Vestibular Rehabilitation SIG

Summary of Monthly Abstract of the Week Topics From July 2017 to present

Summary of July 2017 Topic: Vestibular Rehab in Concussion

Dizziness is a common symptom following concussion, according to one abstract occurrence rates are 67-77%. Imbalance, dizziness, visual and vestibular impairments were possible risk factors for prolonged recovery or worse outcomes following concussion.

The abstracts, including a systematic review, investigated whether vestibular therapy would reduce recovery time, improve outcomes, and is effective in the concussion population.

Overall, the research is limited in quality and breadth but suggest that vestibular therapy can be effective in treating this patient population.

The abstracts highlight that testing for vestibular impairments is warranted in the assessment of individuals with concussion. It is also recommended to treat those specific vestibular impairments. The abstracts also found that additional high-quality research is needed to better determine the efficacy of vestibular intervention in concussion management.

Summary of August 2017 Topic: Relaxation/meditation Strategies for Balance & Vestibular Treatment

Abstracts in August looked at possible relaxation and meditation strategies that could be useful in persons with vestibular disorders. While the research is more limited in these treatment options, the abstracts showed possible interventions that may be beneficial.

The first abstract confirmed that Interdisciplinary treatment improves patient coping, functionality, and satisfaction and decreases overall health care utilization in vestibular patients (1). Breathing techniques were shown to be beneficial in two of the abstracts provided. The results suggest that regulation of the breathing pattern may have an influence on disability related to chronic vestibular disease, while proprioception exercises may improve postural control (2). It was found that diaphragmatic breathing subjects, compared to those in the control group, displayed significantly greater heart rate variability and reported feeling less motion sickness during exposure to the virtual reality experience than those in the control group (5).

Yoga practice can significantly reduce cognitive motor interference, which improves balance, by improving allocation and utilization of attentional resources for both balance control and executive cognitive functioning; thus, resulting in better performance under dual task conditions (3).

Finally, a study suggested mindfulness practice can promote effective heart rate regulation, and thereby promote effective recovery after a stressful event for individuals with headache conditions. Moreover, headache conditions may be associated with dysregulated stress recovery, thus more research is needed on the cardiovascular health and stress resilience of headache sufferers (4).

Summary of Monthly Abstract of the Week Topics From July 2017 to present

1. Naber CM, Water-Schmeder O, Bohrer PS, Matonak K, Bernstein AL, Merchant MA. Interdisciplinary treatment for vestibular dysfunction: the effectiveness of mindfulness, cognitive-behavioral techniques, and vestibular rehabilitation. Otolaryngol Head Neck Surg. 2011 Jul;145(1):117-24.
2. Jáuregui-Renaud K, Villanueva Padrón LA, Cruz Gómez NS. The effect of vestibular rehabilitation supplemented by training of the breathing rhythm or proprioception exercises, in patients with chronic peripheral vestibular disease. J Vestib Res. 2007;17(1):63-72.
3. Subramaniam S, Bhatt T. Effect of Yoga practice on reducing cognitive-motor interference for improving dynamic balance control in healthy adults. Complement Ther Med. 2017 Feb;30:30-35.
4. Azam MA, Katz J, Mohabir V, Ritvo P. Individuals with tension and migraine headaches exhibit increased heart rate variability during post-stress mindfulness meditation practice but a decrease during a post-stress control condition - A randomized, controlled experiment. Int J Psychophysiol. 2016 Dec;110:66-74.
5. Stromberg SE, Russell ME, Carlson CR. Diaphragmatic breathing and its effectiveness for the management of motion sickness. Aerosp Med Hum Perform. 2015 May;86(5):452-7.

Summary of September 2017 Topic: Meniere's Disease

The September topic was Meniere's disease and the selected articles aimed to provide evidence to support clinical presentation of Meniere's disease.

One article assessed whether endolymphatic cavity enlargement could be detected in T2 weighted MRI and therefore used to indicate endolymphatic hydrops and confirm a diagnosis Meniere's Disease. The study found that subjects with Meniere's Disease had a statistically significant increased endolymphatic cavity size compared to controls. Therefore, the current protocols using T2 MRI of the temporal bone can be used to help diagnose Meniere's Disease. (2)

Another article used MRI to measure endolymphatic hydrops in order to differentiate between Meniere's Disease and Vestibular Migraine diagnoses. Meniere's Disease showed significant endolymphatic hydrops via 3D-real-IR MRI but not in subjects with Vestibular Migraine. Therefore, this type of MRI can be helpful to rule in/rule out Meniere's Disease or Vestibular Migraine. This is especially useful because the clinical vestibular presentation of the two diagnoses can be similar. (1)

The final study aimed to examine the role of the vestibular system's influence on postural hemodynamics through examination of patients with Meniere's Disease who experience syncope. The study reinforced the function of vestibular system on circulation regulation via the vestibular sympathetic reflex. (3)

These articles support proper diagnosis and therefore appropriate treatment of patients with Meniere's Disease.

1) Sun W, Guo P, Ren T, Wang W. Magnetic resonance imaging of intratympanic gadolinium helps differentiate vestibular migraine from Ménière disease. Laryngoscope. 2017 Feb 21.
2) Keller JH et al. Detection of endolymphatic hydrops using traditional MR imaging sequences. Am J Otolaryngol. 2017 Apr 6. pii: S0196-0709(16)30622- 6.

3) Pyykkö I, Manchaiah V, Zou J, Levo H, Kentala E. Vestibular syncope: A disorder associated with drop attack in Ménière's disease. Auris Nasus Larynx. 2017 May 3. pii: S0385-8146(17)30088-3.

Summary of October 2017 Topic: Pain and the Vestibular System

These past month's abstracts looked at the link between the vestibular system and pain. In the first abstract a specific link between the two was discussed. There are remarkable parallel neurochemical phenotypes for inner ear and trigeminal ganglion cells and these afferent channels appear to converge in shared central pathways for vestibular and nociceptive information processing. These pathways share expression of receptors targeted by anti-migraine drugs (1).

The second abstract assessed the incidence of vestibular dysfunction in patients receiving medication for chronic, noncancer pain or other underlying neurologic disorders and to determined associated follow-up therapeutic and diagnostic recommendations. It was found that patients being treated with medications for chronic, noncancer pain or other underlying neurologic disorders may have a higher-than-average incidence of vestibular dysfunction. Baseline assessment and monitoring of the vestibular apparatus may be indicated for these patients (2). Another study determined whether patients with fibromyalgia, compared to age-matched healthy controls, have differences in dynamic posturography, including sensory, motor, and limits of stability despite having a normal clinical neurological examination (3).

A final study sought to determine if reduced head-on-trunk movement alters VOR suppression and gaze accuracy similar to experiments involving normal subjects and if intentionally increasing head and neck movement affects these dynamics. In patients with chronic neck pain, the internal commands issued for combined eye-head movements have large enough amplitudes to create accurate gaze saccades; however, because of increased neck stiffness and viscosity, the head movements produced are smaller, slower, longer, and more delayed than they should be. VOR suppression is disproportionate to the size of the actual gaze saccades because sensory feedback signals from neck proprioceptors are non-veridical, likely due to prolonged coactivation of cervical muscles. The outcome of these changes in eye-head kinematics is head-on-trunk stability at the expense of gaze accuracy. In the absence of vestibular loss, the practical consequences may be dizziness in the short term and imbalance and falls in the long term (4).

1. Balaban CD. Migraine, vertigo and migrainous vertigo: Links between vestibular and pain mechanisms. J Vestib Res. 2011;21(6):315-21. doi: 10.3233/VES-2011-0428.
2. Gilbert JW, Vogt M, Windsor RE, Mick GE, Richardson GB, Storey BB, Herder SL, Ledford S, Abrams DA, Theobald MK, Cunningham D, Kelly L, Herring KV, Maddox ML. Vestibular dysfunction in patients with chronic pain or underlying neurologic disorders.J Am Osteopath Assoc. 2014 Mar;114(3):172-8. doi: 10.7556/jaoa.2014.034.
3. Jones KD1, King LA, Mist SD, Bennett RM, Horak FB. Postural control deficits in people with fibromyalgia: a pilot study. Arthritis Res Ther. 2011 Aug 2;13(4):R127.

4. Johnston JL, Daye PM, Thomson GT. Inaccurate Saccades and Enhanced Vestibulo-Ocular Reflex Suppression during Combined Eye-Head Movements in Patients with Chronic Neck Pain: Possible Implications for Cervical Vertigo. Front Neurol. 2017 Jan 30;8:23. doi: 10.3389/fneur.2017.00023. eCollection 2017.

Summary of November 2017: Whiplash Associated Disorder (WAD)

The November Topic was Whiplash Associated Disorder (WAD). The five articles ranged in focus including oculomotor control, cervical spine proprioception, dizziness, and balance. Common to all of the articles was that the subjects had a whiplash injury.

One systematic review examined oculomotor control after whiplash injury. Overall the results varied but a main finding was that compensatory eye movements were common, especially in smooth pursuits. Based on this finding, it was proposed that this could negatively affect head and eye coordination. (1)

Four articles looked at the efficacy of physical therapy on reducing symptoms from WAD. The first suggested that neck exercises including a behavioral approach could reduce pain, dizziness and improve balance compared to just performing neck exercises. However, this intervention did not resolve these impairments fully. The authors suggested that the effect of specific exercises for the neck, dizziness and balance should be studied. (2)

An article examined the effect of vestibular physical therapy on neck pain and cervical spine range of motion. Vestibular therapy did not decrease pain intensity nor improve range of motion but it clearly did not worsen either of these. (4) Another article examined the potential benefits of vestibular physical therapy on balance and self-perceived dizziness and balance handicap, using the Dizziness Handicap Inventory. Both of these measures improved after six weeks of vestibular PT. (5)

Finally, an article summarized that known mechanisms for dizziness, imbalance, impaired oculomotor control, cervical spine proprioception exists due to cervical afferent dysfunction following a whiplash injury. This article recommended the examination and targeted treatment of these impairments. (3)

Overall, these articles verify the association between dizziness, imbalance and visual disturbances following a whiplash injury and suggest that targeted assessment and treatment of these impairments is important in the rehabilitation of these patients.

1) Ischebeck BK, de Vries J, Van der Geest JN, Janssen M, Van Wingerden JP, Kleinrensink GJ, Frens MA. Eye movements in patients with Whiplash Associated Disorders: a systematic review. Man Ther. 2016 Apr;22:122-30. doi: 10.1016/j.math.2015.10.017.
2) Treleaven J, Peterson G, Ludvigsson ML, Kammerlind AS, Peolsson A. J Orthop Sports Phys Ther. Balance, dizziness and proprioception in patients with chronic whiplash associated disorders complaining of dizziness: A prospective randomized study comparing three exercise programs. 2017 Jul;47(7):492-502. doi: 10.2519/jospt.2017.7052.

3) 3) Treleaven J. Dizziness, Unsteadiness, Visual Disturbances, and Sensorimotor Control in Traumatic Neck Pain. J Orthop Sports Phys Ther 2017;47(7):492-502. Epub 16 Jun 2017. doi:10.2519/jospt.2017.7052
4) Hansson EE, Persson L, Malmström EM. Influence of vestibular rehabilitation on neck pain and cervical range of motion among patients with whiplash-associated disorder: a randomized controlled trial. J Rehabil Med. 2013 Sep;45(9):906-10. doi: 10.2340/16501977-1197.
5) 5) Ekvall Hansson E, Månsson NO, Ringsberg KA, Håkansson A. Dizziness among patients with whiplash-associated disorder: a randomized controlled trial. J Rehabil Med. 2006 Nov;38(6):387-90.

Summary of December 2017: Motion Sensitivity

Motion sickness is a common disturbance occurring in healthy people as a physiological response to exposure to motion stimuli that are unexpected on the basis of previous experience. The motion can be either real, and therefore perceived by the vestibular system, or illusory, as in the case of visual illusion. A multitude of studies has been performed in the last decades, substantiating different nauseogenic stimuli, studying their specific characteristics, proposing unifying theories, and testing possible countermeasures (1).

One study sought to look at the relationship between migraine and motion sickness. Migraine is associated with enhanced motion sickness susceptibility and can cause episodic vertigo, but the mechanisms relating migraine to these vestibular symptoms remain unclear. In this study a hypothesis was tested that the central integration of rotational cues (from the semicircular canals) and gravitational cues (from the otolith organs) is abnormal in migraine patients. They found eye movement responses in Vestibular Migraine patients differed from migraine and normal subjects in three ways: the VOR axis shifts were larger in Vestibular Migraine patients, the normalized axis shift and normalized dumping efficacy were not correlated in VM patients, and the residual conflict in Vestibular Migraine patients was positively correlated with motion sickness susceptibility (2).

Another study compared the rates of carsickness in patients with Vestibular Migraine, Non-vestibular migraine, and Meniere's disease.Overall, 78.4% of the Vestibular Migraine patients had experienced carsickness in their lifetime. 89.2% of the 'definite Vestibular Migraine' patients, and 70.5% of the 'probably Vestibular Migraine' patients had a history of carsickness compared to 43.6% of the Non-Vestibular Migraine patients, and 18.2% of the Meniere's patients. Among the patients who had experienced carsickness, most had experienced carsickness in childhood before the onset of Vestibular Migraine, Non-Vestibular Migraine, or Meniere's disease (3).

For more information the first abstract has a full text with many other studies cited for further review: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4753518/

1. Bertolini G, Straumann D. Moving in a Moving World: A Review on Vestibular Motion Sickness. Front Neurol. 2016 Feb 15;7:14. doi: 10.3389/fneur.2016.00014. eCollection 2016.

2. Wang J, Lewis RF. Contribution of intravestibular sensory conflict to motion sickness and dizziness in migraine disorders. J Neurophysiol. 2016 Oct 1;116(4):1586-1591. doi: 10.1152/jn.00345.2016. Epub 2016 Jul 6.
3. Chang TP, Hsu YC. Vestibular migraine has higher correlation with carsickness than non-vestibular migraine and Meniere's disease. Acta Neurol Taiwan. 2014 Mar;23(1):4-10.

Summary of January 2018: Psychological Disorders and Vestibular Dysfunction

January's five abstracts were on the topic of psychological disorders and vestibular dysfunction. One article looked at the correlation of patients with vestibular dysfunction and psychological disorders. This article found that about 20% of this patient population had significant psychological distress, depression and anxiety. The author's conclusion was that consideration of psychological evaluation is warranted in this population. (3)

Another article concluded that vestibular therapy with patients with psychological disorders is warranted and successful. However, these patients may not have as good of outcomes compared to those without psychological disorders. (1) An abstract examined the anxiety and depression severity of patients with acute and chronic dizziness. This article found that patients with chronic dizziness had significantly more anxiety and depression with correlated with a higher emotional subscale of the Dizziness Handicap Inventory. Based on their findings they hypothesized that emotional status may prolong recovery from dizziness. (4)

The next abstract looked at the correlation of anxiety and migraine and found that patients with vestibular migraines had increased anxiety compared to migraines without vertigo. (2). Lastly, an article studied patients with mild brain injury and to see if the post-concussive symptoms could be predicted based on psychological factors assessed by standardized testing. This article found that only affective symptoms could be reliably predicted by psychological factors but postconcussive symptoms of vestibular, somatic, anxiety, depression nor cognitive could not be predicted in this way. (5)

These articles highlight the close connection between vestibular disorders and psychological status and should be assessed by clinicians and appropriately addressed for optimal outcomes.

1) MacDowell SG, Trommelen R, Bissell A, Knecht L, Naquin C, Karpinski A. The impact of symptoms of anxiety and depression on subjective and objective outcome measures in individuals with vestibulardisorders. J Vestib Res. 2017 Nov 10. doi: 10.3233/VES-170627. [Epub ahead of print]
2) Kutay Ö et al. Vestibular migraine patients are more anxious than migraine patients without vestibular symptoms. J Neurol. 2017 Oct;264(Suppl 1):37-41. doi: 10.1007/s00415-017-8439-6. Epub 2017 Mar 9

3) Kim SK, Kim YB, Park I-S, Hong SJ, Kim H, Hong SM. Clinical Analysis of Dizzy Patients with High Levels of Depression and Anxiety. Journal of Audiology & Otology. 2016;20(3):174-178. doi:10.7874/jao.2016.20.3.174.
4) Roh KJ, Kim MK, Kim JH, Son EJ. Role of Emotional Distress in Prolongation of Dizziness: A Cross-Sectional Study. J Audiol Otol. 2017 Dec;22(1):6-12. doi: 10.7874/jao.2017.00290. Epub 2017 Dec 29.
5) Sullivan KA1, Edmed SL, Greenslade JH, White M, Chu K, Lukin B, Lange RT, Lurie JK. Psychological Predictors of Postconcussive Symptoms Following Traumatic Injury. J Head Trauma Rehabil. 2017 Oct 27. doi: 10.1097/HTR.0000000000000347. [Epub ahead of print]

Summary of February 2018: Persistent Postural-Perceptual Dizziness (PPPD)

Persistent postural-perceptual dizziness (PPPD) is a newly defined diagnostic syndrome that unifies key features of chronic subjective dizziness, phobic postural vertigo and related disorders. . It describes a common chronic dysfunction of the vestibular system and brain that produces persistent dizziness, non-spinning vertigo and/or unsteadiness. Once recognised, PPPD can be managed with effective communication and tailored treatment strategies, including specialised physical therapy (vestibular rehabilitation), serotonergic medications and cognitive-behavioural therapy (1).

The second abstract discussed the diagnostic criteria for PPPD. PPPD manifests with one or more symptoms of dizziness, unsteadiness, or non-spinning vertigo that are present on most days for three months or more and are exacerbated by upright posture, active or passive movement, and exposure to moving or complex visual stimuli. PPPD may be precipitated by conditions that disrupt balance or cause vertigo, unsteadiness, or dizziness, including peripheral or central vestibular disorders, other medical illnesses, or psychological distress. PPPD may be present alone or co-exist with other conditions (2). Patients with PPPD also show significantly lower mean scores than normal individuals on conditions 2-6 of the Sensory Organization Test and the composite, and lower than patients recovered from an acute vestibular syndrome on conditions 2-3. Recovered patients had significantly lower mean scores than normal individuals on conditions 4-6 and the composite. Patients with PPPD had the greatest likelihood of abnormal sensory analyses (3).

Recent physiologic and neuroimaging data suggest that greater reliance on visual cues for postural control and dysfunction in central visuo-vestibular networks may be important pathophysiologic mechanisms underlying PPPD. Dysfunctions are thought to involve insular regions that encode recognition of the visual effects of motion in the gravitational field. This final abstract tested for altered activity in vestibular and visual cortices during self-motion simulation. For patients with PPPD, difficulties using visual data to discern the effects of gravity on self-motion may adversely affect balance control, particularly for individuals who simultaneously rely too heavily on visual stimuli. In addition, increased activity in the visual cortex, which correlated with severity of dizziness handicap, may be a neural correlate of visual dependence (4).

Summary of Monthly Abstract of the Week Topics From July 2017 to present

1. Popkirov S, Staab JP, Stone J. Persistent postural-perceptual dizziness (PPPD): a common, characteristic and treatable cause of chronic dizziness. Pract Neurol. 2018 Feb;18(1):5-13. doi: 10.1136/practneurol-2017-001809. Epub 2017 Dec 5.
2. Staab JP, Eckhardt-Henn A, Horii A, Jacob R, Strupp M, Brandt T, Bronstein A. Diagnostic criteria for persistent postural-perceptual dizziness (PPPD): Consensus document of the committee for the Classification of Vestibular Disorders of the Bárány Society. J Vestib Res. 2017;27(4):191-208. doi: 10.3233/VES-170622.
3. Söhsten E, Bittar RS, Staab JP. Posturographic profile of patients with persistent postural-perceptual dizziness on the sensory organization test. J Vestib Res. 2016 Jul 2;26(3):319-26.
4. Riccelli R, Passamonti L, Toschi N, et al. Altered Insular and Occipital Responses to Simulated Vertical Self-Motion in Patients with Persistent Postural-Perceptual Dizziness. Frontiers in Neurology. 2017;8:529. doi:10.3389/fneur.2017.00529

Summary of March 2018 Topic: CSM Recap

There were four articles highlighting topics presented at CSM 2018. The first article describes a framework for clinical decision making in the acute setting. TiTrATE is an algorithim for assessing dizziness based on timing, triggers, targeted exam and tests. The goal of TiTrATE is to optimize accurate diagnoses. (1)

The next article addressed the question: Should youth who have sustained a concussion always be symptom free prior to returning to sport? The article established occurrence rates of symptoms such as excessive fatigue, headache and anxiety in the youth general population. The goal was to examine if youth who have who have sustained a concussion might have symptoms that occur typically post-concussion even at baseline. This study established that youth in general have do have post-concussion type symptoms at baseline; therefore, it is not necessarily true that concussed youth should be symptom free prior to return to sport. (2)

The next was a systematic review, included 14 articles, looking at the potential benefits of treating posterior canal BPPV with multiple sessions as well as multiple Epley maneuvers in a single session. The rate of success increased to 100% after 5 sessions and success increased from 84% with one repositioning to 92% after 3 were performed in a single session. Overall, repeating the Epley at least twice and multiple sessions achieved the greatest benefit. (3)

The final article looked at the use of Maddox rod test to assess cyclotorsion. The study demonstrated the subjective test may have a high level of assessor and subject error and results could misinform the clinician's clinical decision making. (4)

1.Newman-Toker DE, Edlow JA. TiTrATE: A Novel, Evidence-Based Approach to Diagnosing Acute Dizziness and Vertigo. Neurol Clin. 2015 Aug;33(3):577-99, viii. doi: 10.1016/j.ncl.2015.04.011.
2. Hunt AW, Paniccia M, Reed N, Keightley M. Concussion-Like Symptoms in Child and Youth Athletes at Baseline: What Is "Typical"? J Athl Train. 2016 Oct;51(10):749-757. doi: 10.4085/1062-6050-51.11.12. Epub 2016 Nov 11.

3. Reinink H, Wegner I, Stegeman I, Grolman W. Rapid systematic review of repeated application of the epley maneuver for treating posterior BPPV. Otolaryngol Head Neck Surg. 2014 Sep;151(3):399-406. doi: 10.1177/0194599814536530. Epub 2014 May 29.
4. Marsh JD, Durkin MW, Hack AE, Markowitz BB, Cheeseman EW. Accuracy of Double Maddox Rod with Induced Hypertropia in Normal Subjects. Am Orthopt J. 2014;64:76-80. doi: 10.3368/aoj.64.1.76.

Summary of April 2018: Exercise, Physical Activity and the Vestibular System

The benefits of exercise physical activity are widely known. This past month's abstracts sought to look at how physical activity may affect the vestibular system.

The first abstract looked at the effect of exercise in migraines. The aim of the study was to investigate the efficacy and possible anti-inflammatory benefits of exercise in patients with vestibular migraine. They found the group undergoing exercise training showed significant symptomatic improvement and demonstrated suppressed antioxidant enzyme activity (1).

The second abstract compared the effects of galvanic vestibular stimulation (GVS) on postural control for participants of different physical activity status - active and non-active. The main results indicated that the regular practice of sports activities counteracts postural control disruption caused by GVS. The active group demonstrated better postural control than the non-active group when subjected to higher vestibular manipulation. The study concluded active participants could identify the relevant sensory input, thought a better central integration, which enables them to switch faster between sensory inputs (2).

Another abstract investigated the relationships between motion sickness susceptibility (MSS) in adulthood and physical and sporting activities (PSA). Subjects having practiced a sport before the age of 18 have less MSS than the other subjects. By practicing PSA, subjects are less dependent on visual input and use vestibular afferences better (3).

The final abstract study aimed to evaluate physical activity-related benefit on vestibular function. They concluded starting physical activity has immediate beneficial effects on the vestibule, in terms of vestibular stimulation mechanisms these effects soon disappear if this activity is stopped (4).

1. Lee YY, Yang YP, Huang PI, Li WC, Huang MC, Kao CL, Chen YJ, Chen MT. Exercise suppresses COX-2 pro-inflammatory pathway in vestibular migraine. Brain Res Bull. 2015 Jul;116:98-105. doi: 10.1016/j.brainresbull.2015.06.005. Epub 2015 Jul 4.
2. Maitre J, Paillard T. Postural Effects of Vestibular Manipulation Depend on the Physical Activity Status. PLoS One. 2016 Sep 14;11(9):e0162966. doi: 10.1371/journal.pone.0162966. eCollection 2016.
3. Caillet G, Bosser G, Gauchard GC, Chau N, Benamghar L, Perrin PP. Effect of sporting activity practice on susceptibility to motion sickness. Brain Res Bull. 2006 Apr 14;69(3):288-93. Epub 2006 Jan 19.
4. Gauchard GC, Vançon G, Gentine A, Jeandel C, Perrin PP. Physical activity after retirement enhances vestibulo-ocular reflex in elderly humans. Neurosci Lett. 2004 Apr 22;360(1-2):17-20.

Summary of May 2018: Topic: Visual Considerations in Vestibular Rehabilitation

The May topic was visual considerations in vestibular rehabilitation. The first article developed the Pediatric Visually Induced Dizziness Questionnaire (PVID) to measure the visually induced dizziness in children. Nearly 300 subjects were included, healthy subjects and those with vestibular or migraine disorders. The PVID was found to be a valid measure to identify visually induced vertigo. (1)

The next article examined the connection between migraine and convergence insufficiency. Four cases were used to highlight this connection in cases where patients with migraines reported difficultly reading and persistent eye strain; convergence insufficiency may have played a role. (2)

Next, the study sought information from the Vestibular/Ocular Motor Screening (VOMS) that could indicate a prolonged recovery post-concussion in youth. Based on a retrospective chart review of 167 patients, all VOMS domains except convergence and accommodation deficits were associated with prolonged recovery. It was proposed that the VOMS could be used to help prognosticate recovery in addition to quantify deficits. (3)

The next article aimed to use visual examination as a biomarker for the presence of concussion. Patients with concussion were compared to healthy controls. Average constriction velocity (ACV), average dilation velocity (ADV) and near point convergence were found to significantly affected in those with acute concussion and therefore could be used to help diagnose the presence of concussion. (4)

The final article looked at the role of contrast lighting in the adaptation of the VOR. They found that adaptation was optimized when using a contrast threshold of ~ 1000 during VOR retraining. They note that this optimal level of contrast is far greater than what typical room light provides. (5)

1. Pavlou M, Whitney SL, Alkathiry AA, Huett M, Luxon LM, Raglan E, Godfrey EL, Bamiou DE. Visually Induced Dizziness in Children and Validation of the Pediatric Visually Induced Dizziness Questionnaire. Front Neurol. 2017 Dec 5;8:656. doi: 10.3389/fneur.2017.00656. eCollection 2017.
2. Singman EL, Matta NS, Silbert DI. Convergence insufficiency associated with migraine: a case series. Am Orthopt J. 2014;64:112-6. doi: 10.3368/aoj.64.1.112.
3. Anzalone AJ, Blueitt D, Case T, McGuffin T, Pollard K, Garrison JC, Jones MT A Positive Vestibular/Ocular Motor Screening (VOMS) Is Associated With Increased Recovery Time After Sports-Related Concussion in Youth and Adolescent Athletes. Am J Sports Med. 2017 Feb;45(2):474-479. doi: 10.1177/0363546516668624. Epub 2016 Oct 28
4. Capó-Aponte JE, Beltran TA, Walsh DV, Cole WR, Dumayas JY. Validation of Visual Objective Biomarkers for Acute Concussion. Mil Med. 2018 Mar 1;183(suppl_1):9-17. doi: 10.1093/milmed/usx166.
5. Muntaseer Mahfuz M, Schubert MC, Todd CJ, Figtree WVC, Khan SI, Migliaccio AA. The Effect of Visual Contrast on Human Vestibulo-Ocular Reflex Adaptation. J Assoc Res Otolaryngol. 2018 Feb;19(1):113-122. doi: 10.1007/s10162-017-0644-6. Epub 2017 Nov 6.

Summary of June 2018 Topic: Migraine

This past month's studies focused various symptoms associated with migraine and the effects vestibular rehabiliation can have on those symptoms, as well as other disorders associated with migraine. The first study aimed to compare the effects of vestibular rehabilitation on headache and other outcomes relating to dizziness, and the psychological factors in patients with vestibular migraine, patients with dizziness and tension-type headache, and patients without headache. Vestibular rehabilitation contributed to improvement of headache both in patients with vestibular migraine and patients with dizziness and tension-type headache, in addition to improvement of dizziness and psychological factors (1).

The aim of the second study was to compare anxiety disorders in 3 groups: patients with vestibular migraine (VM), patients with migraine but without vertigo (MO) and healthy controls (HC). The study showed that VM patients are significantly more anxious and agoraphobic than MO patients and HC, displaying higher sensitivity to separation and being more prone to seeking medical reassurance (2).

Recent studies have looked at the response of patients with Mal de Debarquement Syndrome (MdDS) to management with migraine prophylaxis, including lifestyle changes and medical therapy. One study found that management of MdDS as vestibular migraine can improve patients' symptoms and increase the quality of life. In addition, nearly all the patients suffering from MdDS had a personal or family history of migraine headaches or had signs or symptoms suggestive of atypical migraine (3).

Currently, there are no known definitive diagnostic tests that can reliably distinguish between Meniere's Disease and Vestibular Migraines, their differentiation is often difficult. Future studies are needed to help adequately distinguish the diagnosis of both diseases (4).

1. Sugaya N, Arai M, Goto F. Is the Headache in Patients with Vestibular Migraine Attenuated by Vestibular Rehabilitation? Front Neurol. 2017 Apr 3;8:124. doi: 10.3389/fneur.2017.00124. eCollection 2017.
2. Kutay Ö, Akdal G, Keskinoğlu P, Balcı BD, Alkın T. Vestibular migraine patients are more anxious than migraine patients without vestibular symptoms. J Neurol. 2017 Oct;264(Suppl 1):37-41. doi: 10.1007/s00415-017-8439-6. Epub 2017 Mar 9.
3. Ghavami Y1, Haidar YM1, Ziai KN1, Moshtaghi O1, Bhatt J1, Lin HW1, Djalilian HR1,2. Management of mal de debarquement syndrome as vestibular migraines. Laryngoscope. 2017 Jul;127(7):1670-1675. doi: 10.1002/lary.26299. Epub 2016 Oct 12.
4. Tabet P, Saliba I. Meniere's Disease and Vestibular Migraine: Updates and Review of the Literature. J Clin Med Res. 2017 Sep;9(9):733-744. doi: 10.14740/jocmr3126w. Epub 2017 Jul 27.

Summary of Monthly Abstract of the Week Topics From July 2017 to present

Summary of July 2018 Topic: Unilateral Vestibular Hypofunction

The topic for July was unilateral vestibular hypofunction. The first article sought to assess the efficacy of vestibular rehabilitation with this patient population. The authors performed a systematic review including 39 articles representing over 2000 patients with unilateral vestibular hypofunction. The evidence was compelling that vestibular rehabilitation is effective in managing patients with unilateral vestibular hypofunction. (1)

The next article looked at the testing to diagnose hypofunction. It compared caloric testing, the historical gold standard, to video head impulse test (vHIT). 324 patients with unilateral hypofunction were given caloric and vHIT. 12% had an abnormal vHIT while 35% had an abnormal caloric testing. A positive vHIT had a high positive predictive value of an abnormal caloric test. Therefore, the vHIT does not replace caloric testing but is a good clinical test for screening of unilateral hypofunction. (2)

The next article aimed to gain information about the functional differences between those with unilateral or bilateral hypofunction and those who did not. 24 subjects were tracked in their gait patterns and eye gaze during stair climbing and descending. Patients with hypofunction looked more at the structure, ie- stairs or ramp. (3)

The final study examined gait mechanic differences between those with unilateral vestibular hypofunction and healthy subjects. Subjects walked on a treadmill with over 30 joint position sensors. The hypofunction group had a wider step width and decreased stability. (4)

1. Is vestibular rehabilitation effective in improving dizziness and function after unilateral peripheral vestibular hypofunction? An abridged version of a Cochrane Review. Hillier S1, McDonnell M. Eur J Phys Rehabil Med. 2016 Aug;52(4):541-56. Epub 2016 Jul 12.
2. Determining vestibular hypofunction: start with the video-head impulse test. van Esch BF1, Nobel-Hoff GE2, van Benthem PP3, van der Zaag-Loonen HJ4, Bruintjes TD4. Eur Arch Otorhinolaryngol. 2016 Nov;273(11):3733-3739. Epub 2016 Apr 25.
3. Patients with chronic peripheral vestibular hypofunction compared to healthy subjects exhibit differences in gaze and gait behaviour when walking on stairs and ramps. Swanenburg J1,2, Bäbler E1,3, Adelsberger R4, Straumann D5, de Bruin ED3. PLoS One. 2017 Dec 18;12(12):e0189037. doi: 10.1371/journal.pone.0189037. eCollection 2017.
4. Characterizing Patients with Unilateral Vestibular Hypofunction Using Kinematic Variability and Local Dynamic Stability during Treadmill Walking. Liu P1,2, Huang Q2, Ou Y2, Chen L2, Song R1, Zheng Y2. Behav Neurol. 2017;2017:4820428. doi: 10.1155/2017/4820428. Epub 2017 Jul 13.

Summary of August 2018 Topic: Optometric Examination

This past month's abstracts covered topics related to eye movements that maybe helpful in determining vestibular pathology during examination.

Skew deviation can be defined as vertical misalignment of the eyes that does not map to any of cyclovertical muscles, in association with neurologic symptoms and signs and with posterior fossa lesion.

Summary of Monthly Abstract of the Week Topics From July 2017 to present

It is commonly caused by ischemia of the posterior paramedian pons, medial thalamus, or cerebellum. When the vestibular nuclei are involved, skew deviation may occur with acute vestibular syndrome. (1).

In addition to a skew deviation, ocular tilt reaction (OTR) may be present and involves the triad of ocular torsion, skew deviation, and head tilt. Ipsiversive OTR components associated with hearing loss can be early diagnostic signs of anterior inferior cerebellar artery infarction (2)

A review of literature published from January 2016 to August 2017, looked at nystagmus in clinical practice. A structured description of nystagmus including its three-dimensional beating direction, trigger factors, and duration is of major importance. The differential diagnosis of downbeat nystagmus is broad and includes acute intoxications, neurodegenerative disorders and cerebrovascular causes amongst others. In patients with positional nystagmus, the distinction between frequent benign peripheral and rare but dangerous central causes is imperative (3).

Finally, the use of video head impulse test (vHIT) gains and corrective saccades (CSs) at the acute and follow-up stages of vestibular neuritis were assessed. The abnormal rates based on both vHIT gains and CS measurements are similar at the acute stage of VN but are considerably higher at the follow-up stage compared with the abnormal rates based on vHIT gains alone. It is thus advisable to check both CS and vHIT gain while performing vHIT to detect vestibular hypofunction (4)

1. Hernowo A, Eggenberger E. Skew deviation: clinical updates for ophthalmologists. Curr Opin Ophthalmol. 2014 Nov;25(6):485-7. doi: 10.1097/ICU.0000000000000105.
2. Naoi T, Morita M, Kawakami T, Fujimoto S. Ipsiversive Ocular Torsion, Skew Deviation, and Hearing Loss as Initial Signs of Anterior Inferior Cerebellar Artery Infarction. Intern Med. 2018 Jul 1;57(13):1925-1927. doi: 10.2169/internalmedicine.0283-17. Epub 2018 Feb 9.
3. Tarnutzer AA, Straumann D1. Nystagmus. Curr Opin Neurol. 2018 Feb;31(1):74-80. doi: 10.1097/WCO.0000000000000517.
4. Yang CJ, Cha EH, Park JW, Kang BC, Yoo MH, Kang WS, Ahn JH, Chung JW, Park HJ. Diagnostic Value of Gains and Corrective Saccades in Video Head Impulse Test in Vestibular Neuritis. Otolaryngol Head Neck Surg. 2018 Aug;159(2):347-353. doi: 10.1177/0194599818768218. Epub 2018 Apr 10.

Summary of September 2018 Topic: Vestibular Paroxysmia

The September abstracts' topic was vestibular paroxysmia (VP). One article outlines the diagnostic criteria for VP which requires: ten or episodes vertigo lasting less than 1 minute; stereotyped phenomenology; response to carbamazepine/oxcarbazepine; and not accounted for by another diagnosis. Important diagnostic differentials include Meniere's disease, vestibular migraine, BPPV, stroke, fistula and others. The criteria for probable VP was also described. (2)

Another article described the clinical presentation of 3 pediatrics with VP. Nystagmus can be observed during an episode and MRI may reveal compression. VP Should be considered in pediatrics with multiple brief daily episodes of vertigo. (3)

Summary of Monthly Abstract of the Week Topics From July 2017 to present

The first article summarized the treatment of VP which primarily is medication, carbamazepine or similar. There are other medication classes available if the above mentioned is not successful. If the symptoms do not respond to medication, a decompression surgery is available to relieve the pressure of the 8th cranial nerve most commonly caused by a loop of the anterior inferior cerebellar artery. Surgery is reserved for intractable cases. (1)

The final article was a study to evaluate the efficacy of oxcarbazepine with a RCT, 18 patients included. The medication group had a significant reduction in episodes and no adverse side effects were revealed. (4)

1. Brandt T, Strupp M, Dieterich M. Vestibular paroxysmia: a treatable neurovascular cross-compression syndrome. J Neurol. 2016 Apr;263 Suppl 1:S90-6. doi: 10.1007/s00415-015-7973-3. Epub 2016 Apr 15.
2. Strupp M, Lopez-Escamez JA, Kim JS, Straumann D, Jen JC, Carey J, Bisdorff A, Brandt T. Vestibular paroxysmia: Diagnostic criteria. J Vestib Res. 2016;26(5-6):409-415. doi: 10.3233/VES-160589.
3. Lehnen N, Langhagen T, Heinen F, Huppert D, Brandt T, Jahn K. Vestibular paroxysmia in children: a treatable cause of short vertigo attacks. Dev Med Child Neurol. 2015 Apr;57(4):393-6. doi: 10.1111/dmcn.12563. Epub 2014 Aug 22.
4. Bayer O, Brémová T, Strupp M, Hüfner K. A randomized double-blind, placebo-controlled, cross-over trial (Vestparoxy) of the treatment of vestibular paroxysmia with oxcarbazepine. J Neurol. 2018 Feb;265(2):291-298. doi: 10.1007/s00415-017-8682-x. Epub 2017 Nov 27.

Summary of October 2018 Topic: ICVR Recap

See the Fall Winter Newsletter

Summary of November 2018 Topic: vHIT

The first article was a review of the literature regarding the video head impulse test (vHIT). The review included 27 articles. One finding is that the video HIT is more sensitive than the clinical head impulse test (cHIT). If the vHIT is negative, caloric testing should be performed to rule out a hypofunction. All canals should be tested in an attempt to isolate the weakness.

The next study aimed to compare the results of vHIT and caloric testing in adolescents. 49 subjects were included in the prospective study, average age was 16. All participants underwent bi-thermal caloric testing with air and vHIT on the same day. Calorics were normal in all cases. 84% had abnormal vHIT and approximately 1/3 of these had multiple canal involvement, of these all had the same ear affected. Posterior canal was most commonly affected. vHIT is a good test for adolescents and children and provides useful information.

The main objective of the next study was to assess if a relationship exists between vHIT and self-reported dizziness. Secondary goal included comparing the vHIT to caloric testing. 115 participants filled

out the Dizziness Handicap Inventory (DHI) and had caloric and vHIT testing on the same day. It was determined that the DHI could not be used to predict outcomes of vHIT. The study also showed that vHIT and caloric testing are not redundant but instead complimentary, providing different functional integrity information of the horizontal canal. The vHIT lacks some sensitivity compared to calorics but is easier for the patient to tolerate and takes less time to complete.

Summary of December 2018 Topic: Concussion

December abstracts looked at the role of the vestibular system in concussion, various baseline measurements and their relationship to one another, and also explored the idea of being symptom free before staring a return to play protocol.

The assessment and treatment of sport-related concussion (SRC) often requires a multifaceted approach. Vestibular dysfunction represents an important profile of symptoms and pathology following SRC, with high prevalence and association with prolonged recovery. The most common vestibular disturbances after SRC include benign paroxysmal positional vertigo, vestibulo-ocular reflex impairment, visual motion sensitivity, and balance impairment. When vestibular dysfunction is identified, there is emerging support for applying targeted vestibular rehabilitation to manage this condition. (1)

In the next study there was a focus on the physiological signs of concussion to help narrow the differential diagnosis of PCS in athletes. The physiological effects of exercise on concussion are especially important for athletes. Some athletes with PCS have exercise intolerance that may result from altered control of cerebral blood flow. Systematic evaluation of exercise tolerance combined with a physical examination of the neurologic, visual, cervical, and vestibular systems can in many cases identify one or more treatable postconcussion disorders. (2)

Collegiate varsity athletes participated in study to assess relationships between various concussion baseline assessments including a demographic questionnaire, graded symptom checklist, neurocognitive assessment, and the Sensory Organization Test (SOT). Reaction time and executive function demonstrated significant relationships with SOT balance performance. These cognitive processes may influence athletes' ability to organize and process higher order information and generate appropriate responses to changes in their environment, with respect to balance and injury risk. (3).

After a concussion, guidelines emphasize that an athlete should be asymptomatic before starting a return-to-play protocol. However, many concussion symptoms are nonspecific and may be present in individuals without concussion. Limited evidence exists regarding the presence of "typical" or preinjury (baseline) symptoms in child and youth athletes. Children and youths commonly experienced symptoms

at baseline, including fatigue and nervousness. (4)

1. Mucha A, Fedor S, DeMarco D. Vestibular dysfunction and concussion. Handb Clin Neurol. 2018;158:135-144. doi: 10.1016/B978-0-444-63954-7.00014-8.
2. Leddy J, Baker JG, Haider MN, Hinds A, Willer B. A Physiological Approach to Prolonged Recovery From Sport-Related Concussion.J Athl Train. 2017 Mar;52(3):299-308. doi: 10.4085/1062-6050-51.11.08.
3. Vander Vegt CB, Register-Mihalik JK, Ford CB, Rodrigo CJ, Guskiewicz KM, Mihalik JP .Baseline Concussion Clinical Measures Are Related to Sensory Organization and Balance. Med Sci Sports Exerc. 2018 Sep 19. doi: 10.1249/MSS.0000000000001789. [Epub ahead of print]
4. Hunt AW, Paniccia M, Reed N, Keightley M. Concussion-Like Symptoms in Child and Youth Athletes at Baseline: What Is "Typical"? J Athl Train. 2016 Oct;51(10):749-757. doi: 10.4085/1062-6050-51.11.12. Epub 2016 Nov 11.

Summary of January 2019 Topic: Complementary therapies for balance disorders and management of anxiety

The first article looked at the effect of Tai Chi on balance. This study compared balance outcome measures including Berg, TUG, Functional Reach, 50-foot walk test, 5x sit to stand and ABC. Some then participated in Tai Chi while others in the study did not. Those who performed Tai Chi improved on most of the measures and the control group did not. The average age of participants was 80 years and the Tai Chi program was 16 weeks long. The study concludes that Tai Chi can improve mobility, balance and function, however the n was only 16. (1)

Next, a systematic review was performed to evaluate the effect of Tai Chi on risk of falling. Overall Tai Chi was found to decrease risk of falls especially as the frequency of exercise increased. (2)

Lastly, a review of practice of yoga with or without mindfulness practice was examined based on its effect on stress as measured by physiologic parameters such as BP, HR, cortisol levels. The findings were that practice including postures and yoga poses had a regulating effect on sympathetic nervous system. (3)

1. Bubela D, Sacharko L, Chan J, Brady M. Balance and Functional Outcomes for Older Community-Dwelling Adults Who Practice Tai Chi and Those Who Do Not: A Comparative Study. J Geriatr Phys Ther. 2017 Nov 9. doi: 10.1519/JPT.0000000000000153.
2. Huang ZG, Feng YH, Li YH, Lv CS. Systematic review and meta-analysis: Tai Chi for preventing falls in older adults. BMJ Open. 2017 Feb 6;7(2):e013661. doi: 10.1136/bmjopen-2016-013661
3. Pascoe MC, Thompson DR, Ski CF.Yoga, mindfulness-based stress reduction and stress-related physiological measures: A meta-analysis. Psychoneuroendocrinology. 2017 Dec;86:152-168. doi: 10.1016/j.psyneuen.2017.08.008. Epub 2017 Aug 30.

Summary of Monthly Abstract of the Week Topics From July 2017 to present

Summary of February 2019 Topic: Pediatric Concussion

Sport-related concussion (SRC) is a major public health problem. Approximately 90% of SRCs in high school athletes are transient; symptoms recover to baseline within 1 week. However, a small percentage of patients remain symptomatic several months after injury, with a condition known as postconcussion syndrome (PCS). Multiple studies this past month discussed risk factors for prolonged recovery. Vision and vestibular-related deficits are common after concussion and are associated with prolonged recovery times, substantially impacting the quality of life for children. Vestibular rehabilitation in children with concussion is associated with improvement in symptoms as well as visuovestibular performance (1).

The second abstract discussed clinical variables associated with vestibulo-ocular dysfunction (VOD) detected at initial consultation among pediatric patients. Out of 306 subjects, 30.1% of those with acute SRC (65.0% male, mean age 13.9 years) and 43.0% of those with PCS (41.9% male, mean age 15.4 years) met the criteria for VOD at initial consultation. Independent predictors of VOD at initial consultation included female sex, preinjury history of depression, posttraumatic amnesia, and presence of dizziness, blurred vision, or difficulty focusing at the time of injury. Independent predictors of PCS among patients with acute SRC included the presence of VOD at initial consultation, preinjury history of depression, and posttraumatic amnesia at the time of injury.

They also discussed that VOD at initial consultation is associated with prolonged recovery (2).

Another study showed among youth with SRC, risk for development of PCS was higher in those with a personal and/or family history of mood disorders, other psychiatric illness, and migraine (3).

Finally, ADHD was shown to be an antecedent risk factor for SRC and may contribute to a more complicated course of recovery from SRC (4).

1. Storey EP, Wiebe DJ, D'Alonzo BA, Nixon-Cave K, Jackson-Coty J, Goodman AM, Grady MF, Master CL. Vestibular Rehabilitation Is Associated With Visuovestibular Improvement in Pediatric Concussion. J Neurol Phys Ther. 2018 Jul;42(3):134-141.
2. Ellis MJ, Cordingley DM, Vis S, Reimer KM, Leiter J, Russell K. Clinical predictors of vestibulo-ocular dysfunction in pediatric sports-related concussion. J Neurosurg Pediatr. 2017 Jan;19(1):38-45. doi: 10.3171/2016.7. PEDS16310. Epub 2016 Sep 30.
3. Morgan CD, Zuckerman SL, Lee YM, King L, Beaird S, Sills AK, Solomon GS. Predictors of postconcussion syndrome after sports-related concussion in young athletes: a matched case-control study. J Neurosurg Pediatr. 2015 Jun;15(6):589-98. doi: 10.3171/2014.10.PEDS14356. Epub 2015 Mar 6.
4. Iaccarino MA, Fitzgerald M, Pulli A, Woodworth KY, Spencer TJ, Zafonte R, Biederman J. Sport concussion and attention deficit hyperactivity disorder in student athletes: A cohort study. Neurol Clin Pract. 2018 Oct;8(5):403-411.

Summary of March 2019 Topic: Vestibular Impairments with Thiamine Deficiency

The topic for Abstract of the Week in March 2019 is vestibular impairments with thiamine deficiency. The first article reviewed literature to identify of oculomotor signs presence prior to onset of encephalopathy due to thiamine deficiency. Decreased horizontal vestibular ocular reflex, horizontal nystagmus, and ophthamloparesis may occur prior to encephalopathy and may respond to medical treatment of the thiamine deficiency. (1)

Next, a case study was done to examine VHIT and manual HIT in a patient with known thiamine deficiency. The horizontal VOR was decreased and improved with thiamine supplementation. (2)

Lastly, a retrospective study of patients with Wernicke's encephalopathy (WE) was done. Peripheral and central vestibular impairments were identified including gaze evoked nystagmus, ataxia and impaired head impulse testing, specifically involving the horizontal semi-circular canals due to medial vestibular nuclei neurons susceptibility to thiamine deficiency, were prevalent. Therefore, VHIT is useful in examining for suspected WE. (3)

1. Kattah JC. The Spectrum of Vestibular and Ocular Motor Abnormalities in Thiamine Deficiency. Curr Neurol Neurosci Rep. 2017 May;17(5):40. doi: 10.1007/s11910-017-0747-9.
2. Kattah JC, Guede C, Hassanzadeh B. The medial vestibular nuclei, a vulnerable target in thiamine deficiency. J Neurol. 2018 Jan;265(1):213-215. doi: 10.1007/s00415-017-8670-1. Epub 2017 Nov 15.
3. Lee SH, Kim SH, Kim JM, Tarnutzer AA. Vestibular Dysfunction in Wernicke's Encephalopathy: Predominant Impairment of the Horizontal Semicircular Canals. Front Neurol. 2018 Mar 12;9:141. doi: 10.3389/fneur.2018.00141. eCollection 2018.

Summary of April 2019 Topic: Biobehavioral Aspects of Vestibular Rehab

Anxiety is strongly associated with vestibular disorders; however, there is a lack of understanding about how physiotherapists respond to people presenting with anxiety within vestibular rehabilitation. This study aimed to explore physiotherapists' current practice in assessing and treating patients with anxiety in vestibular rehabilitation. Ten Physiotherapists in this study requested tailored training and guidance to enhance their ability to manage patients with anxiety more effectively in vestibular rehabilitation (1).

The next abstract evaluated the evidence for psychological treatments for persistent postconcussion symptoms following mild traumatic brain injury. Counselling or cognitive behaviour therapy have the most support but the evidence remains limited. The best results are seen when postconcussion programs use counselling or cognitive behaviour therapy and are targetted for people with an increased risk of persistent symptoms (2).

The association between depression and benign paroxysmal positional vertigo (BPPV) remains debated. Another study aimed to investigate the risk of BPPV in patients with depressive disorders and found that

patients with depressive disorders may have an increased risk of developing BPPV, especially those who have hyperthyroidism and systemic lupus erythematosus (3).

Lastly, it is known that dizziness is frequently encountered in medical practice, often takes a chronic course, and can impair the health-related quality of life (HRQoL). However, results on the extent of this impairment of HRQoL are mixed. 203 patients were evaluated for this using the SF-36. Both the physical (PCS-36) and mental (MCS-36) HRQoL are significantly impaired in patients with dizziness. While the impairment in PCS-36 can be explained by clinical symptoms of the dizziness, MCS-36 impairment is largely associated with psychosocial factors. To improve the patient's overall well-being significantly and permanently doctors have to keep in mind both, the clinical symptoms and the psychosocial factors. Therefore, in addition to the physical examination doctors should integrate a basic psychological examination into the daily routine with dizziness patients (4).

1. Walker A, Kantaris X, Chambers M. Understanding therapeutic approaches to anxiety in vestibular rehabilitation: a qualitative study of specialist physiotherapists in the UK. Disabil Rehabil. 2018 Apr;40(7):829-835. doi: 10.1080/09638288.2016.1277393. Epub 2017 Jan 27.
2. Sullivan KA, Kaye SA, Blaine H, Edmed SL, Meares S, Rossa K, Haden C. Psychological approaches for the management of persistent postconcussion symptoms after mild traumatic brain injury: a systematic review. Disabil Rehabil. 2019 Feb 11:1-9. doi: 10.1080/09638288.2018.1558292.
3. Hsu CL, Tsai SJ, Shen CC, Lu T, Hung YM, Hu LY. Risk of benign paroxysmal positional vertigo in patients with depressive disorders: a nationwide population-based cohort study. BMJ Open. 2019 Mar 30;9(3):e026936. doi: 10.1136/bmjopen-2018-026936.
4. Weidt S, Bruehl AB, Straumann D, Hegemann SC, Krautstrunk G, Rufer M. Health-related quality of life and emotional distress in patients with dizziness: a cross-sectional approach to disentangle their relationship. BMC Health Serv Res. 2014 Jul 22;14:317. doi: 10.1186/1472-6963-14-317.

Summary of May 2019 Topic: Vestibular Schwannoma

The topic for May was Vestibular Schwannoma. The first article looked at the functional effect of persons with vestibular schwannoma who were managed conservatively, without surgery etc. Several balance measures showed inferior balance and mobility of the group with vestibular schwannoma. Despite this variance those with schwannoma still had a low fall risk and supports monitoring this population with balance outcome measures. (1)

The next article examined the efficacy of diagnosis of unilateral vestibular schwannoma using both vHIT and caloric testing. 20/30 subjects with diagnosed vestibular schwannoma demonstrated a hypofunction via calorics but only 10/30 had an abnormal gain indicating a unilateral hypofunction using the vHIT. (2)

The next article evaluated the type of schwannoma's effect on vestibular function. The larger cystic tumors had more of a negative impact on gain. (3)

The final article assessed saccades via a PR score, measure of scatter and refixation of saccades, before and after surgical resection of 36 patients with vestibular schwannomas. Patients with worse pre-op

dysfunction had faster compensation after surgery. PR score could be used to evaluate recovery post-op. (4)

1. Low Choy NL, Lucey MM, Lewandowski SL, Panizza BJ. Impacts of small vestibular schwannoma on community ambulation, postural, and ocular control. Laryngoscope. 2017 May;127(5):1147-1152. doi: 10.1002/lary.26105. Epub 2016 Aug 13.
2. Tranter-Entwistle I, Dawes P, Darlington CL, Smith PF, Cutfield N. Video head impulse in comparison to caloric testing in unilateral vestibular schwannoma. Acta Otolaryngol. 2016 Nov;136(11):1110-1114. Epub 2016 May 25.
3. Constanzo F, Teixeira BCA, Sens P, Ramina R. Video Head Impulse Test in Vestibular Schwannoma: Relevance of Size and Cystic Component on Vestibular Impairment. Otol Neurotol. 2019 Apr;40(4):511-516. doi: 10.1097/MAO.0000000000002158.
4. Batuecas-Caletrio A, Rey-Martinez J, Trinidad-Ruiz G, Matiño-Soler E, Cruz-Ruiz SS, Muñoz-Herrera A, Perez-Fernandez N. Vestibulo-Ocular Reflex Stabilization after Vestibular Schwannoma Surgery: A Story Told by Saccades. Front Neurol. 2017 Jan 25;8:15. doi: 10.3389/fneur.2017.00015. eCollection 2017.

Summary of June 2019 Topic: Visual Dependency in Vestibular Disorders

Visual dependence in postural control, often measured by increased postural sway on exposure to visual motion, is an indication of altered visual-vestibular integration with greater weighting towards visual cues for balance. In the first study the relationship between visual dependence in postural control was investigated in relation to cortisol reactivity to psychosocial stress (using the Trier Social Stress Test for groups: TSST-G), as an index of hypothalamic-pituitary-adrenal (HPA) axis function, in healthy young females. In those who exhibited a cortisol response, a negative relationship between stress-induced cortisol reactivity and visual dependence in postural control was observed, since those with the largest cortisol response showed less visual motion induced postural sway (1).

A second study found long-term prognosis after vestibular neuritis is not dependent on the magnitude of the peripheral residual damage. Instead, a combination of visuovestibular psychophysical factors (visual dependence), psychological traits and dysfunctional vestibular perception are relevant. Several functional and structural neuroimaging changes develop after vestibular neuritis, which reflect and underlie the aforementioned psychophysiological and psychological features (2).

Visual dependence can often be present in a patient, although little, if any, measurable pathology is present. Although at times it cannot be accurately measured with either standardized testing or pertinent questionnaires, "hypersensitive" patients have a genuine disease and their symptoms are not of psychiatric origin (3).

The degree to which a person relies on visual stimuli for spatial orientation is termed visual dependency (VD). VD is considered a perceptual trait or cognitive style influenced by psychological factors and mediated by central reweighting of the sensory inputs involved in spatial orientation. VD is often measured with the rod-and-disk test, in which participants align a central rod to the subjective visual vertical (SVV). A final study looked to see what effect torsional nystagmic eye movements may have on individual performance. Using caloric ear irrigation, 3D video-oculography, and the rod-and-disk test, we show that caloric torsional nystagmus modulates measures of VD and demonstrate that increases in tilt after irrigation are positively correlated with changes in ocular torsional eye movements. These findings show that measures of VD can be influenced by oculomotor responses induced by caloric stimulation. The findings are of significance for clinical studies, as they indicate that VD, which often increases in vestibular disorders, is modulated not only by changes in cognitive style but also by eye movements, in particular nystagmus (4).

1. Smyth N, Flynn M, Rajcani J, F Hucklebridge M, Thorn L, Wood C, Golding J, Evans P, Clow A. Attenuated cortisol reactivity to psychosocial stress is associated with greater visual dependency in postural control. Psychoneuroendocrinology. 2019 Jun;104:185-190. doi: 10.1016/j.psyneuen.2019.02.028. Epub 2019 Mar 2.
2. Bronstein AM, Dieterich M. Long-term clinical outcome in vestibular neuritis. Curr Opin Neurol. 2019 Feb;32(1):174-180. doi: 10.1097/WCO.0000000000000652.
3. Maire R, Mallinson A, Ceyte H, Caudron S, Van Nechel C, Bisdorff A, Magnusson M, Petersen H, Kingma H, Perrin P. Discussion about Visual Dependence in Balance Control: European Society for Clinical Evaluation of Balance Disorders. J Int Adv Otol. 2017 Dec;13(3):404-406. doi: 10.5152/iao.2017.4344.
4. Roberts RE, Da Silva Melo M, Siddiqui AA, Arshad Q, Patel M. Vestibular and oculomotor influences on visual dependency. J Neurophysiol. 2016 Sep 1;116(3):1480-7. doi: 10.1152/jn.00895.2015. Epub 2016 Jun 29.

Summary of July 2019 Topic: Vestibulotoxicity

The first article summarized the effects of aminoglycoside otoxicity including symptoms of ataxia, disequilibrium and oscillopsia. This article also presented the risk factors for developing vestibulotoxitcity and the possible dosing implications. (1)

This next was a systematic review that examined the prevalence and the types of adverse effects of aminoglycoside (AG) in order to determine which vestibular tests are best for identifying vestibulotoxicity. 27 studies were included in the review, finding vestibulotoxic side effects ranging from 0 to 60%. Authors hypothesize that VHIT and vestibular evoked myogenic potential are likely better tests for early identification of vestibulotoxicity as AG effects hairs cells more. They recommend more prospective studies. (2)

The next was a descriptive article examining the effects of AG on 71 patients. The authors sugsest that monitoring vestibulotoxicity is essential in this patient population. (3)

The final article was a review that examined the effects of platinum based chemotherapy on the vestibular system. The effect on the horizontal canal as determined by caloric testing was 0-50% across the studies. The conclusion of the review is that platinum based chemotherapy may pose a significant risk for vestibulotoxicity especially cisplatinum and with serial exposure and should be further studied and considered as an adverse effect. (4)

1. Rutka J. Aminoglycoside Vestibulotoxicity. Adv Otorhinolaryngol. 2019;82:101-110. doi: 10.1159/000490277. Epub 2019 Jan 15.
2. Van Hecke R, Van Rompaey V, Wuyts FL, Leyssens L, Maes L. Systemic Aminoglycosides-Induced Vestibulotoxicity in Humans. Ear Hear. 2017 Nov/Dec;38(6):653-662. doi: 10.1097/AUD.0000000000000458.
3. Handelsman JA. Vestibulotoxicity: strategies for clinical diagnosis and rehabilitation. Int J Audiol. 2018 Sep;57(sup4):S99-S107. doi: 10.1080/14992027.2018.1468092. Epub 2018 May 9.
4. Prayuenyong P, Taylor JA, Pearson SE, Gomez R, Patel PM, Hall DA, Kasbekar AV, Baguley DM. Vestibulotoxicity Associated With Platinum-Based Chemotherapy in Survivors of Cancer: A Scoping Review. Front Oncol. 2018 Sep 25;8:363. doi: 10.3389/fonc.2018.00363. eCollection 2018.

Summary of August 2019 Topic: Motion Sickness

Motion sickness (MS) is evoked by the conflict among somatosensory, visual, and vestibular input. Last month's abstracts explored possible treatment options for this.

The first study explored the different vestibular physiologic response retention patterns after Coriolis acceleration training in student pilots and extend the results for use with Chinese astronauts in the future. All subjects were exposed to five-day continuous or intermittent Coriolis acceleration training. Retention of the vestibulo-autonomic reaction after vestibular training was different for control subjects and student pilots. Uncoupling patterns between post-rotatory nystagmus and the vestibulo-autonomic reaction may be helpful in the design of clinical rehabilitation plans for balance-disorder patients and for exploration of artificial gravity in future space missions (1).

Virtual reality (VR) immersion often provokes subjective discomfort and postural instability, so called VR sickness. Using transcranial direct current stimulation (tDCS), we aimed to investigate whether VR sickness could be relieved by the modulation of cortical excitability in the temporoparietal junction (TPJ). The amelioration of VR sickness was found by anodal tDCS over the right TPJ and might result from relief of the sensory conflict and/or facilitation of vestibular function (2).

A third study investigated the effects of TENS on MS. Motion sickness symptoms, blood pressure (BP), skin temperature, heart rate (HR), and heart rate variability (HRV) were measured. Saliva samples were

collected to analyze the level of stress markers. Cognitive function was evaluated with d2 test prior to and after MS provocation. Sympathetic activity increased but parasympathetic activity decreased during MS. TENS was effective in reducing MS symptoms as well as alleviating cognitive impairment (3).

Pitch head-and-trunk movements during constant velocity rotation are a provocative vestibular stimulus that produces vertigo and nausea. When exposed to this stimulus repeatedly, motion sickness symptoms diminish as the subjects habituate. Acetylleucine is a drug that is used to treat acute vestibular vertigo. In this study, we wanted to ascertain whether this drug (a) lessened motion sickness or delayed habituation; (b) accelerated the recovery following habituation; and (c) whether changes in the subjective vertical accompanied habituation.
Acetylleucine neither reduced the nausea associated with this provocative stimulus, nor hastened the acquisition or retention of vestibular habituation of motion sickness and nystagmus but did find. Subjects showed larger error in the subjective visual vertical after habituation, which indicates that spatial orientation is also affected by vestibular training (4).

1. Wang L, Cao Y, Tan C, Zhao Q, He S, Niu D, Tang G, Zou P, Xing L. Uncoupling VOR and vestibuloautonomic retention to Coriolis acceleration training in student pilots and control subjects. J Vestib Res. 2017.

2. Takeuchi N, Mori T, Suzukamo Y, Izumi SI. Modulation of Excitability in the Temporoparietal Junction Relieves Virtual Reality Sickness. Cyberpsychol Behav Soc Netw. 2018.

3. Chu H1, Li MH, Juan SH, Chiou WY. Effects of transcutaneous electrical nerve stimulation on motion sickness induced by rotary chair: a crossover study. J Altern Complement Med. 2012 May;18(5):494-500. doi: 10.1089/acm.2011.0366. Epub 2012 Apr 26.

4. Clément G, Deguine O, Bourg M, Pavy-LeTraon A. Effects of vestibular training on motion sickness, nystagmus, and subjective vertical. J Vestib Res. 2007.

Summary of September 2019 Topic: Back to Basics of Vestibular Therapy

The first article looked at a sample of elderly adults with vestibular impairments, n=57. This retrospective study found vestibular therapy delivered 10 sessions, 2x/week, had a significant positive change on balance, function and dizziness as measured by TUG, gait speed and DHI. (1)
The next article divided 33 healthy adults into 3 groups: 1) no training (control), 2) visual feedback weight shift training (WST) coupled with an active horizontal headshake (HS) activity to elicit a vestibular perturbation, 3) visual feedback WST without HS (NoHS). Six sessions were performed 2x/day every other day, (M-W-F). The Sensory Organization Test (SOT) was performed before and after the treatments. Significant changes in the SOT were found with use of visual feedback training suggesting sensory reweighting adaptation had occurred with the training. (2)

The third study examined residual dizziness and imbalance following repositioning treatment for BPPV. This study was experimental, prospective, randomized, controlled study, n=32, to examine the effects of vestibular therapy on this patient's with BPPV. The subjects were randomly assigned to 2 groups, 1) control group (n=15) performing only repositioning 2) experimental group (n=17) performing the maneuvers and vestibular rehabilitation exercises. The subjects were followed for 6 months and the subjects who were treated with therapy beyond repositioning had significantly decreased dizziness with decreased reoccurrence of BPPV. (3)

The final article examined the relationship between benign paroxysmal positional vertigo (BPPV) and anxiety and assess its association with somatic amplification and health anxiety. 120 subjects were included, 60 with BPPV and 60 healthy (non-BPPV). The Beck Anxiety Inventory (BAI), Short Health Anxiety Inventory (SHAI), and Somatosensory Amplification Scale (SSAS) questionnaires were used. Those in the BPPV group had higher anxiety scores than healthy participants, though the levels of anxiety were normal. The authors suggest that monitoring psychological health may help prevent chronic dizziness. (4)

1. Verdecchia DH, Monzón AM, Urbina Jaimes V, Oliveira FR, Paiva L da S, Carvalho TD de. Patient-Reported and Performance Outcomes Significantly Improved in Elderly Patients with Vestibular Impairment following Rehabilitation: A Retrospective Study. Journal of Aging Research. August 2018:1-8.
2. Appiah-Kubi KO, Wright WG. Vestibular training promotes adaptation of multisensory integration in postural control. Gait Posture. 2019 Sep;73:215-220. doi: 10.1016/j.gaitpost.2019.07.197.
3. Rodrigues DL, Ledesma ALL, Pires de Oliveira CA, Bahmad F Jr. Effect of Vestibular Exercises Associated With Repositioning Maneuvers in Patients With Benign Paroxysmal Positional Vertigo: A Randomized Controlled Clinical Trial Otol Neurotol. 2019 Sep;40(8):e824-e829.
4. Özdilek A, Yalınay Dikmen P, Acar E, Ayanoğlu Aksoy E, Özdilek A. Determination of Anxiety, Health Anxiety and Somatosensory Amplification Levels in Individuals with Benign Paroxysmal Positional Vertigo J Int Adv Otol. 2019 Jul 26. doi: 10.5152/iao.2019.6874.

Summary of October 2019 Topic: Neural Correlates of Dizziness

It is currently unclear how different brain regions/networks process vestibular information and integrate the information into a unified spatial percept related to somatosensory awareness and whether people with recurrent balance complaints have a neural signature as a trait affecting their development of chronic symptoms of vertigo. By using resting state source localized electroencephalography in non-vertiginous state, electrophysiological changes in activity and functional connectivity of 23 patients with balance complaints are analyzed and compared to healthy subjects. The analyses showed increased alpha2 activity within the posterior cingulate cortex and the precuneues/cuneus and reduced beta3 and gamma activity within the pregenual and subgenual anterior cingulate cortex for the subjects with

balance complaints. The study showed that these patients have a neural signature or trait that makes them prone to developing chronic balance problems (1).

In the second abstract using event-related functional magnetic resonance imaging (fMRI) study they investigated how the brain of patients with bilateral vestibular failure (BVF) responds to vestibular stimuli. Using whole brain analysis, group comparisons revealed increased brain activity in early visual cortices (V3) and superior temporal gyrus of patients but there was no significant interaction, i.e. stimulus-response function in these regions were still similar in both groups. Brain activity in these regions during (high)GVS increased with higher dizziness-related handicap scores but was not related to the degree of vestibular impairment or disease duration. The data indicate that perceptible GVS-related cortical responsivity is not diminished but increased in multisensory (visual-vestibular) cortical regions despite bilateral failure of the peripheral vestibular organ (2).

Vestibular patients occasionally report aggravation or triggering of their symptoms by visual stimuli, which is called visually induced dizziness (VID). After using a resting state fMRI scan they found alterations in the visual and vestibular cortical network in VID patients that could underlie the typical VID symptoms such as a worsening of their vestibular symptoms when being exposed to challenging visual stimuli(3).

Finally a group of six studies that strictly met inclusion criteria were analysed to assess cortical-subcortical correlates of acute clinical features related to VN. The present review clearly reveals that sudden UVF may induce a wide variety of cortical and subcortical responses - with changes in different sensory modules - as a result of acute plasticity in the central nervous system (4).

1. Alsalman O, Ost J, Vanspauwen R, Blaivie C, De Ridder D, Vanneste S. The Neural Correlates of Chronic Symptoms of Vertigo Proneness in Humans. PLoS One 2016, Apr 18;11(4):e0152309. doi: 10.1371/journal.pone.0152309. eCollection 2016.
2. Helmchen C, Rother M, Spliethoff P, Sprenger A. Increased brain responsivity to galvanic vestibular stimulation in bilateral vestibular failure. Neuroimage Clin 2019, Jul 19;24:101942. doi: 10.1016/j.nicl.2019.101942
3. Van Ombergen A, Heine L, Jillings S, Roberts RE, Jeurissen B, Van Rompaey V, Mucci V, Vanhecke S, Sijbers J, Vanhevel F, Sunaert S, Bahri MA, Parizel PM, Van de Heyning PH, Laureys S, Wuyts FL. Altered functional brain connectivity in patients with visually induced dizziness. Neuroimage Clin 2017, Feb 28;14:538-545. doi: 10.1016/j.nicl.2017.02.020. eCollection 2017.
4. Micarelli A, Chiaravalloti A, Schillaci O, Ottaviani F, Alessandrini M. Aspects of cerebral plasticity related to clinical features in acute vestibular neuritis: a "starting point" review from neuroimaging studies. Acta Otorhinolaryngol Ital 2016, Apr;36(2):75-84. doi: 10.14639/0392-100X-642. Epub 2016 Apr 29

Summary of November 2019 Topic: Vestibular Hypofunction

The topic for November's abstracts was Vestibular Hypofunction. The first article was intended to examine the optimal timing for performing dynamic visual acuity (DVA) interventions in those with unilateral hypofunction. DVA protocols were provided for 30 min twice per week for 4 weeks. There were 3 groups that followed this protocol but start times were 2 weeks after onset, 3 weeks and after 1 month after onset of hypofunction. The study demonstrated that earlier intervention had better DVA and aVOR recovery and decreased compensatory saccades. (1)

The next abstract examined whether covert saccades help to maintain dynamic visual acuity in those with bilateral vestibular loss. Frequency, latency, consistency of covert saccade initiation, and gain of covert saccades, residual vestibulo-ocular reflex gain were recorded. No correlation was found between residual vestibulo-ocular reflex gain and dynamic visual acuity. Refixation (covert saccades) were found to improve gaze stability in individuals with bilateral hypofunction and support targeted training in these individuals. (2)

The final article was a case report looking at VOR adaptation after 6 months training in an individual with chronic unilateral vestibular hypofunction, 2 years after onset. The subject performed 15 min/day of incremental VOR adaptation (IVA) with an at home device. The VOR adapted substantially, the patient had subjectively less symptoms and participated more in activities. This case study supports further research of the IVA training in chronic unilateral vestibular hypofunction population. (3)

1. Michel L, Laurent T, Alain T. Rehabilitation of dynamic visual acuity in patients with unilateral vestibular hypofunction: earlier is better. Eur Arch Otorhinolaryngol. 2019 Oct 21.
2. Hermann R. Pelisson D. Dumas O, Urquizar C, Truy E. Tilikete C. Are Covert Saccade Functionally Relevant in Vestibular Hypofunction? Cerebellum. 2018 Jun;17(3):300-307
3. Rinaudo CN, Schubert MC, Cremer PD, Figtree WVC, Todd CJ, Migliaccio AA. Improved Oculomotor Physiology and Behavior After Unilateral Incremental Adaptation Training in a Person With Chronic Vestibular Hypofunction: A Case Report. Phys Ther. 2019 Oct 28;99(10)

Summary of December 2019 Topic: The Effect of Vision on VOR

The topic for December Abstracts was the effect of vision on VOR. The first article looked at the effect of target distance on VOR. 5 different target distances were assessed ranging from 10 cm to 150cm in 18 healthy subjects using vHIT. In these subjects, the gain was significantly increased with the closer target distance. Then 10 subjects were tested in the dark and imagined varying distances. These subjects followed a similar pattern. Therefore, closer targets increases gain. (1)

The next article investigated if convergence increases the gain during when irrigated with cold water, intentionally inducing unilateral hyposensensitivity. Their experiments showed that convergence (near

viewing) increases the VOR gain during irrigation (hyposensitivity) compared to far viewing, which is the same as without irrigation. Therefore, cold irrigation does not stop the peripheral vestibular pathway. (2)

The goal of the final article was to examine the role of visual impairment and correction on VOR gain. There were 3 groups: 1- refractory error corrected with glasses, 2- refractory error corrected with and 3- no visual impairment. vHIT was used to assess VOR gain. There was no significant difference found between groups or within groups (amount of gain correlated to amount of refractory error). Therefore, no correction of refractory error is required for training VOR. (3)

1. Castro P, Sena Esteves S, Lerchundi F, Buckwell D, Gresty MA, Bronstein AM, Arshad Q. Viewing Target Distance Influences the Vestibulo-Ocular Reflex Gain when Assessed Using the Video Head Impulse Test. Audiol Neurootol. 2018;23(5):285-289. Epub 2018 Dec 11.
2. Tamás LT, Lundberg YW, Büki B. Vergence increases the gain of the human angular vestibulo-ocular reflex during peripheral hyposensitivity elicited by cold thermal irrigation. J Vestib Res. 2018;27(5-6):265-270. doi: 10.3233/VES-170629.
3. van Dooren TS. The Video Head Impulse Test and the Influence of Daily Use of Spectacles to Correct a Refractive Error. Front Neurol. 2018 Mar 7;9:125. doi: 10.3389/fneur.2018.00125. eCollection 2018.

Summary of January 2020 Topic: BPPV Recurrence

The first study examined recurrence rate and timeline of BPPV. There were two treatment groups randomly assigned to either performing Particle Repositioning Maneuver (PRM) or Brandt Daroff (BD) exercise. 80% of the PRM group had a negative Dix Hall Pike test at 1 week after treatment, opposed to only 25% in the BD group. Of the both groups there was ~35% recurrence rate at 48 months but the time to recurrence was significantly longer in the PRM group. (1)

The second article looked at recurrence rate of BPPV after repositioning. The study included 455 subjects with BPPV, the majority had posterior canal. Telephone follow up revealed a ~11% recurrence rate within 3 years with the highest recurrence occurring in the 51-60 year old demographic. The recurrence of posterior canal and horizontal canal was similar. (2)

The 3rd study aimed to determine if previous canal involvement could be used to predict future canal involvement. For example if the patient initially had R posterior canal BPPV, what is the likelihood that their next occurrence would also be in the R posterior canal? This information could then be used to recommend a home exercise program and subsequent occurrences. The study looked at data from 167 patients and found that recurrences could not be predicted, therefore making a recommendation for home repositioning for a recurrence would likely not be effective. (3)

The final study looked at whether a daily canal reposition procedure (CRP) could prevent recurrence of BPPV. 39 subjects with posterior BPPV were included in the study. 17 performed a daily CRP and 22 in the control group did not. The subjects were followed for 2 years and 41% of the all subjects had a recurrence but there was not significant difference between recurrence rate and onset of symptoms between those who performed CRP and those who did not. The authors concluded that a home program will not affect recurrence of posterior canal. (4)

1. Amor-Dorado JC, Barreira-Fernández MP, Aran-Gonzalez I, Casariego-Vales E, Llorca J, González-Gay MA. Particle repositioning maneuver versus Brandt-Daroff exercise for treatment of unilateral idiopathic BPPV of the posterior semicircular canal: a randomized prospective clinical trial with short- and long-term outcome. Otol Neurotol. 2012 Oct;33(8):1401-7. doi: 10.1097/MAO.0b013e318268d50a.
2. Wang YQ, Li JR, Zou SZ, Ding YL. Clinical features and recurrence rate on benign paroxysmal positional vertigo. 2019 Dec;33(12):1185-1188. doi: 10.13201/j.issn.1001-1781.2019.12.017.
3. Kim HJ, Kim JS. The Patterns of Recurrences in Idiopathic Benign Paroxysmal Positional Vertigo and Self-treatment Evaluation. Front Neurol. 2017 Dec 15;8:690. doi: 10.3389/fneur.2017.00690. eCollection 2017.
4. Helminski JO, Janssen I, Hain TC. Daily exercise does not prevent recurrence of benign paroxysmal positional vertigo. Otol Neurotol. 2008 Oct;29(7):976-81. doi: 10.1097/MAO.0b013e318184586d.

Summary of February 2020 Topic: Vestibular Migraine

The topic for February AoW was Vestibular Migraine. The first article aimed to look at migraine associated features in vestibular migraine. 279 subjects with known vestibular migraine in Europe were observed. The average age of migraine onset was nearly 22 years old. The headaches were less than 24 hours in nearly 80% of the cases. Common symptoms were (in order of highest frequency to lowest) nausea, phonophobia, photophobia, vomiting and lightheadedness. Approximately ¼ experienced auras. There was a high familial connection, 67%. Compared to patients with migraine, the vestibular migraine group had a shorter duration of headaches. (1)

The second article performed a review of the literature to summarize the clinical features of vestibular migraine. The authors found a variety of vestibular symptoms can occur and often more than one does. These symptoms can be transient or persistent and include vertigo and dizziness which are often accompanied by headache. Other migraine type features include auditory symptoms, photophobia, phonophobia, osmophobia and visual aura. Anxiety is commonly found with vestibular migraine. Abortive treatments include triptans, vestibular suppressants or anti-nausea medications. Other migraine prophylaxis are useful as well such as antiepileptics, beta blockers and anti-depressants. Diagnosis is made by linking the vestibular and migraine features and treatment is multifactorial including migraine prevention and lifestyle modification as well as treating co-morbidities. (2)

Summary of Monthly Abstract of the Week Topics From July 2017 to present

The next article used a questionnaire to examine 252 subjects with vestibular migraine. The features of vertigo, accompanying symptoms, familial history, and migraine precursors were the focus of the study. Age of onset of migraine average was 23 but the average age of onset of vertigo was 38. Over ¾ of the subjects reported internal vertigo and ¼ described external vertigo. Approximately half of subjects had vertigo lasting less than 1 hours with 23% of all subjects reporting vertigo lasting less than 5 min. The other half of subjects had symptoms lasting between 1hr and up to 3 days. Only a few subjects had vertigo symptoms lasting longer than 3 days. The next most common symptom was nausea followed by photophobia, phonophobia, vomiting, palpitations, tinnitus, ear fullness and 4% experienced hearing loss. 70% of all subjects had a known family history of migraines and 67% had a known family history of vertigo. 42% had motion sickness in youth, a migraine pre-curser indicating that motion sickness may be predictive of migraine later in life. (3)

The final article reviewed vestibular migraine management, specifically the effects of physical therapy (PT) on vestibular symptoms. Six articles were included and they were inconclusive in demonstrating the effects of PT to minimize vestibular symptoms in patients with VM. The authors recommend more studies, specifically blinded, RTCs. (4)

1. Teggi R et al. Clinical Features of Headache in Patients With Diagnosis of Definite Vestibular Migraine: The VM-Phenotypes Projects. Front Neurol. 2018 Jun 5;9:395. doi: 10.3389/fneur.2018.00395. eCollection 2018.
2. Beh SC. Vestibular Migraine: How to Sort it Out and What to Do About it. J Neuroophthalmol. 2019 Jun;39(2):208-219
3. Teggi R, et al. Clinical Features, Familial History, and Migraine Precursors in Patients With Definite Vestibular Migraine: The VM-Phenotypes Projects.Headache. 2018 Apr;58(4):534-544. doi: 10.1111/head.13240. Epub 2017 Dec 4.
4. Alghadir AH, Anwer S. Effects of Vestibular Rehabilitation in the Management of a Vestibular Migraine: A Review. Front Neurol. 2018;9:440. Published 2018 Jun 12.

Summary of March 2020 Topic: Telehealth and Vestibular Rehab

Summary of April 2020 Topic: Telehealth and Vestibular Rehab

Summary of Monthly Abstract of the Week Topics From July 2017 to present

May 2020 Topic: Bilateral vestibular Summary of Dysfunction and Cochlear Implant

The topic for May was bilateral vestibular dysfunction and cochlear implant. In the first article, 119 patients with bilateral vestibular loss were studied to determine factors related to falling. The cohort was divided into 2 groups, non-fallers and fallers as defined as >/= 1 fall in past 12 months. Only DHI score >47 amd PSQ >27.5 were found to loosely correlate with fall risk. Other data collected were caloric testing, rotarty chair, vHIT, cVEMP, and hearing function but did not predict falls, nor did age, cause of vestibular loss or duration of loss. (1)
The next article aimed to quantify dizziness in 20 subjects with cochlear implant. Overall the testing found low subjective dizziness per the VRBQ and balance was good per ABC and FGA scores but gait speed was abnormal as well as gaze instability and specifically poor performance on SOT condition 5. The conclusions of the authors were that patients should all participate in vestibular rehab given vestibular impairments post cochlear implant. (2)
The third article revealed a new pattern of bilateral hypofunction, bilateral posterior canal dysfunction, as it now can be detected by the vHIT. This was a retrospective study which found this dysfunction most common in the elderly, idiopathic and frequently accompanied by sensorineural hearing loss and posterior downbeat nystagmus with the chief complaint of unstable gait.

1. Dobbels B, Lucieer F, Mertens G, Gilles A, Moyaert J, van de Heyning P, Guinand N, Pérez Fornos A, Herssens N, Hallemans A, Vereeck L, Vanderveken O, Van Rompaey V, van de Berg R. Prospective cohort study on the predictors of fall risk in 119 patients with bilateral vestibulopathy. PLoS One. 2020 Mar 9;15(3):e0228768. doi: 10.1371/journal.pone.0228768. eCollection 2020.
2. Murray D, Viani L, Garvan J, Murphy A, Vance R, Simoes-Franklin C, Smith J, Meldrum D. Balance, gait and dizziness in adult cochlear implant users: A cross sectional study. Cochlear Implants Int. 2020 Jan;21(1):46-52. doi: 10.1080/14670100.2019.1662978. Epub 2019 Sep 18.
3. Lerchundi F, Laffue AH, Olivier M, Gualtieri FJ. Bilateral posterior semicircular canal dysfunction: a new finding with video head impulse test. J Neurol. 2020 Apr 28. doi: 10.1007/s00415-020-09793-5.

Summary of June 2020 Topic: Meniere's Disease

This past month, the abstracts focused on updated treatment for Meniere's disease.

The aim of the first abstract was to investigate current treatment practices and self-reported effectiveness in Ménière's disease. Twenty-four different treatments were reported for Ménière's disease, with dietary modifications, diuretics, and betahistine being the most common. Despite many treatment approaches targeting different proposed pathophysiology for Ménière's disease, all treatments are reported as effective by patients. Intratympanic gentamicin provided the greatest

reductions in vertigo count, functional limitations, and work absenteeism, as well as the fewest respondents reporting post-treatment functional limitations (1).

The second abstract compared the efficacy of intratympanic gentamicin injection on vertigo control, drop attacks, and functional level in Menière's disease patients with and without a history of migraine. They found intratympanic gentamicin appears equally effective in treating vertigo and drop attacks in Menière's disease with and without migraine, but patients with migraine derive significantly less benefit in terms of functional improvement (2).

The next abstract evaluated the change in quality of life (QOL) of patients with Meniere's disease (MD) after treatment with migraine prophylaxis therapy. The Majority of MD patients who had all failed diuretic therapy responded positively to medications used for migraine prophylaxis, as indicated by a significant improvement in QOL. This study may further suggest a correlation between the pathophysiologic basis of disease in MD and vestibular migraine. Patients with MD may be successfully managed with medications intended to treat migraine (3).

In the final abstract the authors discussed that the etiology of both MD and migraine is likely multifactorial, further exploration of the association between the two conditions may illuminate how to best manage them in the future. MD is likely a manifestation of cochleovestibular migraine, which occurs as a result of migraine related changes in both the cochlea and vestibule (4).

1. Ward B, Wettstein V, Golding J, et al. Patient Perceptions of Effectiveness in Treatments for Menière's Disease: a National Survey in Italy. J Int Adv Otol. 2019;15(1):112-117. doi:10.5152/iao.2019.5758
2. Liu YF, Renk E, Rauch SD, Xu HX. Efficacy of Intratympanic Gentamicin in Menière's Disease With and Without Migraine. Otol Neurotol. 2017;38(7):1005-1009. doi:10.1097/MAO.0000000000001460
3. Ghavami Y, Haidar YM, Moshtaghi O, Lin HW, Djalilian HR. Evaluating Quality of Life in Patients With Meniere's Disease Treated as Migraine. Ann Otol Rhinol Laryngol. 2018;127(12):877-887.
4. Sarna B, Abouzari M, Lin HW, Djalilian HR. A hypothetical proposal for association between migraine and Meniere's disease. Med Hypotheses. 2020;134:109430.

Summary of July 2020 Topic: Suppression Head Impulse Paradigm (SHIMP)

The topic for the Abstract of the Week for the month of July was Suppression Head Impulse Paradigm (SHIMP), a test that may reveal information about the function of the canal rather than the dysfunction. The first article was a retrospective study including 15 patients that were diagnosed with a unilateral vestibular neuritits. The study included an exam of the vestibulo-saccadic interaction to determine recovery of these patients and deeded this information as useful. (1)

Summary of Monthly Abstract of the Week Topics From July 2017 to present

The next study aimed to compare SHIMP and Head Impulse Paradigm (HIMP) testing feasibility in adolescents. 29 subjects healthy subjects were tested. During the HIMP, no saccades were seen, consistent with no abnormal function. SHIMP revealed saccades in all subjects. The conclusion was that theses testing methods are feasible. (2)

Another study examined the parameters of the HIMP and SHIMP tests. Subjects with vestibular neuritis were tested and found to have compensatory saccades with the HIMP on the affective sides and no saccades on the unaffected side. SHIMP exam showed saccades on the unaffected side and no or weak saccades on the affected side. The conclusion was that SHIMP can evaluate residual vestibular function or compensation in patients with vestibular neurititis. (3)

The final study also aimed to compare the results of HIMP and SHIMP in patients with acute vestibular neuritits (AVN). A retrospective study of 21 patients with AVN tests were reviewed. The results revealed a correlation between SHIMP & HIPM with SHIMP gain being lower than HIMP and the difference was larger on the affected side. The peak saccadic velocity (PSV) had significant correlation with canal paresis. The authors concluded suggests that SHIMP could be a useful complimentary test in evaluating vestibular function. (4)

1. Manzari L, Tramontano M. Suppression Head Impulse Paradigm (SHIMP) in evaluating the vestibulo-saccadic interaction in patients with vestibular neuritis. Eur Arch Otorhinolaryngol. 2020;10.1007/s00405-020-06085-6.
2. Devantier L, Hoskison E, Ovesen T, Henriksen JM. Suppression head impulse paradigm in healthy adolescents - A novel variant of the head impulse test. J Vestib Res. 2018;28(3-4):311-317.
3. Chen FY, Zhang YZ, Wu CQ, et al.[The application value of suppression head impulse paradigm in vestibular neuritis] . 2018;32(18):1374-1377. doi:10.13201/j.issn.1001-1781.2018.18.003
4. Park JS, Lee JY, Nam W, Noh S, Chang SO, Kim MB. Comparing the Suppression Head Impulse Paradigm and the Head Impulse Paradigm in Vestibular Neuritis. Otol Neurotol. 2020;41(1):e76-e82.

Summary of August 2020 Topic: Postural Threat Influences in Vestibular Function

Standing balance is significantly influenced by postural threat. While this effect has been well established, the underlying mechanisms of the effect are less understood.
The first abstract investigated how vestibulo-spinal reflexes (VSRs) and vestibulo-ocular reflexes (VORs) measured through vestibular evoked myogenic potentials (VEMPs) and video head impulse test (vHIT) outcomes, respectively, are modulated during standing under conditions of increased postural threat. VEMP amplitudes and horizontal and vertical vHIT gains all increased with standing on high surface height conditions. Changes in VEMP amplitudes as well as horizontal vHIT gains were correlated with changes in electrodermal activity. VEMP amplitude also positively correlated with fear . The findings

provide support for a potential central modulation of the vestibular nucleus complex through excitatory inputs from neural centers involved in processing fear, anxiety, arousal, and vigilance (1).

The second abstract examined the effect of threat of perturbation, a different form of postural threat, on coupling (cross-correlation, coherence, and gain) of the vestibulo-muscular relationship. In the "No-Threat" conditions, participants stood quietly on a stable surface. In the "Threat" condition, participants' balance was threatened with unpredictable mediolateral support surface tilts. Surface EMG was recorded from bilateral trunk, hip, and leg muscles. Hip and leg muscles exhibited significant increases in peak cross-correlation amplitudes, coherence, and gain in the Threat condition compared with No-Threat conditions, and significant correlations were observed between threat-related changes in physiological arousal and medium-latency peak cross-correlation amplitude in medial gastrocnemius (2).

The third study repeatedly exposed individuals to height-induced postural threat to determine if reducing the emotional response to threat influences standing balance control. When initially threatened, individuals leaned backward and demonstrated smaller amplitude and higher frequency of COP adjustments; these balance outcomes did not change following repeated threat exposure. Only high frequency COP oscillations (>1.8 Hz) and ankle muscle co-contraction showed any adaptation; regression analyses showed that these behavioural adaptations were accounted for by a combination of emotional and cognitive state changes. This suggests that some threat-induced standing balance changes are more closely linked with the emotional response to threat than others, and are therefore amendable to intervention (3).

Postural threat, known to increase balance-related fear and anxiety, influences vestibular gains during quiet standing in young healthy adults. The final abstract examined whether there is a similar relationship for peripheral unilateral vestibular loss (UVL) patients in comparison to age-matched healthy controls (HC).
By testing subjects center of foot pressure and 90% ranges for angle amplitude and velocity for trunk sway, they provide evidence for a differential effect of height induced postural threat on balance control between UVLs and HCs presumably due to the reduced vestibular-spinal gain in UVL subjects (4).

1. Naranjo EN, Cleworth TW, Allum JHJ, Inglis JT, Lea J, Westerberg BD, Carpenter MG. Vestibulo-spinal and vestibulo-ocular reflexes are modulated when standing with increased postural threat. J Neurophysiol. 2016 Feb 1;115(2):833-42. doi: 10.1152/jn.00626.2015. Epub 2015 Dec 2.
2. Lim SB, Cleworth TW, Horslen BC, Blouin JS, Inglis JT, Carpenter MG. Postural threat influences vestibular-evoked muscular responses. J Neurophysiol. 2017 Feb 1;117(2):604-611. doi: 10.1152/jn.00712.2016. Epub 2016 Nov 9.
3. Zaback M, Adkin AL, Carpenter MG. Adaptation of emotional state and standing balance parameters following repeated exposure to height-induced postural threat. Sci Rep. 2019 Aug 28;9(1):12449. doi: 10.1038/s41598-019-48722-z.

4. Cleworth TW, Allum JHJ, Luu MJ, Lea J, Westerberg BW, Carpenter MG. The Effect of Unilateral Vestibular Loss on Standing Balance During Postural Threat. Otol Neurotol. 2020 Aug;41(7):e945-e951. doi: 10.1097/MAO.0000000000002485.

Summary of September 2020 Topic: COVID-19 Neurologic Implications

The topic for Abstract of the Week for September was Neurologic Implications of COVID-19. One article sought to review the literature on clinical otorhinolaryngological presentations due to COVID-19. The main symptoms found were cough, sore throat, shortness of breath. Other symptoms included runny nose, congestion, dizziness and decreased sense of smell. In younger population upper respiratory symptoms were common especially initially when COVID testing could still be negative. Therefore, otolaryngologists should wear proper PPE when examining patients. (1)

The next two articles also reviewed the literature for neurologic symptoms associated with COVID-19. Neurologic symptoms include: headache, dizziness, convulsions and cerebrovascular disease. (3) The systematic review included 61 articles and included 51 articles in the meta-analysis. Smell impairment occurred in 35%, taste impairment in 33%, 19% muscle pain, 12% headache, 10% low back pain, 10% dizziness, 3% cerebrovascular disease and 2% impaired consciousness of patients. Both studies were performed to increase awareness of clinicians treating patients with COVID-19 of these neurologic symptoms and facilitate early diagnosis and treatment. (4)

The final article examined the satisfaction of patients receiving therapy via telehealth across many diagnoses. 205 participants were surveyed about their experiences with overall satisfaction ranging from 93-99% for patient centered outcomes and 86% valued the ability to have telehealth in the future. The pandemic has allowed for widespread use of telehealth which patients value. This is evidence for lawmakers that telehealth should be a benefit extended beyond the pandemic. (2)

1. Krajewska J, Krajewski W, Zub K, Zatoński T. COVID-19 in otolaryngologist practice: a review of current knowledge. Eur Arch Otorhinolaryngol. 2020;277(7):1885-1897. doi:10.1007/s00405-020-05968-y
2. Tenforde AS, Borgstrom H, Polich G, et al. Outpatient Physical, Occupational, and Speech Therapy Synchronous Telemedicine: A Survey Study of Patient Satisfaction with Virtual Visits During the COVID-19 Pandemic [published online ahead of print, 2020 Aug 14]. Am J Phys Med Rehabil. 2020;10.
3. Gklinos P. Neurological manifestations of COVID-19: a review of what we know so far. J Neurol. 2020;267(9):2485-2489. doi:10.1007/s00415-020-09939-5
4. Abdullahi A, Candan SA, Abba MA, et al. Neurological and Musculoskeletal Features of COVID-19: A Systematic Review and Meta-Analysis. Front Neurol. 2020;11:687. Published 2020 Jun 26. doi:10.3389/fneur.2020.00687

Summary of October 2020 Topic: Gait

Locomotion involves complex combinations of translational and rotational head movements. The first study investigated horizontal and vertical angular VOR (aVOR) and linear gaze stabilization (lGS) as well as compensation for linear head movements by angular counter rotation of the head during treadmill walking and running at different velocities (0.4 to 2.4 m/s) while fixating either a close (0.5 m) or distant (2.0 m) target. In the horizontal plane, the aVOR predominated throughout all locomotor speeds, whereas the compensation of linear translations was highly variable and generally insufficient. In contrast, in the vertical plane, eye and angular head motion steadily became more in phase with increasing locomotor speed, which served to optimize linear motion compensation. Thus, horizontal and vertical gaze stabilization strategies appear to be considerably different (1).

In lower vertebrates, gaze stabilization during locomotion is at least partially driven by a direct coupling of spinal locomotor commands with extraocular motor signals. The present study thus investigated whether changes in eye-head coordination during human locomotion can be explained by concurrent changes in head movements. Potential correlations between aVOR performance and HMP were analyzed in dependence of locomotor speed and gait cycle phase. They found that the vertical aVOR appears to be suppressed during faster walking and running, whereas at the same time, the predictability of resultant head movements increases. This suggests that during stereotyped human locomotion, internal feed-forward commands supplement or even suppress sensory feedback to mediate gaze stabilization in the vertical plane.

The final study sought to develop a novel sensor-based system to investigate dynamic visual acuity (DVA), walking trajectory, head and trunk movements and the chest-pelvis rotation ratio during forward and backward overground walking in both healthy individuals and patients with vestibular hypofunction. It was demonstrated that individuals with Bilateral Vestibular Hypofunction (BVH) had significant impairments in walking posture and gaze stability using a novel DVA device combined with motion capture. This evaluation may provide detailed and precise information about difficulties patients encounter in their daily lives.

1. Dietrich H, Wuehr M. Strategies for Gaze Stabilization Critically Depend on Locomotor Speed. Neuroscience. 2019 Jun 1;408:418-429. doi: 10.1016/j.neuroscience.2019.01.025. Epub 2019 Jan 29.
2. Dietrich H, Wuehr M. Selective suppression of the vestibulo-ocular reflex during human locomotion. J Neurol. 2019 Sep;266(Suppl 1):101-107. doi: 10.1007/s00415-019-09352-7. Epub 2019 May 9
3. Chen PY, Chou LW, Jheng YC, et al. Development of a Computerized Device for Evaluating Vestibular Function in Locomotion: A New Evaluation Tool of Vestibular Hypofunction. Front Neurol. 2020;11:485. Published 2020 Jun 12. doi:10.3389/fneur.2020.00485

Summary of November 2020 Topic: Current Concepts in Concussion

The topic for Abstract of the week was current concepts in concussion as it relates to vestibular therapy. The first article looked at single and dual task TUG and tandem gait performance in pediatrics with concussion. There were 23 subjects with concussion and 27 controls. All participants performed the protocol twice, average of 10 days later. TUG times were slower in the concussion group in both single and dual task conditions in both first and follow up assessments. Symptoms were significantly worse compared to the control group in the first testing only. Single task tests improved greater than dual task tests and the authors hypothesized that the cognitive component required for dual task execution is delaying improvement. (1)

The next article sought to quantify postural sway in youth with concussion about 7 days after concussion and compared this group to healthy controls. A sensor was used to measure various aspects of sway during single and dual task activities. Significant difference in sway were found between the groups. The goal of the study was to determine if postural sway could be used to classify the severity of concussion. Given the significant differences between the groups, the authors concluded that further research is needed to continue to study which aspects of postural sway are most significant to those with concussion. (2)

1. Howell DR, Wilson JC, Brilliant AN, Gardner AJ, Iverson GL, Meehan WP 3rd. Objective clinical tests of dual-task dynamic postural control in youth athletes with concussion. J Sci Med Sport. 2019 May;22(5):521-525. doi: 10.1016/j.jsams.2018.11.014. Epub 2018 Nov 22.
2. Bonnette S, Diekfuss JA, Grooms D, Myer GD, Meehan WP 3rd, Howell DR. Integrated linear and nonlinear trunk dynamics identify residual concussion deficits. Neurosci Lett. 2020 Jun 11;729:134975. doi: 10.1016/j.neulet.2020.134975. Epub 2020 Apr 13.

Summary of December 2020 Topic: Cognitive Behavior Therapy and Vestibular Therapy for Persistent Dizziness

The December topic for abstract of the week was cognitive behavioral therapy (CBT) and vestibular therapy in treating dizzy patients. The first article proposed that studying combining CBT and vestibular rehab (VR) could be effective in treating dizziness, function and quality of life of people with dizziness. The authors designed a study protocol for future research. The study design proposed was a randomized control trial with 125 subjects from Norway that had been dizzy at least 3 months. The intervention group into treatment group with VR and CBT for 8 sessions or control group with 1 vestibular therapy session. (1)

The next article examined if multiple types of therapy are effective in treating Persistent postural perceptual dizziness (PPPD). The study was retrospective and examined 657 medical records of patients

with PPPD and somatic diagnosis. The study showed that patients with PPPD benefit from multiple types of therapies. (2)

The final study examined the long-term efficacy of therapy on treatment of PPPD. 27 patients underwent a treatment program of acceptance and commitment therapy in combination with vestibular therapy 1x/week for 6 weeks. The scores on the Dizziness Handicap Inventory 6 months after treatment. After 6 months, 40% had scores </=14/100 (remission) and 59% had a reduction in score >/=18. 74% had achieved either remission or reduction in score classified as a treatment effect. Therefore, the authors concluded that combined therapy is possible and may have a long term effect but randomized control studies are needed. (3)

1. Kristiansen, L., Magnussen, L. H., Wilhelmsen, K. T., Mæland, S., Nordahl, S., Clendaniel, R., Hovland, A., & Juul-Kristensen, B. (2019). Efficacy of intergrating vestibular rehabilitation and cognitive behaviour therapy in persons with persistent dizziness in primary care- a study protocol for a randomised controlled trial. Trials, 20(1), 575.
2. Axer, H., Finn, S., Wassermann, A., Guntinas-Lichius, O., Klingner, C. M., & Witte, O. W. (2020). Multimodal treatment of persistent postural-perceptual dizziness. Brain and behavior, e01864. Advance online publication.
3. Kuwabara, J., Kondo, M., Kabaya, K., Watanabe, W., Shiraishi, N., Sakai, M., Toshishige, Y., Ino, K., Nakayama, M., Iwasaki, S., & Akechi, T. (2020). Acceptance and commitment therapy combined with vestibular rehabilitation for persistent postural-perceptual dizziness: A pilot study. American journal of otolaryngology, 41(6), 102609

Summary of January 2021 Topic: Central Vestibular Disorders

The January topic for abstract of the week was Central Vestibular Dysfunction. The first article looked to examine the structural changes and cortical morphometric features that are associated with migraine and vertigo attacks in patients who have VM. There were 20 patients with VM and 20 normal volunteers who were scanned on an MRI scanner, and their grey matter volume was estimated. The results showed that VM patients have decreased gray matter volume in the prefrontal cortex, posterior insula-operculum regions, inferior parietal gyrus, and supramarginal gyrus. This demonstrates that there are abnormalities in the central vestibular cortex, and there is a linkage between VM and grey matter volume showing that there is a pathophysiological role in these regions in VM patients. (1)

The next article looked at resting state fMRI to look at the changing brain function in patients with persistent postural perceptual dizziness (PPPD). There were 38 patients with PPPD and 38 healthy patients who we compared this data to and also used a machine learning algorithm to classify subjects using the results from the resting state fMRI. The results showed that patients with PPPD showed reduced connectivity in the areas involved in multisensory vestibular processing and spatial cognition, but increased connectivity in areas linking visual and emotional processing. The algorithm showed that

dizziness handicap, anxiety, and depression all showed connections in clinically meaningful brain regions. This further shows that connectivity patterns could possibly become a biomarker of PPPD. (2)

The next article looked to examine the treatment of vestibular stimulation in the learning deficits of kids with ASD who are minimally verbal. The researchers conducted a randomized controlled trial with 36 children, 18 of which had ASD and the other 18 were typically developed children. All of the children were trained using a visual-motor Serial-Reaction-Time sequence-learning task in 10 short weekly practice sessions, and a group of children received VS prior to each training session. All of the participants showed reaction time improvement with speed gains, and the VS group showed much larger speed gains compared to those who didn't receive the stimulation and compared to those in the typical development group. The study showed that VS has a positive effect on learning in minimally verbal ASD children. (3)

The last article looked to examine the interaction between the vestibular system and processing and modulating pain. The study looked to use virtual reality to cue the vestibular system using visual cues in interacting with pain. There were 24 healthy volunteers who were placed in a virtual room that appeared to have 5 different degrees of rotation. The results showed that rotating a scenario changed the participants' pain thresholds. This shows that vestibular information that is present in static visual cues can modulate acute pain and that there is research that shows that the visual, vestibular, and somatosensory systems all interact with each other. (4)

1. Zhe, X., Gao, J., Chen, L., Zhang, D., Tang, M., Yan, X., . . . Zhang, X. (2020). Altered structure of the vestibular cortex in patients with vestibular migraine. Brain and Behavior, 10(4) doi:http://dx.doi.org.augie.idm.oclc.org/10.1002/brb3.1572
2. Lee, J-O, Lee, E-S, Kim, J-S, et al. Altered brain function in persistent postural perceptual dizziness: A study on resting state functional connectivity. Hum Brain Mapp. 2018; 39: 3340– 3353
3. Katz-Nave, G., Adini, Y., Hetzroni, O.E. and Bonneh, Y.S. (2020), Sequence Learning in Minimally Verbal Children With ASD and the Beneficial Effect of Vestibular Stimulation. Autism Research, 13: 320-337
4. Daniel, A, Barker, L, Martini, M. Pain modulation by illusory body rotation: A new way to disclose the interaction between the vestibular system and pain processing. Eur J Pain. 2020; 24: 1119– 1129

Summary of February 2021 Topic: Dizziness and COVID -19

The Abstract of the Week February Topic was dizziness and COVID-19. The first article sought out literature to document the incidence of dizziness with COVID-19. They found 14 articles including 3 case reports and 11 studies of patients citing dizziness or vertigo as a symptom. However, the majority of these articles only noted dizziness as a symptom and did not detail if it was treated or the specific cause of the dizziness ie- labyrinthitis or stroke. The authors emphasize that dizziness is a significant symptom of COVID-19 and should be evaluated by ENT and follow up treatment recommended. (1)

Summary of Monthly Abstract of the Week Topics From July 2017 to present

The next article sought to describe the neuro-opthalmological presentation of coronaviruses. A review of the literature was performed revealing infrequent eye involvement with coronavirus. The most common was viral conjunctivitis but neuro-opthalmological symptoms included headache, ocular pain, visual disturbances, double vision, cranial nerve palsies, Guillain Barre, encephalitis and nystagmus. The authors recommended that neuro-opthalmolocial findings should be evaluated. (2)

The final study sought to describe the neurologic presentation of patients with COVID-19 and other coronaviruses. A systematic review revealed seven studies, a total of 409 patients. The prevalence of neurologic manifestations ranged 17-36%. The most common neurologic finding was headache (16.8%) followed by dizziness (13.9%). The other main neurologic findings were altered consciousness, vomiting, epileptic crisis, neuralgia, hypoxic encephalopathy, acute cerebrovascular disease. (3)

1. Saniasiaya J, Kulasegarah J. Dizziness and COVID-19. Ear Nose Throat J. 2021;100(1):29-30. doi:10.1177/0145561320959573
2. Luís ME, Hipólito-Fernandes D, Mota C, Maleita D, Xavier C, Maio T, Cunha JP, Tavares Ferreira J. A Review of Neuro-Ophthalmological Manifestations of Human Coronavirus Infection. Eye Brain. 2020 Oct 30;12:129-137. doi: 10.2147/EB.S268828.
3. Correia AO, Feitosa PWG, Moreira JLS, Nogueira SÁR, Fonseca RB, Nobre MEP. Neurological manifestations of COVID-19 and other coronaviruses: A systematic review. Neurol Psychiatry Brain Res. 2020;37:27-32. doi:10.1016/j.npbr.2020.05.008

Summary of March Topic - General Vestibular Knowledge

The March topic for abstract of the week was General Vestibular Knowledge. The first review looked into the everchanging and range of the topic of vertigo. It examined how previous understanding of “unexplained” dizziness in the elderly is changing, looked into the pathophysiology of vestibular migraine and its relationship to “persistent postural perceptual dizziness”, and discussed how an oculomotor assessment may help identify vestibular presentations of stroke. (1)

The next article looked into vestibular dysfunction and differentiating between peripheral dysfunction vs central dysfunction. To distinguish the two, a full and comprehensive physical examination must be done, and a full history must be obtained from the patient. Once determined if peripheral or central, this will determine the therapeutic approach. The article looked to review different aspects such as history, physical examination, evaluation, epidemiology, differential diagnosis, treatment, complications, and critical points to improve the identification of vestibular dysfunction and differentiating peripheral from central dysfunction. (2)

The next article conducted a literature search examining the current classification and treatment for peripheral, central, and functional vestibular vertigo syndromes. It found that there are internationally accepted diagnostic criteria for BPPV, Menière’s disease, bilateral vestibulopathy, vestibular paroxysmia,

and functional dizziness. There are many different treatments for these different pathologies such as: balance is for bilateral vestibulpathy, oxcarbazepine is for vestibular paroxysmia, and vestibular rehabilitation and cognitive behavioral therapy for functional dizziness. This article shows how diagnostically assessing vestibular syndromes has progressed to being much easier now compared to before, but there is still more research that needs to be done when it comes to the treatment of some vestibular syndromes. (3)

The last article looked into the overall role of the vestibular system and how its numerous complex structures and pathways contribute to our sense of proprioception and equilibrium. The central aspect of the vestibular system contains the neural pathways that are responsible for responding to afferent input from the peripheral vestibular system to provide efferent signals to produce our vestibular system reflexes. There is also data that shows the vestibular system plays a role in consciousness where dysfunctions in the system can cause cognitive deficits related to memory, learning, and navigation. (4)

1. Kaski D. Neurological update: dizziness. J Neurol. 2020 Jun;267(6):1864-1869. doi: 10.1007/s00415-020-09748-w. Epub 2020 Mar 4
2. Dougherty JM, Carney M, Emmady PD. Vestibular Dysfunction. 2020 Dec 12. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021
3. Strupp M, Dlugaiczyk J, Ertl-Wagner BB, Rujescu D, Westhofen M, Dieterich M. Vestibular Disorders. Dtsch Arztebl Int. 2020 Apr 24;117(17):300-310. doi: 10.3238/arztebl.2020.0300.
4. Casale J, Browne T, Murray I, Gupta G. Physiology, Vestibular System. 2020 May 24. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan. 2020 May 24.

Summary of April Topic: Exploring Relationship Between Dizziness & Pain

The first article ran 2 studies to examine the relationship between dizziness/vestibular disorders and other medical conditions. The first study sampled 49 patients seeking medical care for balance and dizziness and provided them with a questionnaire about dizziness and pain. 65% of the 49 subjects had both dizziness and pain. The second study sampled seniors (mean age 75) from a fitness center and assessed them for vestibular or balance problems as well as other co-morbidities. 84% of these subjects had a vestibular deficit on testing and 40% also had a cardiovascular co-morbidity, 12% musculoskeletal and 63% reported some other medical problem. Of the 49 subjects, 42% experienced a fall with 1 year of the study start. The authors suggest that examining/addressing vestibular deficits in aging adults is important as well examining for other medical conditions. (1)

The next article further examined the inter-relationship between dizziness and pain. 49 patients referred to a vestibular treatment unit and 62 patients referred to an outpatient psychiatric clinic completed the Dizziness Handicap Inventory. Patients who experienced dizziness had significantly more pain, most commonly located in the head, neck/shoulders and feet. Those with pain also score higher on the

emotional component of the DHI. The authors concluded that patients which dizziness or imbalance frequently present with pain which should be examined and treated. (2)

The final study examined the presence of migraine symptoms in patients with Persistent Postural Perceptual Dizziness (PPPD). 19 of 36 total subjects with PPPD were found to have met criteria for migraine headache while 6 met criteria for vestibular migraine. The authors concluded that a majority of patients with PPPD meet criteria for migraine headache which suggests a connection between the two conditions. (3)

1. Malmström EM, Ekvall Hansson E, Hafström A, Magnusson M, Fransson PA. Co-morbidities to Vestibular Impairments-Some Concomitant Disorders in Young and Older Adults. Front Neurol. 2021 Jan 27;11:609928. doi: 10.3389/fneur.2020.609928.
2. Malmström, E. M., Magnusson, M., Holmberg, J., Karlberg, M., & Fransson, P. A. (2020). Dizziness and localized pain are often concurrent in patients with balance or psychological disorders. Scandinavian journal of pain, 20(2), 353–362
3. Sarna, B., Risbud, A., Lee, A., Muhonen, E., Abouzari, M., & Djalilian, H. R. (2021). Migraine Features in Patients with Persistent Postural-Perceptual Dizziness. The Annals of otology, rhinology, and laryngology, 34894211007233. Advance online publication.

Summary of May Topic: Technology in Vestibular Rehabilitation

Summary of June Topic: Peripheral Vestibular Dysfunctions and Functional Outcome Measures

The June topic for abstract of the week was Peripheral Vestibular Dysfunctions and Functional Outcome Measures. The first article looked to examine walking and turning performance during the TUG test in patients with vestibular deafferentation compared to those without and examine to see if the data improved in patients with vestibular deafferentation following vestibular physical therapy. 26 patients with reports of dizziness not from a vestibular origin and 12 healthy controls were recruited and asked to complete the TUG as fast and safely as possible. Results showed that the turning performance in patients with vestibular deafferentation before therapy was significantly more impaired than the healthy controls. After therapy, turning performance was significantly improved and was normalized as compared to the healthy controls. With the positive results, this shows that the TUG can be used to quantify the change in turning performance in patients with vestibular deafferentation after physical therapy. (1)

Summary of Monthly Abstract of the Week Topics From July 2017 to present

The next article looked to examine the relationship between the ABC scale and Dizziness Handicap Inventory with balance performance and fall status in patients with peripheral vestibular disorders. This was a retrospective study done in an outpatient balance clinic with 97 patients with dizziness or imbalance symptoms. Results showed that patients with a low-level confidence in their balance and a severe score on the DHI had poorer balance and were more likely to experience multiple falls. The two measures showed strong validity with ABC showing better concurrent validity with balance and DHI better with fall history. (2)

The next article looked at the measures of Functional Gait Assessment and quality of life measurements in patients before and after vestibular schwannoma resection and to assess how initial Functional Gait Assessment can predict post-op quality of life. The article took patients older than 18 who underwent the resection where Functional Gait Assessment was administered a week before and after surgery, and the quality of life measure was administered preoperatively and 3 months post-op. Results showed with a statistically significant p-value that pre-op FGA correlated with post-op quality of life measure, but post-op FGA scores did not correlate with post-op quality of life measures. From here, it was determined that although FGA and QOL data showed correlation in the preoperative setting; this was not found postoperatively. More research is needed to determine contributions to post-op quality of life. (3)

The last article looked to examine the different processes that could be used to quantify functional deficits and track improvement in balance following vestibular loss. The 3 processes included: partial peripheral recovery of sensory responses eliciting canal or otolith driven vestibular reflexes, central compensation of vestibular reflex gains, and sensory substitution of visual and proprioceptive inputs for vestibular contributions to balance control. Results showed otolith responses were unaffected, but decreases in all canal driven vestibular ocular reflex gains were observed. Balance control was normal, but VOR gains remained low. This shows how difficult it is to predict balance improvements this way compared to the need to emphasize testing balance control directly to determine true improvements. (4)

1. Kim KJ, Gimmon Y, Millar J, Brewer K, Serrador J, Schubert MC. The Instrumented Timed Up and Go Test Distinguishes Turning Characteristics in Vestibular Hypofunction. Phys Ther. 2021 Mar 26:pzab103. doi: 10.1093/ptj/pzab103.
2. Herssens N, Swinnen E, Dobbels B, Van de Heyning P, Van Rompaey V, Hallemans A, Vereeck L. The Relationship Between the Activities-Specific Balance Confidence Scale and Balance Performance, Self-Perceived Handicap, and Fall Status in Patients With Peripheral Dizziness or Imbalance. Otol Neurotol. 2021 Apr 14. doi: 10.1097/MAO.0000000000003166. Epub ahead of print.
3. Said M, Lee J, Moshtaghi O, Saliba J, Richardson AJW, Ngo V, Mehranpour P, Schwartz MS, Friedman RA. The Relationship Between the Functional Gait Assessment and Quality-of-Life Data in Patients Undergoing Vestibular Schwannoma Resection. Otol Neurotol. 2021 Mar 19. doi: 10.1097/MAO.0000000000003137. Epub ahead of print.

4. Allum JHJ, Rust HM, Honegger F. Functional Testing of Vestibulo-Spinal Contributions to Balance Control: Insights From Tracking Improvement Following Acute Bilateral Peripheral Vestibular Loss. Front Neurol. 2019 May 28;10:550. doi: 10.3389/fneur.2019.00550.

Summary of July Topic: Motor Learning and the Vestibular System

The July topic featured articles co-authored by Dr Michael Schubert, PT, PhD. The first article looked at incremental training of VOR. There were 5 protocols, each performed in 1 single session by 11 patients. Here were the 5 protocols: 1. Unilateral incremental VOR adaptation for 15 min with head impulses equally to each side 2. The head impulse training ratio was increased on the adapting side by 2:1 for 15 min. 3. All impulses were toward the adapting side for 7.5 min. 4. All impulses toward the adapting side for 15 min. 5. All impulses were toward the adapting size and duration of the visual target exposure was doubled. Active and passive VOR were measured before and after each protocol. The results showed that the amount of training time and visual target exposure affected the amount of gain adaptation achieved suggesting that quality and duration of the performance is more important than number of repetitions. (1)

The next article looked at the role of convergence on the VOR gain adaptation. 22 subjects with unilateral hypofunction performed VOR adaptation exercises at a distance of 15cm and 150cm. Results were compared to 12 health subjects. Distance did not affect the amount of gain adaptation. However, it was found that retinal slip was increased at near distances with rotation toward the side of the lesion as compared to far viewing. In addition, the VOR gain adaptation was increased contralateral to the lesion in the near viewing compared to far viewing. This suggests that adaptation for near viewing may warrant increased ipsilateral exercises since retinal slip is increased with near viewing. (2)

The final article sought to examine the effects of incremental VOR training in subjects with chronic peripheral vestibular hypofunction. This was a double blinded randomized controlled study with 24 subjects with vestibular hypofunction, 13 intervention group and 11 in the control group. The control group performed viewing x1 and the intervention group performed incremental VOR exercises daily for 15 minutes for 4 sessions within a 7 day time frame. VOR was measured with video-oculography. Other measures were compensatory saccades, DVA, static balance, gait and subject symptoms. The intervention group gain increased and the control group did not. The control group had decreased compensatory saccade latency. Both groups had improved DVA. The incremental group also had improvements in some dynamic gait index scores and DHI scores. The authors suggest that incremental VOR training has better training effects compared to x1 viewing. (3)

1. Muntaseer Mahfuz M, Schubert MC, Figtree WVC, Todd CJ, Migliaccio AA. Human Vestibulo-Ocular Reflex Adaptation Training: Time Beats Quantity. J Assoc Res Otolaryngol. 2018 Dec;19(6):729-739. doi: 10.1007/s10162-018-00689-w. Epub 2018 Sep 24.

2. Rinaudo CN, Schubert MC, Cremer PD, Figtree WVC, Todd CJ, Migliaccio AA. Once-Daily Incremental Vestibular-Ocular Reflex Adaptation Training in Patients With Chronic Peripheral Vestibular Hypofunction: A 1-Week Randomized Controlled Study. J Neurol Phys Ther. 2021 Apr 1;45(2):87-100. doi: 10.1097/NPT.0000000000000034
3. Rinaudo CN, Schubert MC, Cremer PD, Figtree WVC, Todd CJ, Migliaccio AA. Once-Daily Incremental Vestibular-Ocular Reflex Adaptation Training in Patients With Chronic Peripheral Vestibular Hypofunction: A 1-Week Randomized Controlled Study. J Neurol Phys Ther. 2021 Apr 1;45(2):87-100. doi: 10.1097/NPT.0000000000000348

Summary of August Topic: Motor Learning and the Vestibular System

The August topic for abstract of the week was Motor Learning and the Vestibular System. The first article looked to examine how dizzy symptoms interfere with locomotor learning. 20 patients with vestibular neuritis in the chronic phase and 15 patients with Meniere's disease were compared to 15 healthy individuals by measuring locomotor adaptive learning using the "broken escalator" effect. Results showed that the size of the locomotor aftereffect was related to how symptomatic patients were, but the degree of vestibular loss was not related with symptom load or locomotor aftereffect size. From this, it was found that dizziness symptoms influence locomotor adaptation. (1)

The next article looked to examine the influence of dance training on the VOR suppression during passive head impulses. VOR and VOR suppression were assessed in 12 controls and 12 dancers. The results showed that dancers showed a significantly reduced VOR gain in comparison to controls especially with dancers who had been dancing for more than 10 years. This shows that dance training improves VOR suppression and modulates VOR suppression abilities. (2)

The next article looked at the relationship between separate and distinct brain regions and in vivo networks to reveal the metabolic connectome in a rat. Results showed that there were changes in the metabolic brain connectivity. There was an increase in connectivity that occurred within brain regions that were associated with brainstem-cerebellar and vestibular networks. It was shown that quick changes were found in network organization which can show an initial functional substitution of vestibular loss which then show recalibration and reorganization of sensorimotor networks during VC. (3)

The last article looked to examine the brain's changes in response to learning a balance task with their eyes open versus eyes closed. The eyes open group performed better with this task specific test suggesting that brain changes in response to learning a task differ depending on the learning success and availability of visual input and not just independently on the time spent on learning. (4)

Summary of Monthly Abstract of the Week Topics From July 2017 to present

1. Patel, M, Roberts, E, Arshad, Q, Bunday, K, Golding, JF, Kaski, D, Bronstein, AM. The "broken escalator" phenomenon: Vestibular dizziness interferes with locomotor adaptation. J Vestib Res. 2020; 30(2):81-94. doi: 10.3233/VES-200693.
2. Maheu M, Behtani L, Nooristani M, Delcenserie A, Champoux F. Enhanced vestibulo-ocular reflex suppression in dancers during passive high-velocity head impulses. Exp Brain Res. 2019;237(2):411-416. doi:10.1007/s00221-018-5431-z
3. Grosch M, Lindner M, Bartenstein P, et al. Dynamic whole-brain metabolic connectivity during vestibular compensation in the rat. Neuroimage. 2021;226:117588. doi:10.1016/j.neuroimage.2020.117588
4. Dordevic M, Taubert M, Müller P, Kaufmann J, Hökelmann A, Müller NG. Brain Gray Matter Volume Is Modulated by Visual Input and Overall Learning Success but Not by Time Spent on Learning a Complex Balancing Task. J Clin Med. 2018;8(1):9. Published 2018 Dec 21. doi:10.3390/jcm8010009

Summary of September Topic: Vestibular Implications in Multiple Sclerosis

October

We apologize for the pause in recent Abstracts. This was due to an error with the group we use to publish these, and it is now corrected. The original topic that was planned for October will now be November's topic. The Abstract below was originally sent the first week of October but will be repeated today. The following weeks will be all new abstracts on concussion. Thank you for your ongoing support of Abstract of the Week!

Summary of November Topic: Concussion

The November topic for abstract of the week was Concussion. The first article looked to examine the reasoning behind why there is a difference in outcome measures between women and men after a mild TBI. It was seen that women had worse functional outcome measures 6 months after injury and wanted to investigate if this was due to psychiatric history, gender related sociodemographic variables, or by care pathways. There were 1842 men and 1022 women that were included where natural effects models were used to look at the effect of gender on the outcomes. It was shown that the worse outcomes that were seen in women were partly due to psychiatric history and not explained by the other mentioned outcomes. (1)

The next article looked to determine the discriminative validity of Vestibular/ Ocular Motor Screening (VOMS) item scores and overall VOMS score for identifying college athletes in the first few days following a sports-related concussion. 285 athletes who were concussed and 285 healthy controls completed the VOMS within 3 days of injury. It was shown that if the vertical saccades score is greater than or equal to 1 and if the horizontal vestibular/ ocular reflex is greater than or equal to 2 that these

were the best discriminates to determine concussion from control. Near point of convergence did not significantly show concussion from control group. This shows that individual VOMS items and overall VOMS scores are useful in revealing concussion in collegiate athletes within 3 days of injury and can be used by clinicians to help identify concussion. (2)

The next article looked to examine the effectiveness of near point of convergence testing following concussion compared to previous measures before concussion and to look at the effectiveness of vision therapy on correcting near point of convergence. There was moderate evidence found that patients do have impaired near point convergence up to several months post-concussion, and there was low level evidence shown that the impairments can be treated with vision therapy. (3)

The last article looked to examine the relationship between risk factors and vestibular-oculomotor outcomes after sport-related concussion and to see if there was any association between the two. 85 athletes were assessed where they completed a clinical interview, history questionnaire, symptom inventory, and a VOMS screening. It was found that female sex, on-field dizziness, fogginess, and post-traumatic migraine symptoms including headache, nausea, light sensitivity, and noise sensitivity were predictive of experiencing vestibular-oculomotor symptoms or impairment after a sport- related concussion. (4)

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Summary of December Topic: Postural Threat