

Vestibular Rehabilitation SIG

American Physical Therapy Association/Neurology Section

- In this Issue:**
1. Message from the Chair
 2. Celebrating 20 Years
 3. CSM 2016 Business Meeting Recap
 4. 2016 Elections
 5. VOR and VSR dysfunction in Degenerative Disease
 6. Service to the SIG Award
 7. 2016 Anne Shumway-Cook Lectureship



Message from the Chair

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

Looking Forward: The Next 20 Years

I was so excited to see so many SIG members at our evening celebration and business meeting during CSM this year. We celebrated 20 years of serving physical therapists who manage individuals with vestibular and balance disorders. I want to thank the leadership group who ensured the success meetings and all the individuals and companies that donated items for our raffle. I was so happy to see Dr. Michael Schubert honored with our Service Award and Dr. Neil Shepard receive the Best Article Award for the SIG newsletter. This edition of our Newsletter will highlight our celebration and many of the vestibular presentations at CSM, including the presentation of the first ever clinical practice guidelines for the Academy of Neurologic Physical Therapy, Vestibular Rehabilitation for Peripheral Vestibular Hypofunction. Thank you, Drs. Courtney Hall, Susan Herdman, and Sue Whitney for leading this important effort and the APTA and the Academy of Neurologic Physical Therapy for supporting their work. This work represents a new milestone in

(Continued on page 8)

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For more information go to:
<http://www.neuropt.org/go/special-interest-groups/vestibular-rehabilitation>



VRSIG Celebrating 20 Years!!

By April Hodge PT, DPT, NCS • Social Media Coordinator

The Vestibular Rehab SIG is excited to be celebrating our 20th Anniversary in 2016. We commemorated the milestone at the annual *Vertigo-Go Dinner* during this year's CSM conference in Anaheim, California. The dinner, which was held at McCormick and Schmicks on February 18th, was well attended and it was wonderful to have such a great turn out. The Vestibular Rehab SIG is thrilled with our growing membership, and we're glad that so many of you could be there to, as the Prince song goes, "*Party Like It's 1999.*"

In 1996 our SIG was founded with less than 250 members and today has grown to over 1,900 members. Thanks to the hard work of our many volunteers over the last 20 years, we have been able to provide various services and benefits to our members, such as a highly informative newsletter, the published findings of the Vestibular EDGE Task Force, clinical practice guidelines, an abstract of the week, patient and physician fact sheets, podcasts, and the Dizzy Pub Fare.

The *Vertigo-Go Dinner* provides an opportunity for our members across the country to get together for networking, fun and some friendly competition. We enjoyed celebrating the 20th anniversary at this year's event with food, drinks and the annual coronation of our SIG royalty. Past Chair and Neurology Section Historian, Britta Smith, is the genius behind the creative and entertaining contest that leads to the crowning each year. Holly Roberts was named *Vertigo-Go Queen* after winning this year's game, a vestibular-themed word search. When I was crowned Queen at the 2015 event, for my skit about the vestibular-themed fragrance Canal No. 5, I was whisked away into a world of pomp and pageantry, and I even got a paper crown and a plaque. Enjoy your reign Holly!

Thanks to all our current and past Chairs: Anne Galgon, Sue Whitney, Denise Gobert, Britta Smith, and Susan Herdman. Your leadership has been vital to the continued success and growth of the SIG.





CSM VRSIG BUSINESS MEETING 2016

There is plenty of fun each year at the VRSIG Business Meeting and this year was no exception. We had a record number of **Raffle Give-Away prizes** donated by generous supporters of the VRSIG. The tradition was continued this year with the prize titled **“Day with the Expert.”** We would like to acknowledge and send a sincere thank you to the individuals and companies, listed below, who generously contributed to the Raffle Give-Aways this year!

AND THE WINNERS ARE...

👂 Chad Aldridge each won **Micromedical InView Goggles.**
<http://www.micromedical.com>



👂 Erin Isanhart won **VHI Vestibular and Balance Exercise kits.** <http://www.vhikits.com>

👂 Brady Whetton and Sarah Bosley each won **Neuro Note: Clinical Pocket Guide** from FA Davis Publishing



👂 Eric Anson won **“Follow the Expert”** with Sue Whitney

👂 Michelle Pinker won **“Follow the Expert”** with Michael Schubert

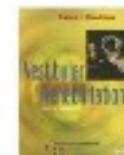


👂 Kimberly Yungbluth won the **Fitter First Soft Board Rocker Board** contributed by VEDA
<http://www.vestibular.org>



👂 Renee Lach won **“Balance Function Assessment and Management”** by Gary Jacobson and Neil Shepard from Plural Publishing http://www.pluralpublishing.com/publication_bfaam.htm

👂 Janet Callahan and Charles Plishka each won a 1 year membership to VEDA <http://www.vestibular.org>



👂 Katie Engelman won **“Vestibular Rehabilitation, 4th Edition”** by Susan Herdman from FA Davis Publishing

👂 Julie Grove won the **APTA Learning Center Gift Certificate**



👂 Britta Smith won a 1 Year subscription to the **Journal of Vestibular Research**

👂 Janet Helminski won the **PhysioTools Vestibular and Balance Exercise DVD Voucher**



👂 Matt Scherer and Kenda Fuller won **A Clinicians Guide to Balance and Dizziness** by C. Plishka

👂 Wendy Schoenewald, Becky Horton and Kristina won **OPK Stimulation Exercises DVD** by Drs. Bronstein and Pavlou



2016 VRSIG Elections

The VR SIG Nominating Committee was excited to present a slate of qualified candidates who have offered their time and service to the SIG. Elections were held electronically and took place between April and May. Anne Galgon, Lexi Miles and Kurt van der Schalie have been elected to the team. As the elections have come to a close, we wanted to acknowledge all those willing to serve and share the background of each candidate. The SIG is fortunate to have candidates with exceptional experience and knowledge.

CHAIR ELECT : *This is a new position for a 1 year term prior to assuming office as Chair to become familiar with the organizational SIG structure*

Anne Galgon, PT, PhD, NCS has served as Chair of the Vestibular SIG since 2013, and previous Vice-Chair from 2010-2013. She has extensive clinical and research experience in Neurologic and Vestibular Rehabilitation. She is Associate Professor in the Department of Physical Therapy at Temple University. She has presented nationally, and is a published leader who has contributed to 16 continuing education courses on Vestibular Rehabilitation.

VICE-CHAIR

Lexi Miles, MPT has served the Vestibular SIG since 2011; and most recently, as the Vice-Chair. She works as a clinical specialist in Vestibular Rehabilitation at Froedtert Hospital in Milwaukee, WI., where she developed their Vestibular Rehabilitation program. She is a lecturer and lab instructor in Vestibular Rehabilitation at Marquette University and the University of Wisconsin. In 2013, Lexi was awarded “Mentor of the Year” by the Wisconsin Physical Therapy Association.

Charles “Chuck” Plishka, PT, DPT, NCS has served the Vestibular SIG as International Liaison since 2013, and recently joined the Mentoring Sub-committee of the Member and Public Relations Committee of the Neurology Section. He has taught continuing education courses on balance and vestibular disorders for the past 7 years and recently published a new book “A Clinician’s Guide to Balance and Dizziness: Evaluation and Treatment.” He is owner of Posture and Balance Concepts, LLC, a continuing education and consulting company and works as a clinical specialist at Our Lady of the Lake Regional Medical Center in Louisiana.

NOMINATING COMMITTEE

Andrew Wagner, DPT is a recent graduate of Gannon University who plans to sit for the NCS examination in March, 2017, following completion of a Neurologic PT residency at Milwaukee VA. He is adjunct faculty in the Physical Therapy Department of Marquette University. He has lectured on evaluation and treatment of Neurodegenerative diseases, balance, Neurologic gait and introduction to Neurologic Physical Therapy.

Kurt van der Schalie, MPT, DPT, ATC, OCS has worked in the field of Vestibular Rehabilitation since 2008, and worked as clinical manager at Medstar Georgetown University Hospital in Washington, DC from 2007-2015. He has served in various leadership roles in DC’s APTA for the past 8 years; including, liaison to the offices of Vice President, Secretary, and Federal Affairs. He received APTA’s “Emerging Leader Award” in 2009.

Selena Bobula, PT, DPT, NCS has served the Vestibular SIG by translating Patient Fact Sheets into Navajo and specializes in Vestibular Rehabilitation for the Navajo area. She is co-founder of Pinon Concussion Task Force and coordinator for the Neurologic Special Interest Group and Navajo Area. She works as a Senior Physical Therapist for Pinon Health Center/Indian Health Service, and has presented extensively at the local and national levels on Vestibular and Concussion management. At CSM 2015, she presented a poster titled “Rural Concussion Screening Implementation.”

We sincerely thank all of the candidates for their interest in serving the VRSIG!



More Common Than You Think: *VOR and VSR Dysfunction in Ageing and Neurodegenerative Disease*

By Courtney Hall PT, PhD • Guest Author

This article is based on CSM 2016 Session Titled More Common than You Think: Vestibulo-ocular and Vestibulospinal Dysfunction in Aging and Neurodegenerative Disease by LE Dibble PT, PhD; CD Hall PT, PhD; MC Schubert PT, PhD

With age and impairment due to neurodegenerative processes, the nervous system expresses symptoms of dizziness and imbalance with a dramatic increase in the risk for falls. While the fall risk of older individuals, those with degeneration of the peripheral nervous system (i.e., diabetic neuropathy), and those with central nervous system degeneration (i.e., multiple sclerosis) is well known, less known are the manifestations of vestibulo-ocular and vestibulo-spinal impairment associated with these conditions. Emerging research shows a clear dysfunction in vestibular physiology in these populations, which adversely affects gaze and postural control and increases fall risk. This educational session addressed the pathophysiology of vestibular function in the context of aging and peripheral and central nervous system damage, critical examination tools, and research based recommendations to augment vestibular motor learning in these patient populations.

I. Vestibulo-ocular reflex (VOR)/Vestibulospinal reflex (VSR) declines in aging and neurodegenerative disease

There is considerable evidence for age-related degeneration in motor and sensory systems that support postural control including loss of muscle strength (Manini and Clark, 2012), somatosensory declines (Mold et al., 2004), visual changes, including visual acuity, contrast sensitivity and depth perception (Petrash, 2013), and vestibular changes.

Morphological studies report that the vestibular sensory hair cells degenerate with age in both the

cristae of the semicircular canals and the maculae of the saccule and utricle. There is also a parallel age-related reduction that occurs in the fibers of the vestibular nerve and in Scarpa's ganglion and central changes in the brainstem. Based on vestibular function tests, there is a high prevalence (80-95%) of vestibular abnormalities in the semicircular canals, followed by abnormalities in the saccule (50-60%) and then the utricle (~20%; Agrawal et al., 2012; McGarvie et al., 2015). Consequences of age-related vestibular degeneration are postural instability and, ultimately falls. One recent study determined that vestibular dysfunction is significantly more prevalent in older adult fallers than non-fallers, highlighting the importance of healthcare providers being aware of the potential for vestibular impairments in older adult fallers (Liston et al., 2004).

The hyperglycemia associated with diabetes mellitus (DM) can have negative consequences on the vestibular system. There are two mechanisms of damage related to hyperglycemia: 1) impaired oxygenation resulting in degeneration of type 1 vestibular hair cells, and 2) lysosomal digestion of the vestibulocochlear nerve. The result is longer latency and reduced amplitude of vestibular evoked potentials (D'Silva et al., 2015). The negative consequences to the vestibular system as a result of multiple sclerosis are demyelination of brainstem white matter pathways including but not limited to, vestibulo-ocular pathways, vestibulospinal and ventral tegmental tracts, and the cerebellar peduncles (Oh et al, 2016; Alpini et al, 2004; 2012). There is considerable evidence of increased incidence of falls in individuals with diabetes and multiple sclerosis. In addition, both diagnoses appear to result in gaze and postural stabilization deficits (as measured by VOR and VSR tests).

Service to the SIG Award:

Michael Schubert PT, PhD

Michael C. Schubert PT, PhD is the recipient of the **2016 Service to the SIG Award** from the Vestibular Rehabilitation Special Interest Group (VRSIG) of the Academy of Neurologic Physical Therapy of the APTA. After careful review of nominees, Dr. Schubert was selected because of his significant and ongoing contributions to the VRSIG and the growing field of Vestibular Rehabilitation. Dr. Schubert's ongoing investigations into vestibular dysfunctions and mechanisms of recovery have advanced the body of scientific literature related to vestibular impairments. With at least 50 published research articles, Dr. Schubert exemplifies a successful Physical Therapist Researcher and has been recognized with the Excellence for Scholarship Award by the APTA in 2010. Given this tremendous amount of work he still finds time to write clinical related articles for the VRSIG newsletter, special publications and volunteer his time for the "Day With the Expert" business-meeting prize. In addition he has consistently contributed to task forces as a content expert and supported VRSIG efforts to develop a description



Dr. Schubert conducting research on the Vestibular Issues in a zero gravity environment affectionately known as the "Vomit Comet."

of advance practice in vestibular rehabilitation. He also provides education on vestibular rehabilitation to clinicians in multiple forums and courses. Here is one clinician's remarks on his teaching: *"The way he teaches the lectures and labs to explain the workings of the vestibular system as well as explaining the complicated vestibular tests-(VNGs, rotary chair, VEMPs) is excellent for the participants to understand gain, phase, directional preponderance, etc without feeling totally overwhelmed. He has the patience for those like me that need extra pictures, diagrams to "get it and make it stick."*

Dr. Schubert has represented Physical Therapy internationally at the prestigious 2016 Barany Society meeting in Seoul, Korea to advance the practice of Vestibular Rehabilitation globally. It is for these reasons that the VRSIG would like to thank Dr. Schubert for his service and acknowledge his efforts with the *Service to the SIG Award*.

*If you would like to find out more about Dr. Michael Schubert, you can link to his profile page at Johns Hopkins, <http://www.hopkinsmedicine.org/profiles/results/directory/profile/2178399/michael-schubert>, or read a recent article he wrote for our SIG special edition entitled: *Advances in Vestibular Diagnostics*, http://www.neuropt.org/docs/default-source/default-document-library/vft-special-publication_winter-2015_2016.pdf?sfvrsn=0*

2016 Anne Shumway Cook Lecture: *Can we change what we do to help those who don't get better?*

Jeff Hoder PT, PhD ● Guest Author



When performing the canalith repositioning maneuver, spend 2 minutes in each position. Additionally, take 60 seconds to rotate the head from one Dix Hallpike position to the other. Repeat this maneuver 5 or 6 times. For recovery of dizziness, perform eye movements (the head is still) slow then quick, first up and down, then side-to-side, then focusing on a finger converging on the nose. Other than your finger coming towards your nose, do not focus on anything specifically when performing eye movements. Next, move your head side to side, then up and down. Do these movements while in bed, sitting, standing and when walking about. Do them until you feel better.

That could very well be the state of vestibular rehabilitation was it not for Susan Herdman. To honor her accomplishments as a clinician and researcher, Dr. Susan J. Herdman, PT, PhD, FAPTA was awarded the Anne Shumway-Cook Lectureship for 2016 by the Neurology Section of the American Physical Therapy Association. The Anne Shumway-Cook Lectureship acknowledges an individual who has made significant contributions within the areas of neurologic physical therapy research and practice. Recipients have distinguished themselves as esteemed neurorehabilitation scientists whose work has influenced neurologic physical therapist clinical practice. Dr. Herdman is the former Program Director and Professor Emerita, Emory University School of Medicine, Department of Rehabilitation Medicine and Department of Otolaryngology-Head and Neck Surgery. Her lecture at CSM 2016 provided an opportunity to share her experiences related to the translation of her research into vestibular rehabilitation clinical practice.

Dr. Herdman's lecture covered the span of her remarkable career; the people she mentored and the research she has conducted and continues to conduct. She started her educational journey at Vassar College, where she received a Bachelors degree in Biology, before going on to the University of Pennsylvania, earning her certificate in PT, and subsequently her PhD in Anatomy. It was while she was working at the University of Pennsylvania that she was initially approached about treating patients with dizziness. She went on to complete a post-doctoral fellowship within the Department of Anatomy at University of Pennsylvania. She has served on faculty at the University of Maryland, Johns Hopkins University, the University of Miami and Emory University from 1981 until 2013, for a total of thirty two years of teaching and research. During that time, she has supervised a dozen doctoral students and post-doctoral fellows, and mentored countless others on their professional journeys. Her contributions are literally *out of this world* as she has been a member of a NASA advisory committee concerning the physiologic effect of prolonged space travel on the vestibular system with a potential trip to Mars.

In addition, she has authored 68 published articles, numerous book chapters, and of course "the book", Vestibular Rehabilitation, which has become the staple textbook for any vestibular therapist. Her research has focused on recovery of persons with vestibular deficits, with a special interest in determining the factors that influence and/or predict recovery following vestibular loss. In 1998, Dr. Herdman spearheaded the course titled "Vestibular Rehabilitation, a Competency-based course". The course has run for 18 years straight, with a combined total of 3600 participants thus far. She has lectured all over the country and in 18 countries world-wide.

Throughout her career, Dr. Herdman has been a constant supporter of the APTA and the neurology section. In 1996 she served as the founding chair of the Vestibular Rehab SIG and she has served on the nominating committee for the neurology section. Along with Drs. Hall and Christy, AKA The Spin Doctors, she ran the marathon portion of the Great Floridian Team Ironman Triathlon in 2005 to raise money for the neurology section. She recently co-authored the Vestibular Rehabilitation for Peripheral Vestibular Hypofunction: An Evidence-Based Clinical Practice Guideline (JNPT, April 2016) and sits on a task force with efforts to advance Vestibular Rehabilitation into a board certification specialty practice.

Dr. Herdman has been awarded the Excellence in research award by the Neurology section in 2000, the Catherine Worthingham Fellow of the APTA in 2001, the John Maley award for Innovative Clinical Practice by the APTA in 2003, the Marion Williams Research Award in 2009, the service award by the Vestibular Rehab SIG in 2010 and the Golden Synapse award for best journal article in 2011.

Dr. Herdman's influence has changed the practice of Vestibular Rehabilitation, for which we are grateful.



With each milestone we have the opportunity to look ahead and envision what the field will be like 20 years from now.

Message from the Chair

(Continued from page 1)

In establishing Vestibular Rehabilitation as an area of specialty practice. With each milestone we have the opportunity to look ahead and envision what the field will be like 20 years from now.

Can you imagine a vibrant Vestibular Rehabilitation SIG with well over 5000 members? This is more than probable. In the fall newsletter, I commented on how fast the SIG has been growing and we should be reaching 2000 members this year. We have seen over 200 new members join the SIG each year since 2010. Hopefully, these numbers show that there continues to be a growing demand for vestibular rehab therapists and members value our resources. However to keep vital, the VRSIG needs to innovate and engage our members. The leadership of the SIG is assessing ways to support member engagement for a new generation of

vestibular therapists. I can envision these therapists bringing technological skills, and innovative ideas that will drive the SIG in the future. If you are a new member or a seasoned member, the SIG leadership invites you to participate in any of our initiatives or discuss new ideas. Find a SIG leader who you admire and talk. <http://neuropt.org/special-interest-groups/vestibular-rehabilitation/leadership-team>

Can you imagine thousands of vestibular rehabilitation clinical specialists providing efficient and effective care to individuals with vestibular disorders? The Vestibular Rehab Practice Analysis Task Force has been working diligently to develop a survey of advance practice. They have collected over 800 signatures including every state in support of vestibular rehabilitation specialization. Once the description of advance practice is created, there will be an application to the ABPST for a clinical specialty in vestibular rehabilitation. The process is proceeding according to plan and we are hopeful that the practice analysis will support the development of this new specialization. Although this may seem like a long time coming, it will be another turning point in vestibular practice. The description of advance practice will also open the door for many opportunities for the SIG.

Can you imagine educational pathways and residencies to advance the practice of vestibular rehabilitation? This is a highly probable. The SIG has many resources that can advance knowledge practice including regional courses, Abstract of the Week, Podcasts, newsletters, and the Dizzy Pub Fare. One of the most frequent questions I received from new members is what continuing education courses should they take to prepare them to practice vestibular rehabilitation. Although there are many educational opportunities available, the structure and guidance to help new clinicians has been lacking. Therefore, the SIG aims to provide more guidance over the next years. With most new clinicians



Message from the Chair (cont.)

practicing in outpatient practice with little mentorship we feel this will important to address. The description of advance practice is should provide the learning objectives needed to guide clinicians. We hope to create a self-directed pathway to support the development of clinicians. Right now, the VR SIG has a great opportunity to work with the Academy to develop a variety of on-line educational opportunities and develop mentoring connections for our members. Fortunately, Lexi Miles and Rachel Trommelen will be working to create the visions for educational offerings and Chuck Plishka will be working to create mentoring opportunities. The SIG welcomes members who wish to participate in these efforts.

Additionally, the VR SIG is aware that there are several institutions who are interested in developing fellowships or residencies in vestibular rehabilitation. The development of these educational programs is also dependent on a description of advance practice in vestibular rehabilitation. The SIG is looking forward to supporting the development of fellowships and residencies, as they could transform how physical therapists are trained in vestibular rehabilitation.

Another important step in developing a pathway for education is to have a standard description of entry-level education in vestibular rehabilitation. In 2003 the SIG created a consensus document, which contained recommended of clinical knowledge and skills for entry-level clinicians. The SIG has formed a work group, which are reevaluating these recommendations. Over the next year or so, we hope to provide guidelines for entry level programs that will be consistent with the current PT educational curriculums and reflect the scope of vestibular rehabilitation practices.

Imagining the Vestibular Rehabilitation SIG 20 years from now is exciting and overwhelming, as there is much work to be done. I can only be thankful that there have been so many energetic members who came before me and currently serve the SIG. As I start my next term as Chair, I look forward to working with these colleagues and a new generation of therapists who are committed to facilitating advances in physical therapy for individuals with balance and vestibular disorders.

CALL FOR NEWSLETTER ARTICLE WRITERS!!!

Do you want to get involved with your SIG? Do you have a poster that you have presented would be helpful to our Members Consider writing an article for the newsletter or sending your poster content to the editors.

You can write on a topic of your choosing or an appropriate topic could be assigned to you. If you are interested in getting involved with the newsletter, please contact Betsy Grace Georgelos at Elizabeth.grace@uphs.upenn.edu or Debbie Struiksma PT, NCS at dstruiksma77@aol.com.



VOR and VSR Dysfunction (continued)

(as measured by VOR and VSR tests). Across several studies, cervical VEMP abnormalities in persons with MS range from 18-70%; whereas, ocular VEMP test abnormalities ranged from 45-85% (Rosengren and Colebatch, 2011; Oh et al, 2015).

III. Examination and differential diagnosis of VOR and VSR

We review vestibular function test findings in the context of aging and neurodegenerative diseases (Table 1).

In terms of assessment of the VSR, it is an old concept to focus on the equilibrium responses and the reflexes that are triggered by visual, vestibular or somatosensory input. The current concept of postural control is as a complex motor skill resulting from the interaction of multiple sensorimotor processes. The systems model of postural control conceptualizes balance as resulting from the interaction of multiple underlying systems, including biomechanical system, limits of stability, anticipatory postural adjustments, automatic postural responses, sensory integration, and dynamic balance during gait. In order to adequately assess balance, multiple tests must be performed including tests of strength/range of motion, visual acuity during head movement, static stance with altered base of support, limits of stability, sensory orientation, automatic postural responses and dynamic balance during gait.

It is important to consider which balance assessment tests are appropriate for people with diabetes and MS. The findings from the assessment tools should guide the plan of care and be able to identify impairments and limitations specific to a client. For example, diabetes can result in diminished sensation due to neuropathy, cognitive impairment and polypharmacy; whereas, MS can result in fatigue, muscle weakness, spasticity and cognitive impairment. The therapist should consider the psychometric properties of the assessment tool to identify reliable, valid, sensitive and responsive measures for the specific population. An ideal assessment tool would have cut-offs

for the intended client population. We review psychometric properties of common fall risk assessment tools for people with diabetic peripheral neuropathy and MS (Table 2).

II. Improving gaze stability to reduce fall risk

Current vestibular rehabilitation is an exercise-based approach that typically includes a combination of four different exercise components to address the impairments and functional limitations identified during evaluation: 1) exercises to promote gaze stability (gaze stability exercises), 2) exercises to habituate symptoms (habituation exercises) including optokinetic exercises, 3) exercises to improve balance and gait (balance and gait training), and 4) walking for endurance. There is considerable evidence to support the effectiveness of exercise programs that include balance training of moderate to high challenge (i.e., reduced base of support, center of gravity training, reduced reliance on upper limb support) and higher total dose of exercise (> 50 hours) to reduce falls in older adults (Sherrington et al., 2011).

It is not clear, however, whether the inclusion of vestibular-specific exercises provides additional benefit for non-vestibular dizziness. There are a considerable number of older adults who experience dizziness, but never receive a vestibular diagnosis. Jung et al. (2009) reported nearly 2/3 of their older patients had no specific cause of dizziness. In this retrospective chart review, Jung and colleagues compared outcomes for patients who were instructed in vestibular rehabilitation, including gaze stability exercises, versus patients who were instructed to perform their daily routine. This study showed significant improvement in intensity of dizziness and balance confidence with vestibular rehabilitation. Hall and colleagues (2010) performed a prospective, randomized controlled study of older adults with non-vestibular dizziness. In this study, all patients received balance and gait training, but were randomized to receive either gaze stability exercises or placebo eye movements.



VOR and VSR Dysfunction (continued)

Both groups improved on all measures of symptoms, balance confidence, and dynamic gait index. However, the group performing the gaze stability exercises reduced fall risk to a greater extent than the placebo group: 90% of the gaze stability group demonstrated a clinically meaningful improvement in DGI compared to 50% of the placebo group.

No published studies have included vestibular function testing or vestibular rehabilitation in persons with

Table 1. Vestibular function test findings in the context of aging and neurodegenerative diseases

Measure	Vestibular Dysfunction	Older Adults	MS	Diabetes
Head Impulse Test	Horizontal and Anterior Canal $< \sim 0.8^1$ Posterior Canal $< \sim 0.55^1$	Yaw $> \sim 0.8^2$ Unknown for vertical canals	Horizontal canal: greater aVOR variability, CS /HR, and CS latency than controls ⁵⁰	Unknown
Caloric	$> 25\%$ unilateral asymmetry	Inconclusive results ⁴⁹	Abnormal frequency, slow phase velocity, or amplitude ^{9,10}	Significant unilateral asymmetry ^{5,22}
Dynamic Visual Acuity	$< 0.118 \pm 0.184$ across ages 3-85 years ⁶ (active)	$< 0.207 \pm 0.216$ ages > 50 years ⁶ (active) Reduced canal plane DVA ¹⁴	Unknown	Abnormal passive canal plane DVA horizontal and anterior SCC ³
Rotary Chair	Abnormal high velocity step and high frequency (sinusoid) gains Recovers at low velocity	Reduced VOR gain at all HZ > 50 years ¹¹	Unknown	No difference in active or passive head rotation VOR gain (> 0.9 , ~ 100 d/s)
Ocular VEMP	Lengthened N1 or P1 latency (delayed) Reduced threshold Reduced or magnified amplitude Asymmetry	Delayed N10 latency with 0.12 ms/decade progression (n=257) ¹² Amplitude decreased by 2.9μ V/decade. (n=257) ¹²	Delayed or absent ⁷ Less commonly have reduced magnitude ^{7,8}	Reduced amplitude ³ Delayed N1/P1 latencies ⁴



VOR and VSR Dysfunction (continued)

with diabetes mellitus! There is evidence that balance training (Tai Chi, virtual reality) is effective at reducing fall risk in persons with DM. There is limited evidence for vestibular rehabilitation in persons with MS. Hebert and colleagues (2011) incorporated gaze stability exercises as part of the intervention compared to a control group. There are several limitations to the study, including the lack of vestibular function testing and the relatively small dose of gaze stability exercises (2-4 minutes per day). The group performing rehabilitation improved significantly; although, the importance of the gaze stability exercises cannot be determined given the research design. Garg et al. also demonstrated improvements in persons with MS at risk for falls after performing daily gaze and postural stability 20 min per day for 2 weeks.

IV. Motor Learning for Vestibular Adaptation

Vestibulo-ocular reflex (VOR) gain adaptation has been shown to occur in the context of retinal slip (when images move on the retina) and head movement. VOR gain has been shown to increase by as much as 60% with hours/days of training with retinal slip during head rotation. Adaptation of the VOR appears most robust for head rotations at frequencies < 4 Hz (Raymond 1998; Broussard 1999; Clendaniel 2001). Adaptation is robust for impulse head rotation (Schubert 2008; Migliaccio and Schubert 2013; 2014) and appears better retained when incrementally applied (Schubert 2008; Migliaccio and Schubert 2013; 2014). The vestibulocerebellum (flocculus, nodulus, adjacent vermis) and portions of the vestibular nuclei that receive projections from the Purkinje cells are critical to VOR adaptation. The relevance of VOR motor learning to vestibular rehabilitation is that head movements are required for the VOR gain to

increase when it is low (i.e., patients with vestibular hypofunction). There is benefit to animals of a consolidation period (i.e., rest period) after motor learning as occurs during VOR adaptation. It is not known if there is any benefit of consolidation of VOR motor learning with an intentional rest period in humans.

The efficacy of VOR adaptation exercises in the context of central vestibular disorders such as MS is unclear. To our knowledge, only the study by Garg et al. has examined the effects of a gaze stability program on VOR gain and compensatory saccade behavior in persons with MS. As a whole, the single group of persons with MS participating in this study did not significantly improve their horizontal angular VOR gain but altered their saccade characteristics. The results of this feasibility should be tested in a larger controlled trial.

It is not known what the optimal dose of gaze stability exercises is as no controlled study has been done. However, based on expert opinion it is now recommended that patients with peripheral vestibular hypofunction (PVH) perform a home exercise program of gaze stability exercises: 1) Acute/subacute PVH: >3 times per day for a total of at least 12 minutes per day; 2) Chronic PVH: >3 times per day for a total of 20 minutes per day. The role of compliance further complicates the picture: 50% of patients in one study were shown to be under-compliant based on wearing a wearable head velocity tracker.

VOR and VSR Dysfunction (continued)

Table 2. Psychometric properties of commonly used outcome measures for activity and participation limitations

Population Measure	Vestibular Dysfunction	Older Adults	MS	Diabetes
Activities-specific Balance Confidence scale		Excellent reliability ²⁴ , >80% high function ²⁵ ; Cut-off: < 67% fall risk ²⁶	Excellent reliability; cut-off: 40 w/ Se: 65%; Sp: 77% ²⁷	
Dizziness Handicap Inventory	Excellent reliability; Mild: 0-30 Moderate: 31-60 Severe: 61-100; MDC: 17, MDIC: 18 points ²⁸		Excellent reliability; cut-off: 59; Se: 50%, Sp: 74%; MDC: 22.5 ²⁷	
Modified Clinical Test of Sensory Interaction on Balance	C1-3: 30s; C4: x=26.6 s; C5: x=13.8 s ³⁰	Excellent reliability; cut-off: total score < 260 sec fall risk w/44% Se and 90% Sp ³¹		
Timed up and go	Cut-off: > 11.1 s fall risk, Se: 80%, Sp: 56% ³² (Whitney)	Excellent reliability; cut-off: > 13.5 s fall risk ³³	cut-off: 13.6s; Se: 73%, Sp: 54% ³⁴	Cut-off 10.7 s; Se: 90%, Sp: 89% ³⁵
Berg Balance scale	Cut-off: 45 impaired balance, 75% sensitivity/specificity ³⁰	Excellent reliability; Cut-off = <45/56 balance deficits/fall risk (Berg); MDC = 3.3-6.3 ³⁷	Excellent reliability; w/ different cut-offs, Se: 32-94%, Sp: 32-90% ^{27,34,38}	Cut-off: 52; Se: 90%, Sp: 77% ³⁵
Dynamic Gait Index	Excellent reliability; MDC=3.2 points ³⁹ ; cut-off: ≤19/24 fall risk ⁴⁰	Excellent reliability; MDC=2.9 points ⁴¹ ; MDIC=1.9 points; cut-off= ≤19/24 fall risk Se: 59%, Sp: 64% ⁴²	Excellent reliability; MDC=4.2-5.5 points; cut-off=12, Se: 45%, Sp: 80% ²⁷	Cut-off: ≤ 22; Se: 90%, Sp: 85% ³⁵
Functional Gait Assessment	Excellent reliability ⁴³ ; MCID=8 points ⁴⁴	Excellent reliability; cut-off = ≤ 22/30 fall risk w/85% sensitivity, 86% specificity ⁴⁵	Excellent test-retest reliability (0.98), SEM = 1.0 points, MDD = 2.77 points ⁵¹	

VOR and VSR Dysfunction (continued)

Table 3. Vestibular rehabilitation in non-peripheral vestibular deficits

Study	Population	Vestibular function test	Intervention	Dose	Outcomes
Beling, JGPT, 2009 ⁴⁶	Older adults (x= 80 years); n=19	None	Balance rehabilitation; Gaze stability (VORx1 horiz/vert)	3x/wk x 1 hr x 12 wks	Berg balance scale; Sensory organization test; TUG
Jung, Am J Oto, 2009 ⁴⁷	Older adults (x= 76.5 years); n=153	ENG, rotary chair, MRI	Gaze stability (VORx1 horiz/vert; imaginary target) and walk with head turns vs. usual activity	3x/day x 3 months	ABC, verbal analog scale
Hall, JNPT, 2010 ⁴⁸	Older adults (x= 74 years); n= 37	calorics, head thrust test, bedside/ neurological exam	Balance rehabilitation and Gaze stability (VORx1 horiz/vert/checkerboard, eye-head b/t targets) vs. balance rehabilitation only	3x/day x 6	ABC, SOT, gait speed, DGI
Hebert, PTJ, 2011	MS	None	Balance rehabilitation and gaze stability vs Exercise control vs control	2x/wk x 6 wks+HEP	Fatigue, SOT, 6 Min Walk Test
Garg et al, 2015 ⁵²	Relapsing Remitting MS	vHIT	Gaze stability (VOR x 1, seated ,standing) Postural stability (standing, walking with head turns)	2-3x/day x 2 weeks	vHIT, FGA, FSST, DHI, ABC

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