?" Even the most exciting science may not immediately be translatable to clinical practice. "Visual Desensitization: Assessment and rehabilitation methods for persons with a vestibular disorder" presented by Marousa Pavlou, PhD clearly has direct clinical application. By the time her whirlwind presentation was completed, attendees had a roadmap allowing identification of patients who will benefit from visual desensitization, what the therapy should consist of, initial and progressive dosing, expected responses, and an idea of which individuals are less likely to benefit from visual desensitization. This review will focus on the highlights of Dr. Pavlou's presentation and provide clinical pearls related to the application of visual desensitization exercises for the treatment of Visual Induced Dizziness (ViD).
Initially, it is important to have a clear definition for ViD. Historically, several research groups described a similar cluster of symptoms using different terminology such as: visual vertigo (Bronstein et al. 1995), space and motion discomfort (Jacob et al. 1993), visual vestibular mismatch (Mallinson & Longridge, 2004), and motorist disorientation syndrome (Page & Gresty, 1985). According to Dr. Pavlou, each of these research groups was likely describing ViD. In 2009, the Bárány society clarified the definition of ViD as follows: "Dizziness triggered by a complex, distorted, large field or moving visual stimulus including the relative motion of the visual surround associated with body movement" (Bisdorff et al. 2009). With ViD the symptom provoking visual motion can occur when viewing environmental motion while the person is stationary or induced by self-motion. Using this definition, patients can be identified who are appropriate for visual desensitization exercises (Bronstein, 2016). Examples of complex full field visual motion which may provoke symptoms include: watching movies, scrolling a computer screen, observing moving crowds or traffic, walking through crowds, and walking down supermarket aisles. ViD is currently thought to occur due to inflexible sensory weighting strategies in postural or perceptual contexts resulting in over-reliance on visual inputs (Maire et al. 2017). Therefore, Dr. Pavlou recommends treatment emphasizing neural adaptation and sensory re-weighting from vision to vestibular inputs.
Clinically, ViD can often be identified through the patient history but there are several surveys that capture symptoms of ViD including: 1) the Situational Characteristics Questionnaire (Jacob et al. 1993); 2) the Visual Vertigo Analogue Scale (Dannenbaum et al. 2011); or 3) the Pediatric Visually Induced Dizziness Questionnaire (Pavlou et al. 2017). The rod and frame test and dynamic posturography do not identify or distinguish individuals with ViD from healthy controls. According to Dr. Pavlou, the rod and disc test is the only known objective measure that distinguishes individuals with ViD from healthy individuals (Cousins et al. 2014). Unfortunately at this time there are no identified diagnostic cut off values for rod and disc scores to identify ViD. Therefore, Dr. Pavlou's current recommendation for documenting the presence of ViD is based on a thorough clinical history and one or more of the validated questionnaires listed above. Determining from the patient history which visual motion scenarios trigger symptoms is imperative to guide treatment.

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Visual Desensitization: Assessment and Rehabilitation Methods for Persons with a Vestibular Disorder cont.

Marousa Pavlou, PT, PhD, BA, MCSP
By: Eric Anson, PT, PhD

After identifying individuals with ViD, the next step is to develop an intervention protocol. The key to treating ViD is to incorporate optokinetic stimulation (OKS) into an individualized vestibular rehabilitation program. Dr. Pavlou highlighted that OKS should not be used in isolation to treat ViD. According to Dr. Pavlou's research, the most important treatment aspect is including appropriate OKS training and the method (i.e. videos vs. expensive disco-ball) is less important (Pavlou et al. 2013). In her study, OKS was provided 1x/week for 8 weeks in supervised sessions lasting 45 minutes using either a disco-ball or videos on a DVD. All subjects watched the OKS video DVD at home daily in addition to their customized vestibular rehabilitation exercises. A third group only viewed the OKS DVD at home without the weekly supervised visits. The OKS stimulation was presented in 2 minute bouts with 1 or more minutes of rest starting with 4 exercises and increasing by 2 additional exercises each week. During the OKS, subjects gradually progressed from sitting to standing to walking and from head still to head turning. Similar reduction in ViD symptoms was reported in all groups. Interestingly, the dropout rate of the unsupervised group was 55% while only 10% dropped out from either of the supervised groups highlighting the greater impact for supervised rehabilitation through less attrition.
Dr. Pavlou also discussed factors essential to consider when patients experience limited or slow recovery or worsening of ViD symptoms. OKS must be carefully introduced, as too much or too soon will be overwhelming and slow progress. The OKS stimuli must be appropriate, meaning it should result in increased symptoms. However, activities should be stopped if they provoke moderate to severe symptoms. Incorrect or non-specific instructions and lack of progression will also limit the benefit of OKS for ViD. Migraneurs and individuals with abnormal binocular vision (strabismus and convergence insufficiency) will also progress more slowly. Individuals with vestibular migraine in particular may need shorter OKS exposure times (15 seconds vs. 2 minutes) and slower progression to avoid excessive provocation.

CLINICAL PEARLS

- Do not introduce OKS too early! The first session in clinic may be too early and overwhelming which could lead to a negative outcome.
- Screen size matters, a cell phone is too small. An iPad or laptop is a more ideal screen size. A full immersive surround is also unnecessary.
- Visual motion videos exist on You Tube: walking, driving, running, rollercoasters, and optokinetic stripes allow for flexibility and variety.
- Vary the distance to the screen from near to far.
- Progress from sitting to standing to walking, without then with head motions.
- Give specific instructions on "how to watch" the OKS: Start with "stare through the motion," progress to target fixation, scanning, saccades, or X1 viewing.
- Gradually progress exposure and exercise complexity!

Visual Desensitization: Assessment and Rehabilitation Methods for Persons with a Vestibular Disorder cont.

Marousa Pavlou, PT, PhD, BA, MCSP
By: Eric Anson, PT, PhD

In summary, carefully structured and gradually progressed OKS in conjunction with individualized vestibular rehabilitation can be effective in treating visual induced dizziness. Dr. Pavlou reminded us that many unanswered questions remain regarding optimal type and dosing of OKS, and whether virtual reality will prove to be a useful training method. There are several research groups actively investigating those questions, so expect updates in the future. Dr. Pavlou provided evidence supporting the use of OKS for the treatment of visual induced dizziness which we can all implement with appropriate patients on Monday!

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Light cupula: An emerging new concept for positional vertigo

Dr. Chang-Hee Kim, MD, PhD
By: Becky Bliss, PT, DPT, NCS

Dr. Kim Chang-Hee gave an enlightening discussion on the emerging new concept for positional vertigo, “Light Cupula.” In individuals with benign paroxysmal positional vertigo (BPPV) involving the lateral (horizontal) canal, the nystagmus is characterized as directional-changing positional nystagmus (DCPN). When the DCPN beats towards the lower ear or towards the ground (geotrophic) it is considered canalithiasis. In canalithiasis, the otolith particles are moving dependent of gravity and elicits transient nystagmus that is fatigable. In the rare case of light cupula, patients show persistent geotrophic DCPN without latency or fatigability. In normal functioning, the semicircular canals are said to be independent of gravity because the specific gravity of the cupula is equal to that of the surrounding endolymph. The theory of light cupula has emerged and is explained by the cupula becoming “lighter” than the surrounding endolymph and the deflection of the cupula occurs under the influence of gravity and therefore produces persistent nystagmus. The observed nystagmus would be seen in the upright seated position and be spontaneous beating towards the unaffected side. The nystagmus would cease when the head is bent forward 30 degrees placing the horizontal canal parallel to the horizontal plane and perpendicular to the direction of the gravitational force. Therefore, persistent nystagmus toward the affected side and towards the healthy side would be seen in the bowing and leaning positions respectively.

When performing a head roll test (HRT) a persistent geotrophic nystagmus would be present and the intensity would be stronger toward the affected side secondary to Ewald’s Law. When the head is turned slightly towards the affected side in the supine position until the horizontal canal cupula is aligned with the plane of the gravitational vector the nystagmus stops and this is named the “null plane.” The presence of this null plane is critical in differential diagnosis and determination of the laterality of the cupula involved. Table 1 from Kim et al. describes differentiating light cupula from horizontal canalithiasis.

Table 1. Characteristic findings in positional nystagmus to differentiating LSCC canalolithiasis from light cupula

	LSCC canalolithiasis	Light cupula
Head-roll test		
Direction	Geotropic DCPN	Geotropic DCPN
Duration	Transient	Persistent
Latency	Yes	No
Null plane	No	Yes
Fatigability	Yes	No

Adapted from Kim, et al. Laryngoscope 2014;124:E15-9 [3]. DCPN: direction-changing positional nystagmus, LSCC: lateral semicircular canal

Treatment of this condition has not been established yet as the pathophysiological mechanism is unknown. Procedures such as Barbecue Roll and Gufoni have been ineffective and symptoms of vertigo and positional nystagmus resolve spontaneously within 2 weeks in individuals with suspected light cupula. This condition is not well known and is emerging and therefore may be underdiagnosed. It will be exciting to see continued research evolve as well as treatment methodologies.

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Mal de Debarquement and TMS: New findings

Dr. Yoon-He Cha, MD
By: Sara Oxborough, MS, PT

Mal de Debarquement is a syndrome that typically occurs after exposure to passive transport, although it can also occur spontaneously. The features of MdDS include oscillating vertigo, fatigue, mental clouding "brain fog," visual motion intolerance, anxiety, headaches, and tinnitus. Symptoms go away with re-exposure to passive motion such as going back to riding in a car and patients will even rock or sway themselves. The literature has shown 69% of cases are due to water transportation, there is a 4 to 1 female to male incidence, and the median age of onset is 44 years old, with a range from 12-70. Current treatment options for Mal de Debarquement Syndrome (MdDS) are limited but recent research presented by Dr. Yoon He-Cha at the ICVR shows promising results. This synopsis will review some of those results.

The current thought is that MdDS is a neurological condition that represents a maladaptive brain state resulting from entrainment to external oscillating motion at very low frequencies. The connectivity and activity in the entrainable elements of the brain are different in MdDS patients than healthy controls. Therefore, the goal in treating MdDS is using a second oscillator to uncouple underlying abnormal functional connectivity via Transcranial Magnetic Stimulation (TMS).

Repetitive transcranial magnetic stimulation (rTMS) is a noninvasive procedure that uses magnetic fields to stimulate nerve cells in the brain by inducing an electrical current. Low frequency rTMS (<=1Hz) induces local inhibition whereas high frequency rTMS (>=5Hz) induces local excitation. According to imaging studies, when compared to healthy controls, patients with MdDS have shown a relative hypermetabolism in the left entorhinal cortex (EC) and amygdala with relative hypometabolism in prefrontal cortex, including the dorsolateral prefrontal cortex (DLPFC); rTMS intervenes by normalizing the abnormal connectivity.

Subjects who qualified for use of rTMS in studies done by Dr. Cha have had symptoms for over 6 months, have failed at traditional vestibular therapy, and SSRI and/or benzodiazepine medications are ineffective. In the first study done using rTMS for MdDS in 2013, symptom improvement was noted with a treatment protocol that included one session each of four counterbalanced protocols: left 10Hz, left 1Hz, right 10Hz, and right 1Hz rTMS over the DLPFC. High frequency left DLPFC stimulation gave the most positive effects and subjects tolerated the treatment well.

A study in 2017 refined the treatment protocol further and used functional imaging to examine the neuromodulatory effect of rTMS on MdDS to determine if biomarkers exist that could predict the success of rTMS. Twenty individuals with MdDS underwent five daily treatments of rTMS over the DLPFC of 1Hz over right DLPFC followed by 10 Hz over left DLPFC. The positive responders showed a reduction in functional connectivity between the EC and the precuneus, right inferior parietal lobule, and the contralateral EC, which are part of the posterior default mode network. They had also started with a higher baseline functional connectivity between the DLPFC and the EC than other subjects. Symptom improvement was also noted to be correlated with resting-state intrinsic functional connectivity (IFC) or baseline connectivity. A study done in 2018 sought to look at IFC changes induced by rTMS using EEG and determined symptom correlation. IFC between different components quantified as Inter-Independent Component Phase Coherence (ICPC) measured at six different frequency bands: delta (1–4Hz), theta (5–7Hz), low alpha (8–10Hz), high alpha (11–13Hz), beta (14–30Hz), and gamma (>30Hz). Those with improvement showed fronto-parietal connectivity changes with an increase in low alpha connectivity and a decrease in high alpha/beta/ gamma connectivity. Furthermore, as patients with MdDS exhibit a broad pattern of highly synchronous theta and alpha activity over most brain regions, it was found that the more IFC desynchronizations that occurred the better.

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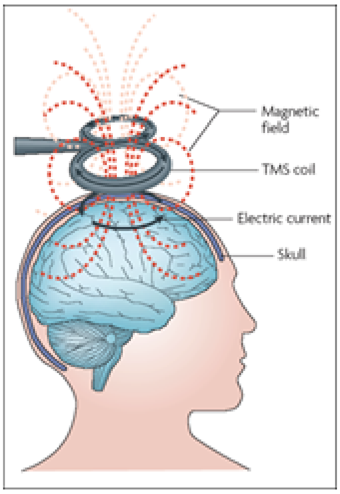
Mal de Debarquement and TMS: New findings cont.

Dr. Yoon-He Cha, MD
By: Sara Oxborough, MS, PT

To date, all the previous studies have helped to establish possible biomarkers and to look to target specific frequency bands for treatment. Dr. Cha's current work is looking at continuous theta burst stimulation to 3 areas of the brain: the parietal/occipital cortex, cerebellar vermis VII, and lateral cerebellum. Subjects are currently undergoing 30 hours of treatment during a five-day period with follow up measures taken over six weeks. So far theta burst stimulation showed more improvement compared with the prior protocol of 1Hz right /10Hz left over the DLPFC.
Current treatment is limited for those with MdDS. Transmagnetic stimulation is showing promising results with good patient tolerance. Mapping of connectivity between different parts of the brain may help to determine who would best benefit from rTMS. The type of rTMS also continues to be investigated. As the research continues to be refined patients may someday be able to look forward to TMS kits that could be used in a clinic setting to reduce or eliminate symptoms from MdDS.



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Implications for Vestibular Input to the Hippocampus for Vestibular Rehabilitation

Dr. Paul F. Smith, MAppl, Stat (Hons), PhD, DSc
By: Janet Callahan PT, DPT, MS, NCS

Recent evidence details changes in cognitive function associated with vestibular dysfunction and dizziness and finds that balance training improves memory and spatial cognition in healthy adults.(1,2) The basis for this relationship involves the hippocampus and its role in spatial cognition and spatial memory. Hippocampal neurons encode an animal's location via what are known as "place cells" that fire when an animal is in a specific location in the environment. The tuning of these place cells is dependent upon the integration of both self-motion and external cues. The role of the vestibular system in detecting self-motion of the head render it a likely source of information to the hippocampus which Dr. Smith detailed nicely in his presentation.

Evidence from both human and animal studies details the impact of vestibular dysfunction on spatial memory, attention, and learning documenting changes at both the physiologic and structural levels of the hippocampus. In a study by Brandt et al, patients demonstrated significant deficits compared to age matched controls when performing a virtual Morris water test in which patients are presented with a virtual pool with certain visual cues and are required to locate an escape platform by utilizing directional computer keys to negotiate the environment.(3) Zheng et al (2009) looked at the association between vestibular dysfunction and attention using a five choice serial reaction time task.(4) Rats with surgically induced bilateral vestibular dysfunction (BVD) took longer than sham animals to reach the designated 70% correct response rate and produced more errors. In a different study, Zheng et al (2007) used a spatial forced alteration task in a T maze which is sensitive to the integrity of the hippocampus to evaluate learning and memory in rats with BVD compared to sham controls.(5) Rats with BVD made significantly fewer correct choices at 3 weeks, 3 months and 5 months following surgery. The authors concluded that BVD causes long-term impairment of hippocampal function. Semenov et al, using data from the National Health and Nutrition Examination survey studied the association between vestibular dysfunction and cognitive dysfunction in 1,303 adults > 60 years of age and determined that vestibular dysfunction, measured by the modified Romberg test mediated 14.3% of the affect of age on cognitive performance.(6)

Dr. Smith then goes on to detail the nature of the changes in the hippocampus. Studies by Graf(7) and Russell et al(8) found a significant loss of location specificity for places in the environment by hippocampal place cells in rats with BVD compared to sham animals. Harvey et al looked at hippocampal place cells in otoconia deficient mice and found reduced spatial coherence and formed place fields.(9) The authors concluded that linear self-motion information from the otoliths is necessary for the development of stable place fields. Using MRI volumetry, Brandt et al found that patients with acquired chronic vestibular loss develop a significant 17% loss of the hippocampus bilaterally compared to controls.(3) Further, when tested with a virtual Morris water task patients demonstrated significant spatial memory and navigation deficits.

Lastly, Dr. Smith addressed the interaction between the hippocampus and the striatum. According to Lee et al the hippocampus is responsible for processing spatial information while the striatum is engaged in instrumental conditioning, a learning process by which behavior is modified by the reinforcing or inhibiting effects of the resulting consequences. Using a modified water maze task with mice surgically lesioned in either the hippocampus or striatum, Lee et al found that the hippocampal and striatal systems compete with each other in a bidirectional fashion.(10) Disruption of the dorsal hippocampus resulted in impaired spatial memory and increased cued or procedural learning due to enhanced striatal function while lesions in the striatum resulted in improved spatial memory and decreased procedural learning. Machado et al studied the results of BVD on learning strategies of a spatial task in rats using a reversed T-maze paradigm and found that 100% of rats with BVD shifted to a response strategy or procedural learning while controls used spatial and response strategies equally.(11)

Implications for Vestibular Input to the Hippocampus for Vestibular Rehabilitation cont.

Dr. Paul F. Smith, MAppl, Stat (Hons), PhD, DSc
By: Janet Callahan PT, DPT, MS, NCS

There is clear-cut evidence that vestibular dysfunction results in impaired spatial cognition with associated changes to the hippocampus that has an affect on learning strategies used by impaired individuals. Since spatial cognition is integrated with other forms of cognition, these changes may impede the way in which patients with vestibular dysfunction respond to vestibular rehabilitation. Indications that the otoliths have a role in forming stable place fields might suggest that linear movement could also be an important component of a comprehensive vestibular rehabilitation program. Findings that vestibular rehabilitation and balance retraining may improve cognitive deficits should encourage clinicians to consider evaluating and treating vestibular dysfunction in older individuals who have a proclivity to hair cell loss and associated age-related vestibular dysfunction. Finally, availing ones self of ways to evaluate spatial cognition, i.e. computer based virtual reality programs, may provide for an important outcome measure in addition to a source of clinical research.

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JOHNS HOPKINS MEDICINE
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Vestibular Loss and Cognitive Decline in Aging Adults

Dr. Yuri Agrawal, MD, MPH
By: Linda D'Silva

The relationship between aging and cognitive decline has been well established, as has the relationship between aging and the vestibular system. However, the mechanism by which vestibular loss affects cognition in aging adults is not clear. At the International Conference of Vestibular Rehabilitation 2018, this relationship was explored by many speakers. Dr. Yuri Agrawal and Dr. Peter Smith focused their presentations on examining the relationship between the vestibular organs, the hippocampus, and cognitive decline.

The 5 domains of cognitive function include: language, executive function, attention, memory and visuospatial ability. Vestibulo-cortical-hippocampus connections are vital for spatial memory and spatial navigation. The hippocampus contains "spatially selective" neurons called place cells, which play an important role in spatial memory (O'Keefe 1971). Animal studies have shown that rats with bilateral vestibular loss have impaired spatial memory and made more errors during navigation while performing foraging tasks (Baek 2010). Patients with bilateral vestibular loss had reduced hippocampal size and impaired spatial memory and navigation (Brandt 2005). In fact, in a large NHANES study examining 1303 community dwelling adults, vestibular dysfunction was an important mediator, accounting for 14.3% of the relationship between age and performance on cognitive tests (Semenov 2016). Of interest to healthcare professionals, the cognitive impairment that resulted from vestibular loss contributed to difficulty performing ADLs and falls.

In a longitudinal study of community dwelling older adults, the relationship between vestibular loss and performance of visuospatial cognitive tests showed that decreased vestibular function was associated with poor visuospatial ability, and working memory and attention. Of all the vestibular organs, saccule function was significantly associated with spatial cognitive skills and working memory (Bigelow 2015). In another longitudinal study examining the relationship between vestibular function and hippocampal volume in 103 adults over 60 years of age, Kamil et al. found a strong relationship was seen between saccule function and hippocampal volume. In fact, for every 1µV amplitude increase in cVEMP amplitude there was a 319.1 mm3 increase in mean hippocampal volume (Kamil 2018). Besides hippocampal volume change, changes were seen bilaterally in the caudate nucleus, putamen, amygdala, thalamus, and insula cortex.

Another proposed theory is that degeneration of the connections between the horizontal semicircular canals and various parts of the cortex, particularly the posterior parietal-temporal, medial-temporal, and posterior cingulate are possible mechanisms leading to Alzheimer's disease (Previc 2013). Patients with Alzheimer's disease may present with various impairments, with some having a memory impairment compared to other with spatial impairments. Vestibular loss is the proposed mechanism in patients with Alzheimer's disease with the spatial subtype of Alzheimer's disease. In this subtype, patients have spatial disorientation, wandering and falls. Wei et al. noted that in patients with Alzheimer's disease who were spatially impaired, 96% had vestibular loss (Wei 2017). Figure 1 is a conceptual model showing the relationship between aging, vestibular loss, and neurodegeration leading to loss in cognitive function.

Vestibular Loss and Cognitive Decline in Aging Adults cont.

Dr. Yuri Agrawal, MD, MPH
By: Linda D'Silva

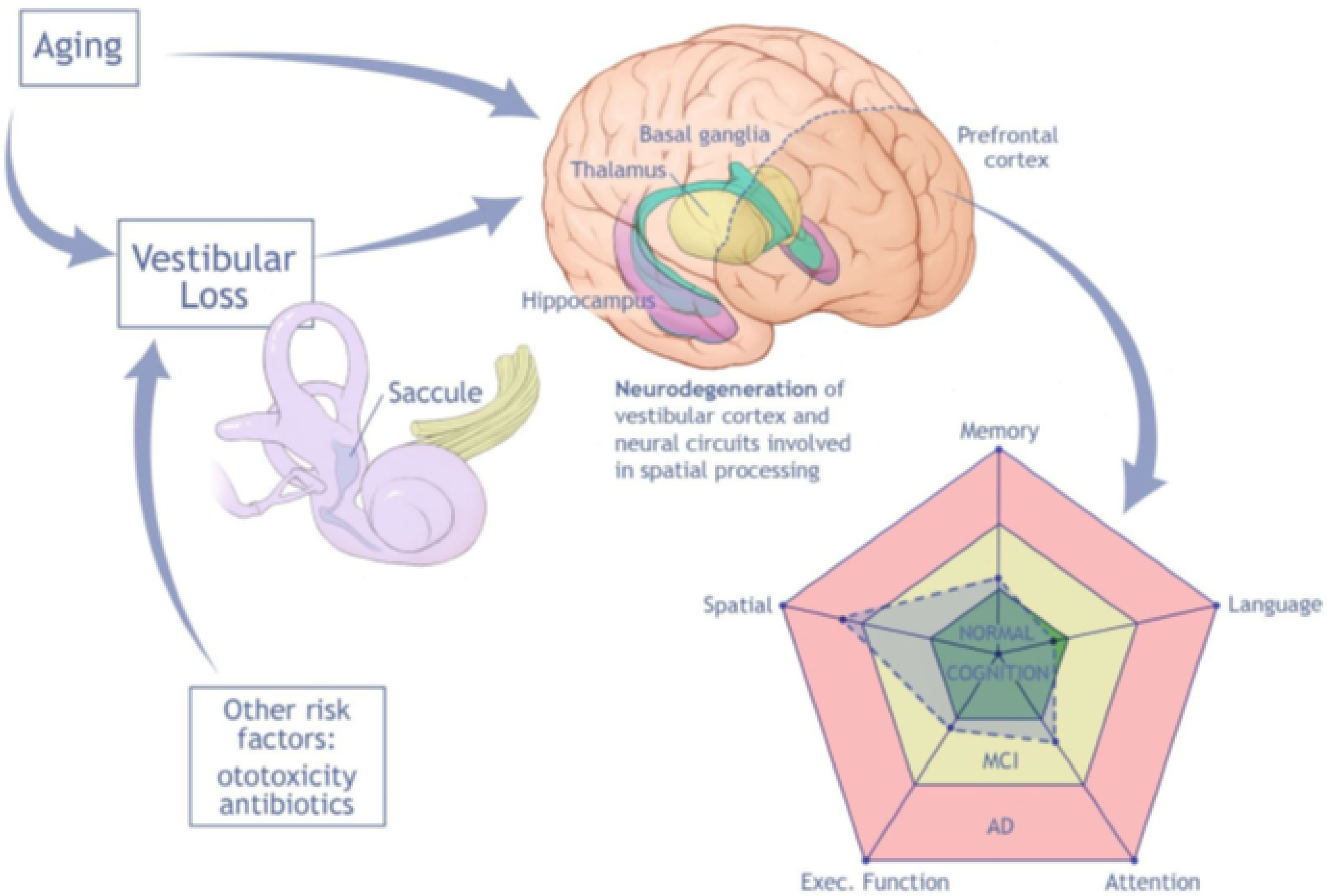

Figure 1. Conceptual model: Vestibular loss and cognition in aging. Presented by Dr. Yuri Agrawal, Johns Hopkins Medical Center

Implications for Vestibular Rehabilitation

Considering the strong relationship between vestibular loss and cognitive function, physical therapists need to consider cognitive function as a target of vestibular therapy. Vestibular rehabilitation should broaden its scope to include spatial memory training and navigation training. We need to consider vestibular therapy for people with Alzheimer's disease and dementia.

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DSGZ

DIZZYNET – The European Networks Attempt to Collect "Big Data"

Dr. Andreas Zwergal, MD
By: Chuck Plishka

Dr. Andreas Zwergal presented the work of European clinicians and researchers on developing DIZZYNET - an organizational structure developed to collect data and further the efforts of vestibular rehab and research. There are 70 members representing 20 European countries that began organizing in 2014. The vision is that the organization is a "platform for interaction of clinicians and researchers in the field of vestibular medicine in the areas of:"

- Basic and clinical research
- Clincal studies
- Patient Management
- Teaching and Training

DIZZYNET has created a pilot databank to collect data which will be available to members for research. Through their efforts a European UEMS initiative for common curriculum in vestibular medicine has been created. They also provide annual joint teaching events, network meeting and joint publications. Through an initiative with the Barany Society, DIZZYNET is establishing a UEMS Certification in Vestibular Medicine and decided to setup a subsection for Vestibular Medicine. A pilot study comparing vertigo patients from Germany and Turkey has just been completed using the collective database. This type of investigation is allowing scientists to study how vertigo affects individuals across cultures and identify similarities as well as differences. DIZZYNET is an exciting example of how a collective group of experts can advance vestibular medicine and ultimately, improve patient care.

DIZZYNET

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Winner for Best Poster for Original Research

Preliminary Evidence and Associated Characteristics for Vestibular and Oculomotor Clinical Profiles following Concussion

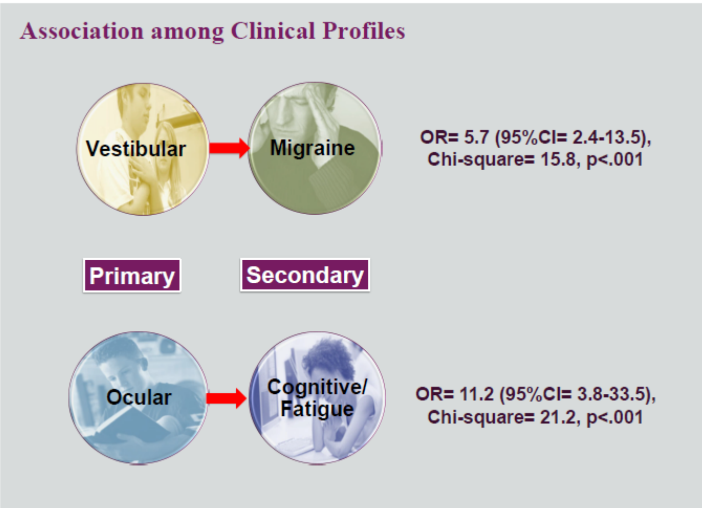
Anne Mucha, PT, DPT, NCS; Victoria Kochick, PT, DPT, NCS; Michael W. Collins, PhD; Anthony P. Kontos, PhD

Background and Purpose: Following concussion, unique clinical profiles may present.1 Vestibular and oculomotor findings are highly prevalent and associated with worse outcomes.2 Despite the negative relationship to recovery, these deficits may be modified with rehabilitation.3 The purpose of this study is to examine the prevalence of vestibular and oculomotor profiles; identify associated clinical findings and risk factors; and examine the relationship between vestibular, oculomotor and other profiles after concussion.

Methods: A total of 141 patients seen for initial evaluation in a multi-site specialty concussion clinic were included in the study. All patients were seen between October 2016 and November 2016, within 90 days of a diagnosed concussion. Following IRB approval, data were obtained from de-identified medical records and included demographics, medical and injury history, clinical exam findings, Vestibular Ocular Motor Screening (VOMS), and Post-Concussion Symptom Scale (PCSS). Patients were adjudicated by clinicians to be in one or more of the following clinical profiles: 1) vestibular, 2) oculomotor, 3) cognitive, 4) migraine, 5) anxiety/mood. A series of chi-square analyses and odds ratios (OR) followed by logistic regression (LR) were used to determine which factors were associated with the vestibular clinical profile. Chi squares with odds ratios were used to evaluate the relationship of the vestibular profile to other clinical profiles.

Results: Participants included 55% females (n=78), between 9-60 years (M=23.3, SD=12.7). The vestibular profile was the primary profile in 23% (n=32) and oculomotor was the primary for 15% (n= 21). Results of the first LR (R^2= .17, p<.001) indicated that an increase in VOMS VOR over baseline (Adj OR= 6.4, p<.001) was the best predictor of the vestibular profile. Results of the second LR (R^2= .40, p<.001) indicated that being male (Adj OR= 5.0, p=.01), reporting vision difficulties (Adj OR= 4.0, p=.02), difficulty reading (Adj OR= 6.6, p=.005), and a near point of convergence distance > 5cm (Adj OR= 5.1, p=.02) were the best predictors of the oculomotor profile. The vestibular profile was associated with an increased likelihood of a co-occurring migraine profile (chi square= 15.8, p<.001, OR= 5.7, 95% CI= 2.4-13.5). The oculomotor profile was associated with an increased likelihood of a co-occurring migraine profile (chi square= 21.2, p<.001, OR=11.2, 95% CI= 3.8-33.5).

Discussion/Conclusion: Vestibular and oculomotor profiles appear to be the primary presenting profile in a significant portion of patients following concussion. Important evaluative findings and risk factors are linked to identification of these profiles and can be utilized to inform clinical care and identify those who may benefit from vestibular and oculomotor therapies. Both vestibular and oculomotor profiles are significantly comorbid with the post-traumatic migraine profile.



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Winner for Best Poster for Case Study

Use of Posturographic Data as a Clinical Education Tool to Decrease Fear-Avoidance Behaviors in Persons with Dizziness: A Case Study

Stephanie Semerda, PT, DPT, Tina Stoeckmann, PT, DSc, MA, Brittany Kennedy, PT, DPT, NCS

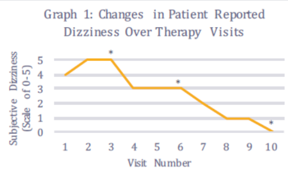
Background and Purpose: Half of the individuals who report having dizziness experienced some disability related to their symptoms, and 46% reported anxiety and/or avoidance of the movements and situations eliciting dizziness and anxiety. Patients with dizziness often restrict their activities due to associations of instability and fear of falling resulting from their symptoms which can result in fear-avoidance behaviors (FAB). Computerized posturography measures sensory interactions for equilibrium, and provides a quantitative way to assess sensory reorganization. Therefore, while posturographic data provides a means to document improvements in sensory reorganization, and can also be used as visual feedback to illustrate progress in therapy. In this case study, we hypothesized that posturography performance could be used as an education tool to demonstrate progress in vestibular rehabilitation to decrease FAB and health anxiety in a patient with acute dizziness.

Case Description: A 72-year-old male presented to the outpatient physical therapy clinic following a three-day acute onset of dizziness. Patient evaluation revealed a right unilateral vestibular hypofunction. PMH significant for phobias related to hospital procedures. Within two weeks of onset of physical therapy plan of care, the patient started to demonstrate increased disease preoccupation, and self- limitation of exercise and activity. Use of Sensory Organization Test (SOT) results over the course of 10 weeks were used to document progress and were discussed with the patient to minimize his FAB and health anxiety symptoms.

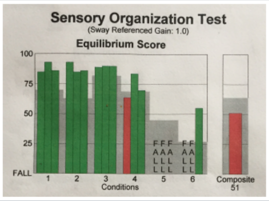
Outcomes: Improvements were seen between SOT test and re-test data from week 3 (n = <5%), week 6 (n = 30%) and week 10 (n = 60%). Following education of progress with posturographic data, patient reported a decline in subjective reports of dizziness from baseline report of 4/5 to visit 4 at 3/5, visit 7 at 2/5, and visit 10 at 0/5. Return to previously avoided activities such as lying down/sitting up, walking for exercise, and walking to/from appointments occurred by discharge.

Discussion: We propose that the use of posturographic data can be used as a means to educate patients on their progress, and as a way to deescalate arising anxiety symptoms and FAB. In our case, the use of objective posturographic data served as a means to decrease patient subjective reports of dizziness and assisted this patient in returning to previously avoided activities.

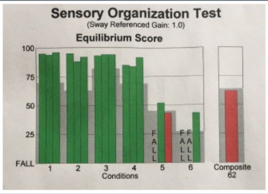
GRAPH 1



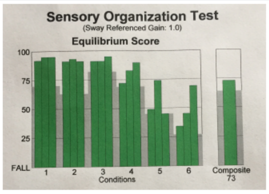
POSTUROGRAPHIC DATA VISIT 3



POSTUROGRAPHIC DATA VISIT 6



POSTUROGRAPHIC DATA VISIT 10



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Winner for Honorable Mention for Original Research

Unilateral Incremental Vestibulo-ocular Reflex Adaptation (IVA) Training Dynamically Tailored for Each Subject

Christopher J Todd, Michael C Schubert, William VC Figtree, Americo A Migliaccio

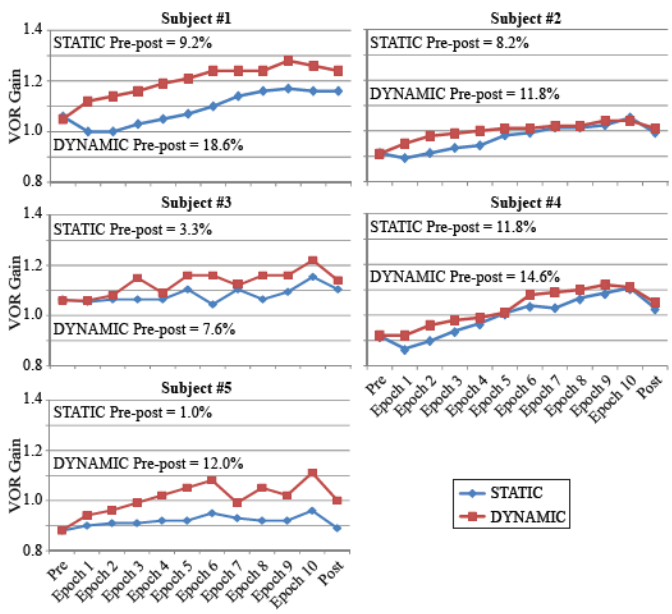
Background and Purpose: Unilateral VOR adaptation (IVA) increases the VOR gain (=eye/head velocity) for head rotations to one side by ~10%. Prior IVA studies involved setting the initial VOR training gain demand at the subject's starting value (=1 in a normal subject), with the gain pre-set to increment by 0.1 every 90 secs over 15 mins. At some point during training the VOR can no longer match the gain demand. We determined if a dynamically calculated gain demand (=actual gain+0.1) would result in greater adaptation.

Methods: Using a hybrid video-oculography and StableEyes training system we measured the active (self-generated head impulse) and passive (imposed, unpredictable, head impulse) VOR gain in 5 normal subjects before and after 15 mins of STATIC (i.e. pre-set) and DYNAMIC IVA training consisting of active, leftward and rightward, horizontal head impulses (peak-amplitude 15deg, peak-velocity 150deg/s and peak-acceleration 3000deg/s^2). We also measured the active VOR gain during training.

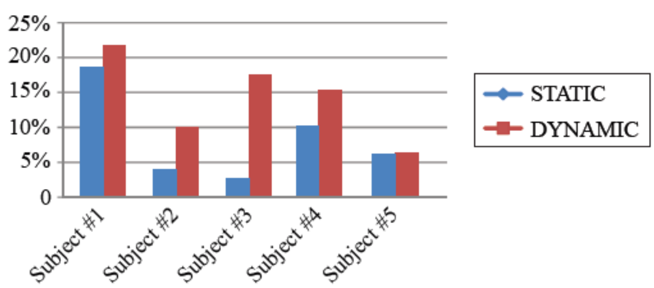
Results: In these subjects, the active and passive VOR gains, measured before and after training, respectively, increased towards the adapting side by 6.7 ± 4.5% and 8.2 ± 6.6% after STATIC and 12.9 ± 4.0% and 14.2 ± 6.0% after DYNAMIC IVA training (paired t test between STATIC and DYNAMIC: active p=0.02, passive p=0.07). The active VOR gain increase peaked at 12.5 ± 4.8% during STATIC and 19.6 ± 4.4% (paired t test, p=0.06) during DYNAMIC IVA training.

Discussion and Conclusions: Our data suggest that DYNAMIC IVA training is optimal for VOR adaptation and has the added benefit that the training demand is dynamically adjusted for each subject. This means the VOR gain demand is always a small amount above the actual gain, as opposed to the situation where there is a steadily increasing gap between actual and training demand gains. It also allows more flexible training, e.g., spread training over several smaller time blocks, without undoing prior adaptation.

Active VOR before (pre), during and after (post) adaptation training



Passive VOR gain % increase as a result of adaptation training



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Winner for Honorable Mention for Original Research

Size Matters for Vestibular Perception of Spatial Orientation

Eric Anson, PT, PhD, Yoav Gimmon, PT, PhD, Peter Boutros, BS, Michael Schubert, PT, PhD

Background/Purpose/Hypothesis: Chronic dizziness can lead to abnormal self-motion perception. Perceptual training may improve chronic dizziness. In darkness, accurate rotation perception across rotation sizes depends on some intact vestibular function. Prior studies limited rotation numbers to avoid vestibular reflex and perception attenuation, as occurs with repeated constant velocity rotations. We hypothesize that self-motion perceptual accuracy will decrease as rotation size increases, but not degrade with repetition.
Subjects: 15 healthy adults, mean age 31.2 (SD = 7.96) years were tested.
Materials/Methods: Individuals sat in a motorized rotary chair and experienced 100 position step rotations (10 blocks of 10 rotations) in the dark of 45, 90, 135, and 180 degrees following a trapezoidal velocity profile with peak velocity of 60 degrees/second. Rotation directions alternated right and left. The order of rotation size was randomly determined for each subject. After each rotation, subjects verbally reported the perceived size of the rotation. Perceptual responses were compared to actual rotation size to determine accuracy (Perceptual Gain). Subjects did not receive feedback regarding their accuracy. Repeated measures ANOVAs were used to determine 1) whether average perceptual gain changed with rotation size; 2) whether average perceptual gain decreased across rotation blocks; and 3) whether the number of errors increased across rotation blocks, while accounting for within subject repeated rotations. Alpha was set to 0.05 for all comparisons.
Results: Perceptual accuracy for vestibular spatial orientation significantly declined with increasing rotation amplitude ($F(1,3) = 18.22$, $p < 0.001$). Average perceptual gain was stable across the 10 blocks of rotations ($F(1,9) = 1.52$, $p < 0.208$). The number of errors did not change across the 10 blocks of rotations ($F(1,9) = 1.15$, $p < 0.342$).
Conclusions: These results indicate that larger rotation sizes in fact do reduce the accuracy of vestibular perception of spatial orientation in healthy adults. However, the number of position step rotations does not impact the accuracy between repetitions. This provides the groundwork for how to develop novel treatments for perceptual impairments in chronic dizziness.
Clinical Relevance: Repeated position step rotations could be incorporated into a perceptual re-training paradigm with clinical applications to individuals with chronic dizziness.

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Winner for Honorable Mention for a Case Study

Undetected Cranial Cerebrospinal Fluid Leak in a Young Woman Referred to Physical Therapy for Chronic Dizziness

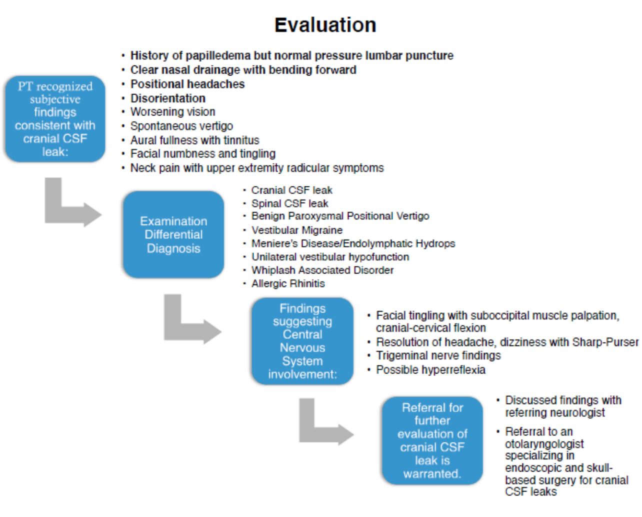
Chelsea R. Van Zytveld, PT, DPT

Background and Purpose: Cranial cerebrospinal fluid (CSF) leaks are challenging to diagnose as patients with leaks often present with non-specific symptoms including vertigo, imbalance, visual changes, and headache. CSF leaks are usually caused by head trauma or sinus surgery but can occur spontaneously. The purpose of this case report is to educate providers about the signs and symptoms of cranial CSF leaks by describing the physical therapy evaluation and differential diagnosis of chronic dizziness in a young woman.

Case Description: An overweight female in her 20s presented to an outpatient physical therapy clinic for evaluation of dizziness described as spinning, disorientation, and unsteadiness. Her dizziness began 7 years ago and increased with standing upright, closing her eyes, getting out of bed, bending forward, walking in stores, moving her eyes, and raising her head after looking down. She also reported spontaneous vertigo independent of position change, imbalance, frequent falls, daily headaches, aural fullness, tinnitus, worsening vision, neck and back pain, and tingling in her face, neck, and back. Further questioning revealed she had clear drainage from her nose with bending forward and her headaches were worse standing up. Medical history was notable for 7 motor vehicle accidents, migraines, seasonal allergies, suspected pseudotumor cerebri, and papilledema. Evaluation of her vestibular system, oculomotor system, and cervical spine revealed findings suggestive of central nervous system pathology.

Results: The physical therapist referred the patient to an otolaryngologist specializing in endoscopic and skull based surgery for CSF leaks. Magnetic resonance imaging of her brain showed signs of low intracranial pressure including dry ventricles and brain slumping resulting in Chiari malformation. A maxillofacial and sinus computed tomography (CT) scan showed an old fracture near the cribiform plate. CSF rhinorrhea was confirmed with radionuclide cisternography with nasal pledgets. The patient underwent endoscopic sinus surgery with repair of a CSF leak in roof of her ethmoid sinus. The patient reported improvement in her symptoms; however, she continued to have intermittent headaches and dizziness. She was referred to a cardiologist and was diagnosed with postural orthostatic tachycardia syndrome (POTS). Her remaining symptoms improved with exercise and increased salt and fluid intake.

Discussion and Conclusions: With careful consideration of the patient's symptoms and medical history, combined with a thorough evaluation of the patient's balance systems, the physical therapist suspected a CSF leak and appropriately referred the patient. Because patients with undiagnosed CSF leaks are likely to be referred for vestibular rehabilitation to improve their dizziness and imbalance, it is critical that providers working in vestibular settings are aware of the clinical presentation of this condition.



Through My Looking Glass

Susan J Herdman, PT, PhD, FAPTA

Being asked to describe what I see in the future for Vestibular Rehabilitation is fun. So many wonderful ideas were presented at the recent International Conference for Vestibular Rehabilitation, held on August 17-19, 2018 in Chicago that the near future seems easy to describe. It's the distant future that is more difficult to predict but that makes it all the more interesting.

The near future: I would hope that we will have a Board Certified Clinical Specialty in Vestibular Rehabilitation. First, I think the depth and breadth of knowledge and skill in the management of people with vestibular dysfunction warrants this recognition. The effort for a therapist to study for, take and pass a board certification exam will help assure that people with vestibular dysfunction are served by those therapists whose expertise has been demonstrated at the highest level possible within the medical profession. Board certification is an important criteria to identify those specialists who are most likely to be well versed in the most current assessment, treatments, and research available. Importantly, board certification is also a mechanism by which a large number of therapists can be recognized for their expertise, unlike residencies and fellowships which currently have relatively limited availability. A Vestibular Clinical Specialty, under the auspices of our professional organization, will also reinforce our role as physical therapists as the provider of choice for vestibular rehabilitation. I hope this happens in my lifetime.

Several diagnoses are continuing to evolve and that evolution will lead to dramatic changes in how we treat patients with vestibular disorders and our expectations for the final level of functional recovery of our patients. One of these disorders, persistent postural-perceptual dizziness (PPPD), was defined by a Barany Society committee in 2017 (Staab et al 2017). PPPD characteristically appears soon after the onset of acute vestibular symptoms or balance problem and may provide the key as to why some people with unilateral vestibular hypofunction do not improve with vestibular rehabilitation consisting of gaze stabilization and balance and gait exercises. It is exciting to recognize that, if PPPD is identified early in the illness, cognitive behavioral therapy results in significant and sustained benefits to the patient and may abort the chronic presentation of PPPD (Holmberg et al 2005; Holmberg et al 2007, Mahoney et al 2013). The challenge is arriving in an early diagnosis of PPPD in patients with vertiginous symptoms and imbalance from acute vestibular loss. If a patient develops an acute vestibular hypofunction AND is referred to a physical therapist with vestibular expertise, that therapist must be prepared to identify PPPD as a separate issue for the patient (that is, outside of the signs and symptoms from the acute UVL). The therapist then needs to refer the patient to a psychiatrist or psychologist for diagnosis and cognitive behavioral therapy. That in itself is often difficult because of the stigma many people associate with seeing a psychiatrist or psychologist. Furthermore, many patients with unilateral vestibular loss are referred for physical therapy in the chronic stage when it becomes clear that they have not recovered on their own. In patients who have already developed PPPD, treatment using habituation exercises and medication with SSRIs as well as cognitive behavioral therapy is more prolonged (three to six months). Once the therapist recognizes that the patient has PPPD as well as a chronic and only partially compensated vestibular deficit, habituation exercises can be incorporated into the treatment plan. Notice that whether the patient is referred to physical therapy in the acute or in the chronic stage, it may be the therapist who first recognizes the signs of PPPD and initiates the proper referrals. This emphasizes the need to assure that physical therapists who specialize in vestibular rehabilitation have the highest level of clinical knowledge and skills.

Through My Looking Glass cont.

Susan J Herdman, PT, PhD, FAPTA

Vestibular migraine is another disorder that should be incorporated into the working algorithms of a vestibular physical therapist. Recognized as a clinical entity by the Barany Society in 2012, Vestibular Migraine is the accepted term used to indicate that a patient's symptoms includes all four of the following criteria:

1. At least five episodes with vestibular symptoms of moderate or severe intensity lasting between 5 min and 72 hours.
2. Migraine or previous history of migraine with or without aura according to the International Classification of Headache Disorders.
3. One or more migraine features with at least 50% of the vestibular episodes.
4. The patient's symptoms cannot be explained by another vestibular disorder (Modified from: Lempert T et al 2012).

Treatment of Vestibular Migraine is directed at prevention, control of symptoms during an episode and treatment of the intra-ictal symptoms of associated with vestibular migraine. Although as physical therapists we often counsel patients on methods that might prevent episodes of vestibular migraine (e.g. stress reduction through exercise), most of vestibular rehabilitation has focused on the treatment of patients during the periods between the episodes themselves. A retrospective study found that patients with vestibular migraine and vestibular hypofunction respond to a course of vestibular rehabilitation and show improvement in subjective complaints of dizziness and fall risk (Whitney et al. 2000). In a prospective study, Vitkovic et al. 2013, compared patients with vestibular migraine to patients with dizziness but not vestibular migraine and found that both groups had improved subjective complaints of dizziness, lower risk for falling, and higher balance confidence following a course of vestibular exercises (Vitkovic et al. 2013). Even though these results are encouraging, there are no controlled trials that have examined the supposed benefits of vestibular exercises in patients with vestibular migraine.

Mal de Debarquement (MDD) is the third diagnosis that may become part of the vestibular related disorders that physical therapists treat. Although less common than PPPD or vestibular migraine, MDD results in disruption of the person's ability to function in everyday activities and therefore poor quality of life. The use of exercises has not been successful as a treatment of MDD. However, the new information on the use of Transcranial Magnetic Stimulation and of Transcranial Electrical Stimulation for MDD show great promise in reducing the symptoms of MDD and may become modalities used by physical therapists who specialize in the treatment of vestibular and vestibular related disorders in the future (Cha et. al. Brain Topography 2018; Cha Y, Mal de Debarquement and TMS: New Findings - presentation at the International Conference for Vestibular Rehabilitation, Aug 17-19, 2018).

New exercise approaches: The use of gaze stabilization and postural stabilization exercises is a proven modality in the treatment of patients with unilateral and bilateral vestibular hypofunction. Yet gaze stabilization exercises do not always result in improved quality of life and typically require that patients come to the clinic on a weekly basis for treatment, which may not be possible for all patients. One of the exciting advances in the treatment of patients with vestibular hypofunction involves the development of modifications of these exercises (Schubert MC et al. 2008). One modification of gaze stability exercises includes the development of a method that uses incremental changes in the target velocity error signal instead of the large error signal jump of going from X1 to X2 viewing of the traditional exercises. When the two exercise were compared, the incremental velocity error signal resulted in a greater increase in aVOR gain than did the traditional shift from X1 to X2 viewing (Schubert MC et al. 2008). A take-off of this idea is found in a retrospective study that used a metronome to set the frequency of head rotations/minute and then to increase the head movement speed by 2-6 bpm every time there was noticeable improvement (essentially every 2 – 4 days) based on symptoms and perceived difficulty (Roller RS, Hall CD. 2018).

Through My Looking Glass cont.

Susan J Herdman, PT, PhD, FAPTA

Another modification of the traditional exercises is to increase the gain of the VOR during head movements in one direction only (Migliaccio AA, Schubert MC. 2013) but needs to be examined in more detail in patients with unilateral vestibular hypofunction. The other exciting development is the use of a portable tool that can be used by the patient to record compliance and to modify treatment as the patient improves (Todd CJ et al 2018).

Finally, the development of visual desensitization techniques in the treatment of visually induced dizziness (ViD), such as is experienced by patients with migraine, holds promise for those patients whose symptoms arise from inappropriate reliance on visual cues. Treatment consists of vestibular exercises customized to the individual and exposure to optokinetic stimuli (Pavlou et al., 2013). The optokinetic stimuli can be presented using a moving drum of vertical stripes or dots that the patient sits or stands in or can be presented through the use of online videos of busy visual stimuli or with a virtual reality system. The important factor is that the stimuli must be guided by the patient's symptom level and that changes in the intensity of the stimuli must be graded.

All of these new or modified approaches to treatment are very promising but all require more research to demonstrate treatment efficacy.

The not so distant future: One area of research that is of particular interest to me is the role of physical therapy in the rehabilitation of people who have vestibular implants. The introduction of vestibular implants as a treatment for patients with vestibular hypofunction doesn't mean the end of vestibular rehabilitation but rather will force us to develop new treatments to train these patients. Vestibular implants are based on research demonstrating that electrical stimulation of individual semicircular canal ampullary nerves produced eye movements in the plane of the canal, mirroring the VOR response produced by head rotation (Cohen et al 1964; Suzuki et al 1969). Several groups are developing vestibular implants using either single or multi-channel prostheses that measure head movement and use that information to produce eye gaze and postural responses. In rhesus monkeys, a three-channel gyroscope is used to detect head movement and the raw gyroscope signal is transformed into an electrical signal and the prosthesis produces eye movements that are similar to the vestibulo-ocular reflex (Hageman KN et al 2016). Similar prostheses have now been implanted in humans with greatly encouraging results, see the publication On the Level Newsletter, Vestibular Implant Gives Hope, Charles Della Santina, Summer 2018 for an encouraging story about a person with bilateral vestibular loss who received a multichannel vestibular implant. The current state of vestibular implants are not without problems – the gain of the produced response is lower than normal VOR gain; additionally, the interaction between the implant generated response and any residual responses of the vestibular system needs to be studied further (van de Berg et al 2017).

The probably not in my lifetime future: I foresee an important role for physical therapists who specialize in the vestibular system and the rehabilitation of people following space travel. Current focus is on preventing or quickly ameliorating the signs and symptoms of a disrupted vestibular system so astronauts can function safely during and immediately after the gravity transitions that occur with space travel. The issues associated with gravity transitions are extremely important to the safety of the astronauts and the success of the flights, but the long term effects of the post-space flight on the human body may be one of the biggest challenges there is. What fun therapists will have answering those challenges!

Through My Looking Glass cont.

Susan J Herdman, PT, PhD, FAPTA

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