Evaluation and Treatment of Motion Induced Disorders

Rachel Wellons PT, DPT, NCS

Sara Oxborough, PT
Today’s Format

• Differential diagnosis of Motion Sensitivity
• Management of Motion Sensitivity
• Case studies of Motion Sensitivity
• Differential Diagnosis of MdDS
• Management of MdDS
• Case Studies of MdDS
• Compare and Contrast Case Studies Wrap up: Future work to build evidence for managing these disorders
• Q and A
Disclosures

Nothing to disclose
Objectives

• Describe the anatomy and physiology of the vestibular system and how it relates to motion induced disorders
• Demonstrate screening and assessment techniques for identifying impairments of body structure and/or function, activity limitations, and participation limitations
• Identify strategies used by experts the field to reduce symptoms of dizziness, improve balance control, and optimize function in patients with these disorders
• Identify possible treatment options consistent with basic science literature and identification of areas for further research
Motion Sensitivity

Sara Oxborough, PT
http://centraldat.blogspot.com/2011/07/air-sickness-or-motion-sickness.html
Background

• 2000 years ago Greek physician Hippocrates noted “sailing on the seas proves that motion disorders the body”
Background

• …our bodies are endowed with what may be termed a supplementary special sense, quite independent of, but at the same time in the closest alliance with, our other special senses, the function of which is "to determine the position of the head in space," and to govern and direct the esthetikokinetik mechanism by which is maintained the equilibrium of the body.  

Irwin J. 1881
Background

- Disturbance to the endolymph, viscera in the abdomen, and subarachnoid fluid in brain
- “irritative hypercemia” of the semicircular canals

Irwin J. 1881
Sensory Mismatch Theory

Situations which provoke motion sickness are characterized by a condition of sensory rearrangement in which the motion signals transmitted by the eyes, the vestibular system and the nonvestibular proprioceptors are at variance one with another, and hence with what is expected on the basis of previous transactions with the spatial environment.

Reason et al 1975
Theory for motion sensitivity

• Sensory conflict or mismatch of visual, vestibular and/or somatosensory information
Sensory Mismatch Theory
Review of Vestibular System

3 Semicircular Canals
- Anterior
- Posterior
- Lateral

2 Otolith organs
- Utricle
- Saccule

Sensory Conflict

- conflict between somatosensory, visual and vestibular input
- conflict between angular (semicircular canals) and linear (otolith organs) vestibular input
  - Vestibular motion sickness
Vestibular Motion Sickness

- conflicts occur among different sensory signals of the vestibular system
  - semicircular canals - head rotation velocity signal
  - otolith organs – gravity signal
- Coriolis/cross-coupling stimulus
Space Motion Sickness

• 60% of astronauts have motion sickness in first part of flight
• Otolith on earth = gravity and linear acceleration
• Otolith on space = linear acceleration
• CNS interpretes linear acceleration to tilt but that’s not true here
Prevalence

• 28% of general population
• 60% of aircrew
• 30% of sea going passengers
• 46% of medical transport personnel reported nausea

Aparna SK 1997, Wright MS 1995
Prevalance

• Females > males at 5:3 ratio
  – Self report vs physiologic differences

• None in children under 2 but then increases up to 15 and then again declines

Predisposition to motion sensitivity

• Anyone could be made sick except those without vestibular system
Predisposition to motion sensitivity

• Migraines
  – 26-60%
• Head injury/post concussive syndrome
• Age
• Genetics
  – Hromatka BS 2015
  – Reavley CM 2006

Paillard et al 2013
Link to Migraine

- Trigeminal system and vestibular nuclei that may have implications for both motion sickness and migraine
  
  *Marcus DA 2005*

- Murdin L et al 2014
  
  5 groups: healthy, vestibular neuritis, Bilateral Vestib Hypofunction, Vestibular Migraine, migraine
  
  - Rotated patients on a chair with tilt and had them rate their nausea from 1-4. Stopped at 4 or max of 20 min
  - VM and migraine similarly enhance motion sickness susceptibility profiles
  - BVH had reduced motion sickness after their disease and VM had increased
Link to Migraine

• Motion sickness was found to be an associated feature in 45% of the cases of childhood migraine, in contrast to a 5% to 7% incidence in the other groups – seizure, nonmigraine headache, and learning disability

Barabas G et al 1983
Link to Migraine

- 131 patients with migraine –
  - 65 with vestibular migraine (MV)
    - 41 with migrainous dizziness (MD)
    - 25 with migraine only (MO)
  - 50 normal controls
- MV/MD showed increased VOR Time Constant & greater suppression of the post-rotatory nystagmus with forward head tilt
- Hypersensitivity of the vestibular system may be an underlying mechanism of motion sickness and increased TC in MD/MV.
- Increased tilt suppression may be an adaptive cerebellar mechanism to suppress the hyperactive vestibular system in migraineurs.

*Jeong SH et al 2010*
Velocity Storage

- 60% had abnormal time constants
  - Controlled by the nodulus and uvula
  - Keeps vestibular responses going after peripheral afferents decay

_Hoffer ME et al 2003_
Velocity Storage

- Increase # of head rotations = shorter time constants

Dai 2003
Evaluation
Motion Sensitivity

• Ongoing passive self-motion that contains certain dynamic and kinematic properties
• Illusions passive self-motion
  – Imax, Video Games, Home movies
Symptoms of motion sensitivity

- Dizziness
- Diaphoresis
- Change in pallor
- Nausea and/or vomiting
- Disorientation
- Fatigue/yawning
Fatigue in Motion Sickness

• Sopite Syndrome
  – Fatigue, drowsiness, and mood changes with motion exposure

• Increased yawning correlated with stronger self report of symptoms

• Lingers for days after prolonged exposure
  – Apathy, bordem, lack of initiative, irritability

Matsangas P et al 2014
Functional Deficits

• Can’t sit in back of the car
• Can’t read while on transportation
• Can’t use cell phone
• Can’t watch home movies/online videos
• Can’t go on certain rides
Functional Deficits

• Studies showing manual performance and cognitive deficits
• Symptoms of motion sickness may be perceived as fatigue and bordem
Tests and Measures

• Examination
  – Rule out other causes such as a vestibular or non-vestibular cause, central causes including post-concussion issues and medication related issues
  – Even if other diagnosis exists such as migraine determining if that is under control
Tests and Measures

- Objective
  - SOT or mCSTIB
  - Motion Sensitivity Quotient (MSQ)
  - Oculomotor Exam
  - Dynamic Visual Acuity
  - Oftentimes testing is WNLs

- Questionnaires
  - Dizziness Handicapped Inventory (DHI)
  - Motion sickness susceptibility questionnaire (MSSQ)/MSSQ-S
  - Simulator Sickness Questionnaire (SSQ)
Sensory Organization Test

• 70% had CDP abnormalities
  
  Hoffer ME et al. 2003

• Looking for overreliance
Motion Sensitivity Quotient

• 16 items
  – Series of motions where symptoms rated 0-5 and time to dissipate is scored

• Raw score: 0-128

• Mild = 0-10; Moderate = 11-30; Severe = 31-100
Motion Sickness Susceptibility Questionnaire (MSSQ)

• Rate before age 12 and within the last 10 years symptoms on different forms of transportation, swings, rides

• Higher score = more susceptible
Dizziness Handicap Inventory (DHI)

- 5 items
- Self-report questionnaire
- Quantifies the impact of dizziness on daily life by measuring self-perceived handicap
<table>
<thead>
<tr>
<th>Disorder</th>
<th>Tempo</th>
<th>Symptoms</th>
<th>Circumstances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuritis</td>
<td>Acute dizziness</td>
<td>Vertigo, imbalance, nausea, vomiting</td>
<td>Spontaneous Increased with head movement</td>
</tr>
<tr>
<td>MdDs</td>
<td>Chronic Dizziness</td>
<td>Rocking or swaying</td>
<td>Better in motion, worse at rest</td>
</tr>
<tr>
<td>Migraine</td>
<td>Spells: minutes</td>
<td>Vertigo, dizziness, motion sickness</td>
<td>Motion induced, spontaneous</td>
</tr>
<tr>
<td>Meniere’s Disease</td>
<td>Spells: hours</td>
<td>Vertigo, imbalance, ear fullness from hearing loss</td>
<td>Spontaneous and with head movement</td>
</tr>
<tr>
<td>Motion Sickness</td>
<td>Spells: hours</td>
<td>Nausea, diaphoresis, dizziness</td>
<td>Movement induced and usually visuovestib mismatch</td>
</tr>
</tbody>
</table>

Vestibular Function Testing

• No relation with calories and MS
• greater susceptibility to motion sickness is associated with larger cVEMP amplitudes and lower interaural cVEMP asymmetries  
  
  Fowler CG et al 2014
Rotational Chair – Time Constant
Management of Motion Sensitivity
Treatment - Behavioral

• Car: Drive the car
  – Anticipating the motion
• Boat: Look at the horizon
• Plane: Window Seat

http://mjsailing.com/a-three-hour-tour-day-1-were-gonna-need-a-faster-boat/
Treatment - Medications

- Promethazine and Scopolamine
  - Most effective

- Meclizine
  - Uneffective in coriolis stimulation  
    Dornhoffer J et al 2004

- Ondansetron
  - Nausea

- Baclofen -> velocity storage mechanism
  Cohen et al 2008
Treatment - Habituation

• Head movements increased steadily in each session with repeated testing
• Vestibulo-ocular reflex (aVOR) time constants declined in each test
• Combining pitch/roll movements with rotation

Habituation

• Repeated exposure drives desensitization

  Yen-Pik Sang F et al 2005

• Choose 2-3 movements from the MSQ or provocative activities to do 2-3x/day

• Symptoms should decrease within a minute after each activity
Habituation Exercises

• Move into positions that provoke the dizziness. Begin in quiet and progress to busy environments.
  – Examples of activities: head turns, rolling in bed, supine to stand, walking fast, walking and turning

• Intensity/Frequency:
  – Perform multiple repetitions (5-10) at a speed that brings on mild symptoms
  – Perform habituation exercises 2-3 times per day
  – Patient response guides modification of program
Habituation

• 1: 4 consecutive days of cross-coupling and on the 5th day they were exposed to simulated aircraft motion
• 2: 4 consecutive days of torso rotation and on the 5th day they were exposed to the simulated aircraft motion
• 3: 5 consecutive days of simulated aircraft motion
• Cross-coupled motion was the most provocative stimulus followed by torso rotation and simulated aircraft motion, Within each motion stimulus, there was evidence of desensitization within 4days

Cheung, B et al 2005
Habituation Exercises

• Results in 2 weeks to but could take up to 6 months
  
  Smith-Wheelock et al 1991

• Typically 4-6 weeks
  
  Telian SA et al 1996

• Do not do during a migraine and caution if the patient gets headache

• Refer or reassess if not progressing after 4 weeks
  
  – ?3pd
Treatment - Habituation
Motion Sickness Bands
Boarding Ring
Case Studies #1

• 48 y/o female with multiple year history of lightheadedness, nausea, and vomiting
• Unable to go on long car rides, watch some movies & TV shows, and rides at a park
• Using meclizine and eating more for symptoms
• No significant PMH
Case Study #1

• Functional Gait Assessment (FGA) = 29/30
• Motion Sensitivity Quotient (MSQ) = 13.4
  – all motions provoked 1/5 sx
  – moderate
• Sensory Organization Test (SOT) = 63% compared to age norm 70%
  – Falls on condition 5
• Dizziness Handicap Inventory (DHI) = 36
Case Study #1

• VNG and Rotational Chair Results
  – High Gain -> central finding
Case Study #1

- Static head nods eyes open
- Static stance on perturbed surface
- Ball Circles
- Turning -> Turning with head nods
- Nintendo Wii Run
Case Study #1 - Discharge

• 13 visits over 8 week period
• She is able to tolerate driving better, she went to a 3D movie without symptoms, has not had to use meclizine, has not had to eat to decrease symptoms.
Case Study #1 - Discharge

- FGA = 30/30
- MSQ = 0
- SOT = 74%
- DHI = 22
Case Study #2

- 32 y/o female with longstanding symptoms that are worsening
- Nausea that progresses to true vertigo, auras that are triggered by her motion sensitivity
- Can only be the driver in car, limited traveling
- PMH: migraines, MRI negative, a trial of PT doing oculomotor exercises -> triggered migraines
Case Study #2

- FGA = 30/30
- MSQ = 0
- SOT = 76%
- DHI = 13

– Unable to reproduce her symptoms at evaluation
Case Study #2

• Trial of therapy
  – Ball circles
  – Wall roll
  – Turning with a vertical nod
  – 2-3xday with a mild reproduction of symptoms
Case Study #2

• 2\textsuperscript{nd} session
  – Felt worse!
  – Decreased reps

• 3\textsuperscript{nd} session
  – Felt better!
  – Able to be a passenger in the car
Case Study #2 - Discharge

• 5 total sessions
  – Passenger in the car and not concerned about travel
• DHI = 0/100
Mal de Debarquement Syndrome (MdDS)

- Defined as a “phantom self-motion perception that occurs after exposure to passive motion”
- First description of “sea legs” appeared in 1881 in Lancet
- Early research in motion sickness completed in sailors
- Associated with motion sickness severity
- MdDS vs. Persistent MdDS

Table 1  Major Features of Mal de Debarquement

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocking, bobbing, swaying or any other self-motion</td>
<td>perception that occurs after passive motion exposure such as on boats, airplanes, or cars</td>
</tr>
<tr>
<td>Transient improvement in symptoms</td>
<td>with reexposure to passive motion (driving, sailing, etc.)</td>
</tr>
<tr>
<td>Symptomatic relief with benzodiazepines</td>
<td></td>
</tr>
<tr>
<td>Other symptoms can include visual motion</td>
<td>intolerance, fatigue, cognitive slowing, and mood changes</td>
</tr>
</tbody>
</table>

Cha, 2009 Tal, 2014
"Sea Legs" vs. Persistent MdDs

- Duration of symptoms: 3 days
- Crew of small seagoing vessels (N=234), average age of 20.5 years and all men
  - 171 (73%) experienced MdDS
  - 127 experienced MdDS immediately upon returning to land
  - 42 experiencing MdDS within 6 hours.
  - 159 subjects (93%), the symptoms lasted 6 hours or less and all were asymptomatic within 24 hours
- No difference in the susceptibility to MdDS based on experience at sea, but there was a direct correlation with susceptibility to seasickness
- 2 subjects had symptoms lasting up to 48 hours

MdDS Pathophysiology

• Issue with recalibration of visual, vestibular, and somatosensory after exposure to prolonged passive movement
  – Failure of neuroplastic adaptation once reaches land
• Maybe a release of “vestibular memory,” in that stored vestibular information from the prolonged passive motion exposure becomes reexperienced as a hallucination
  – Even if someone is fine once stopping motion, sometime later the movement memory can be re-triggered
• Hyperactive limbic connections

Chá, 2015
Recalibration

• Conflict in sensory processing
  – Single sensory system
  – Two or more sensory systems (i.e. visual and vestibular)
  – Motion sickness results when sensory information does not match with previously stored motion patterns
  – This conflict activates neural mechanisms aimed at reweighting the available sensory information, which results in decreasing motion sickness

• When using an artificial horizon, there is some symptom reduction but does not influence the duration and symptoms of Mal de Debarquement

Tal, 2014
Neuroanatomical Processing of Vestibular Information

- Central connections between visual, vestibular, and somatosensory systems
- In macaque there is an area called the parietoinsular vestibular cortex (PIVC)
  - Humans have a similar region in a similar area of the brain
- The PIVC has also been shown to respond to acceleration of visual stimuli and relationship of this visual stimuli to gravitational information
  - PIVC responds to gravitational information from both otolith organs and visually
  - Responds specifically to gravitational forces not just any acceleration

Cha, 2009
Role of the Hippocampus

- Peripheral vestibular loss leads to deficits in spatial learning
  - Can lead to hippocampal atrophy
- Functional imaging studies show that the hippocampus can be activated by caloric stimulation
- Specific response from hippocampal neurons to visual and vestibular information

Cha, 2009
Hyperactive Limbic System

Connections

• Role of the entorhinal cortex contribute to mapping the spatial surround
  – Cells remap when they are in a new environment
  – Connections to hippocampus which helps to consolidate memories during sleep

• fMRI studies investigating glucose metabolism have demonstrated a hypermetabolism in the left entorhinal cortex, prefrontal, and temporal cortex and right amygdala
  – This connection is possibly explains why MdDS symptoms start after waking up

Cha, 2015
MdDS Epidemiology

- Difficult to give an exact number in the population due to difficulty with diagnosis
- Neurotology clinic: 1.3%
- Females impacted much more often than men (75% or more of all MdDs patients)
- Typically 40-50’s, but reported in ages 15-77

Cha, 2015; Cha, 2009
## MdDS Triggers and Symptoms

<table>
<thead>
<tr>
<th>Common Triggers</th>
<th>Symptom Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Water-based activities (boats or ships)</td>
<td>• NOT true vertigo</td>
</tr>
<tr>
<td>• Air travel</td>
<td>• Rocking</td>
</tr>
<tr>
<td>• Extended land travel</td>
<td>• Bobbing</td>
</tr>
<tr>
<td>• Sleeping on a moored boat</td>
<td>• Waving</td>
</tr>
<tr>
<td>• Sleeping on a waterbed</td>
<td>• Swaying</td>
</tr>
<tr>
<td></td>
<td>• “I feel like I’m still on the boat”</td>
</tr>
</tbody>
</table>
Personal Experience
Fun Fish Fact

• Use vision as their reference to where they are in space
  – Position the ground to their belly
• No proprioception against the ground
• No vestibular system
• Under cliffs or in caves you can find them swimming upside down, since they position the cliff or side of cave to their belly
MDdS Associated Symptoms

• Cognitive Slowing
• Visual Vertigo
• Fatigue
Vestibular Disorders and Cognitive Dysfunction

Atrophy of vestibular cortical regions

Affective Disorder

Postural and gaze instability

Vestibular Dysfunction

Common Cause (Age, microvascular disease, etc)

Cognitive Impairment

Perceptual/visuospatial ability

Attention

Executive Function

Memory

Bigelow, 2015
MdDS and Cognitive Slowing

• “Brain fog”
• Unknown exact etiology
• Most likely represents difficulty in working memory
  – Inability to multi task
• Causes?
  – Dealing with the symptoms
  – Actual impact on cognitive processes

http://allergicliving.com/2014/01/01/your-brain-on-gluten-celiacs-effect-on-cognition/

Cha, 2009
MdDS and Visual Vertigo

- Rely more in visual information for stabilization
  - Because they are getting faulty vestibular signals indicating sway
  - Thus, in environments with busy visual stimulation they lose that anchor
- Another rationale may be neuroanatomical connections between visual and vestibular systems
  - fMRI and PET studies demonstrate that the visual and vestibular systems exert reciprocal inhibitory activity on each other to reduce visuovestibular conflict
  - Since vestibular system is hyperactive in MdDS this may result in suppression of visual processing areas

Cha, 2009
MdDS and Fatigue

- Unknown exact etiology
- Extra effort to maintain balance?
- Personal theory
  - Cognitive difficulties
  - Experience of symptoms

http://medscope.blogspot.com/2012/06/fighting-cancer-fatigue.html

Cha, 2009
MdDS and Migraines

- Share a common population
- Can report as similar symptoms
- Differentiation between MdDS vs. Migraines is in tempo of symptoms
  - Migraines tend to be episodic
  - MdDS tends to be more constant
- However in many individuals the onset of rocking motion is related to onset of headache with migraine disorder, so there is likely a pathophysiological relationship that we don’t know about

Cha, 2015
JS Intro

- 63 y/o female presenting with sudden onset of dizziness 6 months prior to eval
- Referred by a neurologist, but had seen a general ENT in the past and was diagnosed with “vertigo”
  - Had a VNG, results unknown
  - MRI: Hardening of small vessels
- Sxs described as “waving, floating, or on a waterbed”
- Constant symptoms, but episodic spikes about 5 times per day (depending on movements)
  - 5/10 at present
  - 3/10 at worse
  - 10/10 at best
- Exacerbating factors: Busy eye movement, environmental stimuli, body movement
- Relieving Factors: Being outside, driving, playing tennis
- Reports previous “minor episodes” of dizziness in the 1990’s but nothing significant
• Reports some blurry vision with movement
• Reports left ear hearing loss and tinnitus bilaterally
• PMHx: HTN, HL
• Medications: Lisinopril, Prevastatin, Scopolamine
• Reports she feels like she is “in a fog” with respect to thinking

• No modifications to driving
• Sleeps 7-8 hours per night
• No falls but reports near falls
• Participation limitations
  – Work is more difficult
  – Unable to garden
  – Overall feels like “less energy”
• Patient goals: “Not to be dizzy anymore”
JS: Background Info

- Lives with husband
- Working full time as office manager
  - Stress at work
  - Interpersonal dynamics
- Reports feeling “nervous” about symptoms
- Reports that symptoms first started the week prior to her son’s wedding
- Has been working 4-6 hours per day
JS Examination Findings

- DHI: 32/100
- ABC: 42.5%
- MSQ: 19.04
- Gait speed (10 MWT)
  - Self Selected=1.33 m/s
  - Fast=1.68 m/s
- FGA 24/30

- mCTSIB: Conditions 1-3=30”, Condition 4=3”
- Ocular Motor
  - Negative saccades, ocular alignment at near and far targets, smooth pursuit, gaze holding nystagmus
  - Positive left sided head thrust, VOR X 1 and VOR X 2 symptomatic
JS: Evaluation

• Unilateral Peripheral Hypofunction of unknown etiology
  – Begin PT and see how the patient proceeds
  – Keeping psychological factors in the back of my mind
  – Consider referral to neurotologist

• Treatment plan: Adaptation, habituation, substitution, balance and gait

• Treatment once per week
15. Interventions

Standing Bends

Stand up, bend over tipping the head down and come up.
Wait for symptoms to stop and count to 10.

5 Repetitions
3 times per day

Repeat for 1 minute, 2 times
Do 1-2 times per day

Ho
Re
Do 1-2 sessions per day.

STANDING DYNAMIC - 8
Turning in Place: Solid Surface

Can progress to full turn if gets easy

Throw a ball over your head and turn quickly making half turn and catch the ball on the other side. Leave at least 10 seconds in between turns.

Repeat ___ times per session.
Do ___ sessions per day.
JS: Progress with PT

• After 2 weeks patient reports that rocking feeling has gone away for 1 hour at a time daily and that she is doing more activities
• Able to work a full day
• After 3 weeks: Attended Jazz Fest and felt great!
JS Progress Continued

• After 4 weeks: Felt great over the weekend (no symptoms), but returned once she got back to work she started to feel tense in shoulders and posterior neck

• After 5 weeks: When to a loud restaurant with friends and symptoms returned (4/10 level when they had been 2/10)
  – Possible causes: Weather changes, sinus congestion, anxiety
  – Time to get the neurotologist on board

• Life Stressors
  – Son’s Wedding
  – Tension at work

• Weeks 6-8: Continues with slow and steady improvements
JS: Re-eval

- 2 months after eval (9\textsuperscript{th} visit)
- Reports feeling “so-so”. Reports new sensation of feeling like she is being pushed down or over
- Took a car ride on during weekend and had a 5 day exacerbation in symptoms
- “When I’m inside I don’t feel good, but when I drive I feel good”. Reports she feels best overall in the car
- Overall 75% better
- FGA=28/30
- DHI=36/100
- ABC=77%
- MSQ=0
- Worsening cervical spine dysfunction, increase in symptoms when head held stationary and body rotating on stool
MdDS Medical Differential Diagnosis

• Diagnosis of exclusion made mostly from history and negative test results for other vestibular disorder
  – MRI is negative
• Possible tests
  – Neurological examination
  – ENG test (electronystagmography)
  – Rotary chair test
  – Caloric Stimulation
  – Blood tests (CBC, blood glucose, vitamin B12)
  – Blood tests for autoimmune disorders that may involve the ear
• VNG tests typically normal or non-specific abnormalities might be found

Related Disorders

• Motion Sensitivity Disorders
  – Differentiate by relief of symptoms with passive motion and history of travel

• Spontaneous MdDS
  – Similar to MdDS but develops symptoms over days or weeks
  – Can occur without travel trigger
  – More common in individuals with migraine disorder

Cha, 2015
Psychosocial Impact

• Patients with a diagnosis of MdDS visit on average 19 physicians before diagnosis
• Costly to the patient
  – Average yearly cost of approximately $13,000
  – 85-95% related to indirect costs
• Higher impact on quality of life as compared with other neurologic diseases
• High levels of depression and anxiety
  – Persistence of symptoms and difficulty with differential diagnosis
  – Disorder that is not well understood by most physicians
  – Difficult explaining it to family/friends
• http://www.mddsfoundation.org

Cha, 2015
Macke, 2012
# MdDS Health Care Visits and Tests

<table>
<thead>
<tr>
<th>Health-care professional</th>
<th>No. of visits</th>
<th>Diagnostic imaging</th>
<th>No. of images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General practitioner</td>
<td>4.37 ± 1.03</td>
<td>MRI</td>
<td>1.13 ± 0.12</td>
</tr>
<tr>
<td>ENT</td>
<td>2.89 ± 0.57</td>
<td>Audiological test</td>
<td>1.61 ± 0.18</td>
</tr>
<tr>
<td>Internist</td>
<td>2.16 ± 1.27</td>
<td>Blood panel</td>
<td>1.67 ± 0.34</td>
</tr>
<tr>
<td>Neurologist</td>
<td>2.39 ± 0.59</td>
<td>Vision screen</td>
<td>1.35 ± 0.20</td>
</tr>
<tr>
<td>Physical therapist</td>
<td>3.39 ± 1.08</td>
<td>Other(^a)</td>
<td>2.09 ± 0.22</td>
</tr>
<tr>
<td>Psychologist</td>
<td>1.02 ± 0.62</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Other(^a)</td>
<td>2.20 ± 0.46</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>After diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical therapist</td>
<td>2.26 ± 0.798</td>
<td>Vestibular</td>
<td>2.11 ± 0.64</td>
</tr>
<tr>
<td>Other(^a)</td>
<td>5.74 ± 1.09</td>
<td>Other(^c)</td>
<td>1.05 ± 0.19</td>
</tr>
</tbody>
</table>

The data presented are means ± SD.

- \(^a\) Includes neuro-otologist/neurologist, ophthalmologist, optometrist, psychiatrist.
- \(^b\) Includes CT, vestibular evoked myogenic potentials, electrooculography, rotary chair.
- \(^c\) Includes general practitioner, ENT, internist, neurologist, neuro-otologist/neurologist, ophthalmologist, optometrist, psychiatrist, and psychologist.

Macke, 2012
### Domains of Daily Health

| Category/subcategory                                      | Score  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical health composite score</td>
<td>51.09 ± 1.73</td>
</tr>
<tr>
<td>Physical health composite score (with balance)</td>
<td>49.40 ± 1.69</td>
</tr>
<tr>
<td>Mental health composite score</td>
<td>52.40 ± 1.83</td>
</tr>
<tr>
<td>Role limitations due to physical problems</td>
<td>18.32 ± 3.20</td>
</tr>
<tr>
<td>Energy</td>
<td>34.42 ± 1.47</td>
</tr>
<tr>
<td>Role limitations due to emotional problems</td>
<td>36.30 ± 4.00</td>
</tr>
<tr>
<td>Change in health</td>
<td>46.29 ± 2.24</td>
</tr>
<tr>
<td>Satisfaction with sexual function</td>
<td>47.52 ± 3.37</td>
</tr>
<tr>
<td>Health distress</td>
<td>50.79 ± 2.60</td>
</tr>
<tr>
<td>Social function</td>
<td>54.21 ± 2.76</td>
</tr>
<tr>
<td>Balance</td>
<td>55.38 ± 2.52</td>
</tr>
<tr>
<td>Health perceptions</td>
<td>57.28 ± 2.18</td>
</tr>
<tr>
<td>Emotional well-being</td>
<td>58.26 ± 1.52</td>
</tr>
<tr>
<td>Overall QOL</td>
<td>59.26 ± 1.89</td>
</tr>
<tr>
<td>Cognitive function</td>
<td>60.10 ± 2.13</td>
</tr>
<tr>
<td>Physical health</td>
<td>60.84 ± 2.63</td>
</tr>
<tr>
<td>Sexual function</td>
<td>64.36 ± 3.11</td>
</tr>
<tr>
<td>Pain</td>
<td>67.64 ± 2.71</td>
</tr>
</tbody>
</table>

*On a scale of 0 (worst) to 100 (best)*

Macke, 2012
JS: Neurotologist Input

• Mal de Debarquement following Vestibular Neuritis
• CT negative for Superior Semicircular Canal Dehiscence
• Borderline increase in Electrocochleography
• Hypersensitivity of visually enhanced VOR (VVOR)
• Start low dose of Clonapin and Betahistine
Electrocochleography (E-Cogs)

- Measurement of summation potential (SP) and action potential (AP) in the cochlea and auditory nerve in response to sound
- Diagnosis of Endolymphatic Hydrops or Meniere’s
  - Normal findings: SP/AP ratio is typically 10%-50%
  - Higher in Endolymphatic Hydrops or Meniere’s Disease

Figure 13.5  (A) Electrocochleogram obtained with a tympanic membrane surface electrode from a normal ear; the summating potential/action potential ratio is normal at 0.13.  (B) Electrocochleogram obtained from the ear of a patient with Meniere’s disease; the summating potential/action potential ratio is elevated (0.81).

Herdman, 2014
Visually enhanced VOR

• VOR is rotational testing is done in light environment
• Increased VVOR could indicate
  – Anxiety
  – Migraines
• Decreased VVOR
  – Major depressive disorders
MdDS Treatment Options

• Medication
• Transmagnetic Stimulation (TMS)
• Vestibular Rehabilitation
Medications for MdDS

• Benzodiazepines are most effective
  – Clonazepam is preferred due to longer half lift
  – Dosage: 0.25-0.5 mg twice daily

• Selective Serotonin Reuptake Inhibitors are worth a trial

Cha, 2009
Repetitive Transcranial Magnetic Stimulation (rTMS)

rTMS is a noninvasive procedure that uses magnetic fields to stimulate nerve cells in the brain.

http://bipolarnews.org/?tag=rtms
TMS for MdDS

- Randomized controlled trial (N=13)
- Inclusion Criteria
- Outcome Measures
  - MiniBEST
  - ABC
- rTMS Treatment
  - Twice per week for 4 weeks
  - 10 Hz in 45 trains or 40 pulses per train for a total number of 1800 pulses (Cha, 2013 protocol)
  - Delivered to F3 or F4 area contralateral to participants dominant arm
  - Control has a sham treatment
- Treatment tolerated well
  - 13 of 14 participants completed (1 who dropped out was control)
  - No serious adverse reactions
  - Only two participants described mild transient headache after only 1 session

Pearce, 2015
rTMS for MdDS: MiniBEST

Average MiniBEST for Control
24.2 ± 4.4 pre
24.7 ± 5.6 post
Effect Size $d=0.1$

Average MiniBEST for Experimental
25.7 ± 1.7 pre
28.2 ± 1.7 post
Effect Size $d=1.6$
rTMS Results: ABC

Average ABC for Control
45.4 ± 5.1% pre
48.2 ± 16.2% post
Effect Size $d=0.26$

Average ABC for Experimental
45.8 ± 10.9% pre
58.9 ± 12.8% post
Effect Size $d=1.11$
rTMS Study Discussion

• Interpret with caution
  – Sample Size, homogeneity, older than what is typically reported
• Other outcome measurements
  – DHI
  – Situational Vertigo Questionnaire or Visual Vertigo Analog Scale
  – FGA
  – Gait speed
• Further investigate dosing, frequency, specific of who will benefit
Physical Therapy Treatment

• Vestibular Rehabilitation
• Optokinetic Stimulation
• Sensory re-weighting (Liphart, 2015)
  – 69 y/o female
  – Balance exercises with altered sensory input
  – Different surfaces
  – Pay attention to sensory system available
  – Static to dynamic
JS: Updated Treatment Plan

- Orthopedic PT Consult and Treatment for C/S Stiffness
- Recommendation of counselor to address work stress
- Discussed benefit of SSRI’s
- Started “grounding” exercises
- Took a break of 6 weeks
  - Medications to ramp up
  - Orthopedic PT
  - Counseling
JS: Treatment Updates

• After 6 weeks off, patient returned and reported no change in symptoms
• Reports that she has continued stress at work
  – Feels great until 3:00 pm
  – Symptoms onset 3:00 pm daily
  – Subside evenings and weekends
• Reports no impact with grounding exercises

• Contacted PT 1 month later with report of sudden onset of spinning when rolling over in bed
  – Positive for right posterior canal BPPV, canalithaisis origin
  – Performed CRT 3 times to right posterior canal
  – Resolved by next session
• Patient continues to work with counseling and seeking Rx for SSRI
JS: Outcome

• Started Cymbalta (SNRI)
• After 5-6 weeks of starting Cymbalta symptoms went away completely
JS Lessons Learned

• Multiple disorders that could have been contributing to her symptoms
• Patient response to guide treatment
• Deep understanding of pathophysiology in absence of solid evidence based treatment
• Role of other health care team members
  – Neurotology
  – Audiology
  – Counseling
  – Internal Medicine Physician
# Motion Induced Disorders

<table>
<thead>
<tr>
<th>MdDS</th>
<th>Motion Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migraine</td>
<td>✓</td>
</tr>
<tr>
<td>Female</td>
<td>✓</td>
</tr>
<tr>
<td>Age</td>
<td>Mid 40s</td>
</tr>
<tr>
<td>Defining symptoms</td>
<td>Constant rocking</td>
</tr>
<tr>
<td>Driving</td>
<td>Eases</td>
</tr>
<tr>
<td>Treatment</td>
<td>??</td>
</tr>
</tbody>
</table>

- Nausea/dizzy while in motion
- Worsens

- Habituation/meds
Research Needed

• Specifically designed VRT program for motion sickness
• Role of VRT in MdDS
• Relation between motion sickness and MdDS
  – Better to be motion sick while on a cruise?
  – Do motion sick meds cause poor vestibular adaptation?
Thank you!

“People are like bicycles. They can keep their balance only as long as they keep moving.”

ALBERT EINSTEIN,
IN A LETTER TO HIS SON EDWARD (FEBRUARY 5, 1922)
References

- Motion Sickness:
References

References

References

- Mal de Debarquement