Objectives

- More effectively select and/or develop methods to optimize identification of and intervention for vestibular impairments in children
- Recognize the shared responsibility of clinicians and researchers to ensure that evidence-based examination and intervention is provided to the families and children we serve.
- Identify the competing perspectives of clinicians, researchers, and families that limit timely and accurate knowledge translation to the clinic, and the design of clinically relevant and feasible research protocol.

Speakers

- Rose Marie Rine, P.T., Ph.D
- Elizabeth Dannenbaum, PT
- Joanne Szabo, P.T.

Knowledge Translation

- Dynamic and iterative process that includes:
  - Synthesis
  - Dissemination
  - Exchange
  - Ethically-sound application of knowledge
- To improve health & provide more effective health services and products and thus strengthen the health care system
**KT Components**

- **Research** – based on science, previous work, identify problem, establish and test hypotheses
- **Synthesis** – contextualization and integration of research findings; must be reproducible and transparent in its methods, using quantitative and/or qualitative methods
- **Dissemination** – articles, seminars, training, e-journals or newsletters
- **Exchange** – the interaction between the knowledge user and the researcher, resulting in mutual learning; collaborative problem-solving between researchers and decision-makers
- **Ethically sound application** – activities for improved health care, consistent with ethical principles and norms, social values, and legal and other regulatory frameworks

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**KT**

- **researcher**, **policy makers**, **clinicians**, **patient/family**

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**Today - Vestibular Related Impairments in Children**

- Research & synthesis – what has been and is being done
- Dissemination – what, how, when?
- Exchange – how did we?
- Application – who, what, how?

**Vestibular Function:**

- Detection of rotational and acceleration forces
- Detect relation/position of head w/respect to gravity
- **Ocular-motor VOR):**
  - Gaze stabilization
- **Postural control – vestibulospinal (Vsp)**
  - Equilibrium responses
  - Postural set
Rehabilitation

• Well established tests for adults & efficacy of intervention
• Peds therapists – there is something here – what?
• Research & Synthesis - disseminated
  – Evidence for effect of vestibular dysfunction in children? Who might be affected?
  – Tests able to address this?
  – Evidence for efficacy of intervention?

Testing Vestibular Function

• VOR (canals) rotary chair
  – post-rotary nystagmus (PRN)
  – observe
  – Head shake, HT and DVA
• Otolith – Vsp
  – perceived alignment (vertical & horizontal)
  • SVV with laser line or bucket test
  – dynamic perturbation test (EMG)
  – Vestibular evoked myogenic potentials (VEMPs)
• Central integrative mechanisms for fx
  – Sensory organization test for PC

Adult onset vestibular hypofunction:

• Vertigo or sense of disequilibrium
• Oscillopsia
• Balance deficit/falls
• Is this the same for children?
• Do children have vestibular deficits?

Effect of Vestibular Hypofunction (VH) since birth on balance? (Rine et al 1996)

• Seven 4-6 yo children with SNHI since birth
  – six 4-6 yo typically developing children
• Those w/ SNHI
  – Screen motor development
  – Screen vestibular fx - PRNT
  – Exclusion criteria: any hx of orthopedic, cognitive or other neurological impairment
• Compared static and dynamic balance
Measures and Results

- **Measures:**
  - Kinematic measures of response to dynamic lateral tilt
  - SLS eyes open and closed
- **Those w/SNHI and concurrent VeD**
  - Decreased SLS
  - Delayed & often aberrant tilt response
  - Failed GM screen/balance components

Preliminary evidence:

- **Balance deficits (SLS and dynamic)**
  - What is happening/not happening w/regard to postural control?
- **Motor development deficit**
  - Not norm referenced standardized test
- **Why not direct relationship to vestibular?**
  - Only tested canals
  - Used PRNT, not rotary chair

Pediatric Physical Therapy. 1996. 8:55-61

Effect of VH on Motor Development?

- **28 children with VH since birth (2.5-8.5 yoa)**
  - PRNT and rotary chair w/electronystagmography
  - Gross Motor Scales of PDMS – standard z scores
  - Repeat testing (n=14) 1 year later
- **Exclusion criteria: any cognitive, orthopedic or other neurological impairment**

Progressive Developmental Deficit

- **Delayed gross motor (p < .03); less w/age**
- **Longitudinal testing: z scores lower (p < .05)**
- **Sensitivity of PRNT for identification of progressive deficit = excellent (91%)**

Section on Pediatrics of APTA, Research Grants

**Sensory Organization Test**

- **Sway referencing technique**
  - Record sway of COP
- **Recording forces on platform**
  - Horizontal – sheer force – hip strategy
  - Vertical – ankle strategy
- **Sensory effectiveness ratios**
- **Need norms for children**

**SOT Child vs Adult**

- Age differences: 3-4 yrs, 4-6.5 yrs, 7-8yrs
- To clarify, calculate sensory effectiveness ratios

*Rine RM Pediatric Physical Therapy 1998*

**Vision Effectiveness ratios**

- Stability SOT 4/ stability SOT 1
  - Adults = .88
  - Child = .52
    - 3 - 8.5 years similar
  - Adult-like 13-15 yrs

**Somatosensory Effectiveness Ratio**

- Stability SOT 3/ stability SOT 1
  - Adults = .94
  - Child = .89
    - LIKE ADULT!
Vestibular Effectiveness Ratio

- Stability SOTS/ stability SOT 1
- Adult = .88
- Child: (age dep)
  - 3-4 yrs = .21
  - 4-6.5 yrs = .23
  - 7-8.5 yrs = .50
  - adult-like > 17 yrs

Effect of VH on Postural Control?

- 43 children 3-8.5 yoa with SNHI
  - normative sample (n=34) on posturography testing
- Exclusion:
  - no neurological or orthopedic condition
- Computerized VOR via rotary chair and PRNT testing

Rine 2000; Rine et al 2001

Postural Control Deficits

- Lower on SCT-3, -4 (p < .04), vision and somatosensory ratios (p < .05)
- Increased latency & amplitude of TA (p = .04)
- Altered relative latency of soleus and TA (p = .05)


Efficacy of Intervention for Children with Bilateral Vestibular hypofunction?

- Subjects:
  - 24 children with SNHI since birth
- Exclusion: cognitive, orthopedic or other neurological impairment
- Screening: DTR’s, cranial nerve, coordination and vision
- Random assignment to 1 of 2 groups
  - matched for vestibular function & motor development level

Supported by NIH grant # HD37820-02 and Foundation for Physical Therapy
Methods:

• Controlled, wait-listed design
• Pre- and post-intervention tests of motor development & postural control
• Intervention:
  – Exercise 12 weeks – placebo 12 weeks = EP
  – Placebo 12 weeks – exercise 12 weeks = PE

**Test 1 – intervention – Test 2 -- intervention – Test 3**

Intervention

• Under direction of PT, by aide
  – 3 x weekly, small groups (2-3)
  – PT – weekly review, advance activities prn
• Activities to facilitate:
  – Vision and somatosensory function
    • Substitution
    • Adaptation
  – Learning & integration

Results:

Test 1 (pre-intervention)

– Motor: below norm all but Reflex (p < .01)
– SCT: Lower on SCT-3, -4 & somatosensory and vision ratios (p < .05)
– DPT: increased latency and amplitude of TA (p < .03); altered relative latency (p = .04) – most lost balance

*as compared to typically developing peers

Results: Test 3 (post-intervention)

• Motor Development –
  • PE not EP improved (p = .01)
  • Gain reversal of AE
• Developmental quotients altered (p = .01)
  = AE pre-test/ chronological age @ pre-test vs post-test

• SCT gains, continued for both (combine scores)
  • Vision & somatosensory ratios improved (p < .04) and like normative sample
Discussion/conclusion

- Exercise intervention:
  - improved function, trend = arrest the delay: related to improved sensory organization & alternative postural strategies
- At withdrawal of exercise – reversal
  - Increased intensity vs duration
  - Require practice, error correction and pre-cursor skills established
- Lack of relationship w/vestibular test:
  - Limitation of testing – omits otolith test (related to acquisition of walking in norms)

Rine RM Braswell J Pediatric Otorhinolaryngology 2004

Gaze Stability – Effect of VeD DVA Test (Rine & Braswell 2003)

- Used symbols rather than letters
  - Used an apparatus to control head mov’t
  - Metronome to control speed, 120 deg/s
- Average of two trials of SVA and DVA
- Good to excellent reliability(ICC(3,1) = 0.82)

DVA scores – children w/VeD and HI

- Children with HI: (n = 25)
  - 14 with negative HT test (nVF)
    - 1.5 ± 0.679 lines diff (like normative sample)
  - 9 with positive HT test (BVH)
    - 6.6 ± 1.722 lines diff (poor gaze stability)
  - 2 with positive HT test (UVH)
    - 3.25 ± 0.353 lines diff (abnormal)

With VeD: DVA and reading acuity impaired (Braswell & Rine 2006)

- Developed test, based on MnREAD
- Measures:
  - Reading Acuity
  - Critical Print Size
  - Critical Reading Speed
**Methods**

- Children either read or signed the groups of words as the words got smaller and smaller (by 0.1 logMAR)
- Reading of each group of words was timed
- Children read until words became too small
- Outcomes calculated
  - critical print size (CPS: the print size that can be read at a normal speed)
  - reading acuity (RA: the smallest print that can be read regardless of speed)
  - critical reading speed (CRS: the speed in words per minute).

**Reading Impairment** (Braswell & Rine 2006)

- Children with VH have CPS and RA scores that are significantly lower than peers (hearing or not) without hypofunction

**Evidence for Improved Gaze Stability**

- 4 children with SNHI and VH
  - 3 with BVH on rotary chair
  - 1 with compensated UVH (inc. phase lead on the right side)
    - All with failure on DVA and RA
- Delayed rx design
  - Test 1: DVA and RA
  - Test 2 (4 weeks later): DVA and RA
  - Test 3 (post-intervention): DVA and RA

**VM exercises**

- Backgrounds on posters or PowerPoint
- Head mov’t in yaw and pitch
- Variables changed at 80% correct responses:
  - Font size (20 point, 16 point, 12 point)
  - Background complexity
  - Speed of head mov’t
Following intervention:

- CPS improved
  - 6-7.5 point to 4.5-6 point (approaching typical)
- RA improved
  - 4.5-6 point to 3.5-6 point (same as typical)
- DVA improved
- children w/ VH: read a smaller print w/ less effort required.

Braswell, Rine 2006

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Child with Acquired BVH (17 mths)

- Teacher/ caregivers commented
  - able to read better, even in car
- Implications:
  - If exercises done earlier (before reading begins) may improve reading acquisition
  - May improve gaze stability for sports/other activities that involve head mov’t

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Children with Otitis Media w/Effusion (OME)

- Reports of hearing loss, motor & balance deficits
  - VeD, in most, not all
    - Only tests of canal function
    - No concurrent tests of DVA and motor ability
    - Do they have otolith deficit that explains why some do vs do not have balance problem?
- Sx treatment = drainage tubes
  - Recover hearing, language development
  - Balance may or may not improve
  - No data on visual stabilization or otolith fx
Recent study  (Rine, Corbin, et al 2009 APTA AC)

• Recruited 6 children with OME
  – Exclusion criteria: musculoskeletal abnormalities of the legs or spine, neuromuscular disease/condition, diminished sensation of the legs, significantly impaired vision, or developmental delay

• Tests done pre and post surgery
  • Head thrust for canal, VEMP for otolith
  • motor development (PDMS II), posturography, DVA

Small sample – power an issue, accepted .10

Results – Pre-test

• Vestibular tests
  – Positive HT tests, bilaterally
  – Positive air & bone VEMP bilaterally

• Posturography
  – Above the 75th percentile on conditions 1-3
  – Below the 50th percentile on conditions 4-6 w/stepping on 5 and 6

• PDMS II
  – Below the 50th percentile & significantly below the norm ( p < .05) on the stationary and object manipulation subtests.

• DVA – 1 child refused, all others had positive tests

Post-testing

• Vestibular tests
  – HT & VEMP negative post sx for most

• Posturography
  – All above 50% on 4-6
  – Nonparametric ANOVA – chg significant (p=.10)

• PDMS
  – T-test improved significantly

Vestibular otolith testing - utricle

• Subjective visual vertical (utricle)
  – Align light bar, w/comparative visual cues minimized
  – Cannot see or feel via alignment control
  – Can children do this?
  – W/in 2 degrees = normal (even as young as 4.5 yo)

L Farrell & RM Rine, CSM 2005
Study to Establish Reliability

- **Methods**
  - 39 adults (mean age = 30.4 years) and 35 children (4.3 to 12 y/o) and 5 adults with peripheral or central deficits
  - Grouped by age:
  - 3 trials of offset vertical to R or L scores were averaged
  - Good consistency of scores; ICC (1,2) = .74

- **Results**
  - good to excellent inter-rater reliability ICC (3,2) = .88.

<table>
<thead>
<tr>
<th>Grp</th>
<th>Age</th>
<th>SVV Error*</th>
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<tbody>
<tr>
<td></td>
<td>Mean (yrs)</td>
<td>Range</td>
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<td>2</td>
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<td>47-70 months</td>
</tr>
<tr>
<td>3</td>
<td>5.80</td>
<td>71-82 months</td>
</tr>
<tr>
<td>4</td>
<td>9.84</td>
<td>83-132 months</td>
</tr>
<tr>
<td>5</td>
<td>30.42</td>
<td>18-83 years</td>
</tr>
</tbody>
</table>

Functional Reach – Control ht & arm position

- Adults & children
- **Measure:**
  - Center of pressure (COP), kinematics and reach @ shoulder & pelvis
  - UE crossed and not
- **Results:** adjusted for height/arm position:
  - over 7 yoa & adults similar
  - To correlate w/COP, UE crossed, measure from pelvis (adult) or shoulder (child)

Correlate with gait - children with CP ; (Rine & Moore, 2005; Moore & Rine 2007, 2009 ISPGR)

5 yo Child with VeD following severe OME (? Neuritis)

- **Male (AG) episodic right lean (w/falls) over 7 m**
  - Med Hx not significant for illness
  - Developmental: Prematurity w/complications: mild L sided hemiparesis @ 6 moa; PT & OT TIW x past 4 years; PT D/C’d – no gait deficits
  - Participated in soccer & basketball
  - Corrective sx for strabismus (5 surgeries)
- **Neurology referral:**
  - MRI’s (head, neck & spine) = negative
  - Ruled out seizure, vision & other CNS factors
- **Otolaryngology referral:**
  - Severe bilateral middle ear infection. Rx: bilateral tube insertion; Post-op lean lessened, but full w/in 4 mos
  - Rotary & caloric tests deferred 2° to tube insertion;
  - PT referral - comprehensive vestibular assessment and Rx
5 yo – Examination (cont’d)

- **Ambulation**: Symmetrical w/o deviations; stop/unsteady walking around/over object.
- **Oculomotor**: OKN negative; Sm Pursuit: negative R, corrective saccades L; Convergence intact.
- **Canal**: HS negative, HT positive L, negative R. DVA positive (3.5 difference) score = .3; During test, progressive lean to R and experienced LOB.
- **VEMP testing**: Normal response R, reduced/absent L, Asymmetry ratio 56%.
- **Posturography**:
  - LOB on conditions 5 & 6; stepping on 3 & 4.
  - Scores on conditions 1 & 2 within age norm.
  - Delayed tibialis on dynamic test (step).

5 yo Evaluation

- Diminished gross motor & oculomotor function consequent to, or exacerbated by UP-VeD involving left horiz. canal and saccule (? Utricle).
- Possible central involvement due to prematurity.
- Impairments include aberrant:
  - sensory organization for balance
  - use of vision & somatosensation for balance
  - verticality
  - oculomotor ability.

Examination (cont’d)

- **Neuromuscular & Musculoskeletal**:
  - Symmetrical gait, no evident hemiparesis.
  - ROM, DTR’s strength negative.
  - Associated movements w/effort.
  - Proprioception intact in both UE & LE’s identified & mirrored.
- **Motor development**: PDMS Gross Motor Scale: Reflex subtest 95%; total score @ 2nd percentile.
  - Deficits: Balance, Non-locomotor & Receipt & Propulsion: SLS < 5 sec ea leg, hop only 1x on either leg.

5 yo UP – VeD Intervention

- **School modifications**: modified seating (chair with arms @ proper seat height, enlarged print & aide). IEP adjusted accordingly.
- **Home exercises**: oculomotor, vision, somatosensory training; 4x/week.
- **Direct PT**: balance & oculomotor training provided 2x/wk for 3 months.
5 yo Rx Results

- Improved alignment w/self correction,
- Improved postural control (SOT)
- Improved DVA
- Improved GM skills
- Head thrust negative bilaterally

Gait and Posture 2005 21;1:S3

Synthesis


How was KT achieved?

- Research & synthesis
  - Established problem & effect on balance, PC, motor development and gaze stability
  - Established reliable valid testing methods
  - Established efficacy of intervention
- Dissemination – what, how, when?
  - Posters, manuscripts
  - Training and presentations
    - APTA
    - Training conference
- Exchange – how did we?
  - Liz and Joanne – course and emails
  - Let’s hear from them!

Elizabeth Dannenbaum, MScPt
Vestibular Program,
Jewish Rehabilitation Hospital, Laval, Quebec, Canada
½ time: vestibular rehabilitation
½ time: research associate
Study 1: Pediatric vestibulopathy screening in an outpatient rehabilitation setting  

- 42 children being treated in the JRH pediatric program completed the Motion Sensitivity Questionnaire (MSQ) + a clinical pediatric assessment
- Subject Characteristics
  - age: 3-13 yo, mean age 5.3 years
  - male: 26, female: 16
  - specific language impairment: 25
  - global developmental delay: 17

Percent of positive vestibular test results for both groups:

A - children suspected of having a vestibulopathy (n=32)
B - children not suspected of having a vestibulopathy (n=31)

Note: the sample size changes per test as certain children were non-cooperative for certain tests.

Motion Sensitivity Questionnaire:

Does your child ever feel dizzy for no apparent reason?

Yes
No
N/A

Does your child ever experience severe headaches or migraines?

Yes
No
N/A

Does your child ever become uncomfortable going on moving things or surfaces (e.g. swings, park toys, moving rides, pony rides)?

Yes
No
N/A

Does your child ever become uncomfortable moving or walking in the dark or in dim environments?

Yes
No
N/A

Has your child ever hit his head with temporary loss of alertness or consciousness?

Yes
No
N/A

Mean change = 28.0 ± 19.4 (p<0.01)

Improvement in DHI

Dannenbaum et al. 2004  

68% change > 18 points
Pediatric vestibulopathy screening in an outpatient rehabilitation setting

<table>
<thead>
<tr>
<th>Number of Positive VSQ Items</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
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</thead>
<tbody>
<tr>
<td>1 or more</td>
<td>33</td>
<td>30</td>
</tr>
<tr>
<td>2 or more</td>
<td>20</td>
<td>58</td>
</tr>
<tr>
<td>3 or more</td>
<td>11</td>
<td>85</td>
</tr>
</tbody>
</table>

3 positive answers on MSQ

<table>
<thead>
<tr>
<th>VE+</th>
<th>VE-</th>
<th>n</th>
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</thead>
<tbody>
<tr>
<td>VSQ+</td>
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</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>VSQ-</td>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>42</td>
</tr>
</tbody>
</table>

21.4%

Study 2: Vestibular assessments in children with global developmental delay:

E. Dannenbaum, M. Villeneuve, L. Salvo, G. Chilingaryan, A. Lamontagne

Objective:

To compare the Dynamic Visual Acuity (DVA), modified Emory Clinical Vestibular Chair Test (m-ECVCT) and Clinical Test for Sensory Integration and Balance (CTSIB) scores of children with Global Developmental Delay (GDD) to those of typically developing children.

Hypothesis of why the MSQ is not valid in children with a co-morbid condition.

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your child ever feel dizzy for no apparent reason?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has your child ever experienced severe headaches or migraines?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is your child uncomfortable going on moving things or surfaces (e.g. swings, park toys, moving rides, pony rides)?</td>
<td></td>
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</tr>
<tr>
<td>Is your child uncomfortable moving or walking in the dark or in dim environments?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your child fall for no apparent reason when walking or standing? and/or would you describe your child as being clumsy while walking?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has your child ever hit his head with temporary loss of alertness or consciousness?</td>
<td></td>
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</table>

Study 2: Vestibular assessments in children with global developmental delay: exploration of test-retest reliability

General characteristics

<table>
<thead>
<tr>
<th></th>
<th>GDD (n=68)</th>
<th>Control (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>7.97 (2.4)</td>
<td>7.23 (2.4)</td>
</tr>
<tr>
<td>Gestation (weeks)</td>
<td>38.65 (2.3)</td>
<td>38.54 (1.3)</td>
</tr>
<tr>
<td>Walking (months)</td>
<td>17.95 (1.3)</td>
<td>16.96 (1.3)</td>
</tr>
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</table>

GDD group characteristics

<table>
<thead>
<tr>
<th></th>
<th>Frequency (n)</th>
<th>Percent (%)</th>
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<tbody>
<tr>
<td>Complications at Birth</td>
<td>8</td>
<td>40</td>
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<tr>
<td>Hearing Impairment</td>
<td>2</td>
<td>10</td>
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<tr>
<td>Mild Intellectual Delay</td>
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<td>6</td>
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<tr>
<td>Dyslexia</td>
<td>11</td>
<td>30</td>
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<td>Attention Deficit Disorder</td>
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<td>15</td>
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<td>7</td>
<td>30</td>
</tr>
<tr>
<td>Autism Spectrum</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>
Results: DVA results for children with GDD and healthy controls

- Normal DVA 0-2 difference in lines (Rine & Braswell 2008, Christy et al 2014)
- Results from present study (n=18, missing data=2)

Results: DVA results for children with GDD and healthy controls

Results: m-ECVCT results for children with GDD and healthy controls

Conclusion: No significant difference in the mean post rotary nystagmus, yet increased variable responses in the GDD group

Results: CTSIB results for children with GDD and healthy controls

Clinical Test of Sensory Interaction and Balance (CTSIB)

1. Eyes Open on floor
2. Eyes Close on Floor
3. Dome on Floor
4. Eyes Open on Foam
5. Eyes close on Foam
6. Dome on Foam

Conclusion: The children with GDD had a significantly lower total CTSIB score than healthy controls.
Results: results of specific GDD children

<table>
<thead>
<tr>
<th>Study Number</th>
<th>m-ECVCT (left)</th>
<th>m-ECVCT (right)</th>
<th>Normal values</th>
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<tbody>
<tr>
<td>1</td>
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<td>22.38</td>
<td>0-2.22</td>
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<td>22.9-30.60</td>
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<td>3</td>
<td>25.34</td>
<td>24.96</td>
<td>26.2-32.70</td>
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<td>4</td>
<td>25.46</td>
<td>25.02</td>
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<td>24.97</td>
<td>24.58</td>
<td>26.22</td>
</tr>
<tr>
<td>15</td>
<td>16.03</td>
<td>15.64</td>
<td>37.68</td>
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<tr>
<td>16</td>
<td>25.87</td>
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<td>25.58</td>
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<tr>
<td>19</td>
<td>26.85</td>
<td>26.46</td>
<td>24.44</td>
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<tr>
<td>20</td>
<td>25.49</td>
<td>25.10</td>
<td>25.18</td>
</tr>
</tbody>
</table>

Conclusion:
- No neat pattern between the test results, leading to a clinical portrait.
- Each result needs to be treated individually.

Pilot project: Accept 5 patients directly in the JRH adult Vestibular program

- November 2012: Meeting with director of rehabilitation services, my clinical supervisor and coordinator of the gait and research laboratory.
- Conclusion: Allow a one year trial period were 5 children can be accepted into the vestibular program.
- Letters were sent out to the pediatric otologists, and we waited....
- Slowly, with time began to have references.

<table>
<thead>
<tr>
<th>Client</th>
<th>Age</th>
<th>Diagnosis</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>16</td>
<td>SNHL, pre cochlear implant</td>
<td>To follow</td>
</tr>
<tr>
<td>b.</td>
<td>16</td>
<td>SNHL, post cochlear implant</td>
<td>To follow</td>
</tr>
<tr>
<td>c.</td>
<td>5</td>
<td>Investigate frequent falls</td>
<td>To follow</td>
</tr>
<tr>
<td>d.</td>
<td>15</td>
<td>Mild Concussion</td>
<td>Non vestibular as neg; DVA, N.E: not provoked normal: CSTIB and FGA</td>
</tr>
<tr>
<td>e.</td>
<td>5</td>
<td>Investigate frequent falls</td>
<td>To follow</td>
</tr>
</tbody>
</table>

Summary of pilot project: child 1

Child 1:
- 16 yo boy with bilateral SNHL secondary to meningitis
- When he was 2 yo, had a left cochlear implant at 2 yo
- Presently questioning if he should have a second cochlear implant.

Vestibular Assessment:
- Hobbies: hockey
- Balance, FGA 30/30, SOT: normal for 18 yo, mSTSIB: 99/120 * Foam eyes closed: 13s, 14s, 30s
- Vestibular testing: right beating spontaneous nystagmus with mastoid oscillation and post horizontal head shake. No clear OCR

Conclusion:
- Client seems to have residual function in operated side (right beating nystagmus)
- Balance WNL therefore has substituted with other sensory cues
- Suggested family continue the path of a second cochlear implant (yet caloric, or VEMP testing may be beneficial).
Summary of pilot project: child 2

- 16 yo girl with bilateral SNHL, recent left cochlear implant
- Referred by another physio re “ataxic gait”
- Clients goal: be able to run and skate with her friends
- 5 vestibular treatments (10/4/13 → 4/7/14)
- HEP x3/day

<table>
<thead>
<tr>
<th>Pre Treatment</th>
<th>Post treatment</th>
</tr>
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<tbody>
<tr>
<td>Dizziness Handicap Inventory (n/100)</td>
<td>42</td>
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<tr>
<td>DVA</td>
<td>-5</td>
</tr>
<tr>
<td>CTSIB</td>
<td>135</td>
</tr>
<tr>
<td>Functional Gait Assessment (n/30)</td>
<td>22</td>
</tr>
<tr>
<td>ADL</td>
<td>Runs in corridor, skates</td>
</tr>
</tbody>
</table>

Summary of pilot project: child 3

- 5 yo boy with GDD referred by an ENT as caloric testing showed a left deficit (84%)
- Parents Goal: reduce frequent falls (2-3x/week)
- Vestibular Assessment: DVA-4, CTSIB 133/180, FGA 25/30, no clear ocular counter roll, a nystagmus was not produced with the infra-red goggles (spontaneous, gaze evoked, post mastoid oscillation or post head shake).
- Conclusion: falls possibly related to decreased ability to perform quick adjustments when vision-somatosensory cues are reduced

Pilot project

- **Barrier:** Once the project was over, no further children were accepted in the vestibular program
- **Facilitator:** On telling on of the otologists, one doctor invited me to work in his specialized vestibular center doing pediatric vestibular rehabilitation part time.
- **Future:** ???

Summary of pilot project: child 3 (continuation)

- Treatment: stimulate vestibular quick reactions, increase gaze stability: 5 sessions of home exercise development
  - eyes closed on bed: “Simone says” or statue game
  - viewing x1 while playing computer games
  - walking: eyes open↔closed, “eye spy” to objects on left ↔ right
  - jumping from a pillow and freezing
  - stairs plus dual task (identify the number of fingers)
- Discharge Assessment
  - less falls, though falls down the two stairs from the kitchen to living room at times, especially when distracted
  - ADL: began hip-hop dancing and ice skating
  - CTSIB: 133 → 172/180, FGA 25 → 28/30
Knowledge Translation at the Individual Level
Joanne Szabo PT, DPT, MHA, PCS

- Implementation science—Why talk about it? (NIH, 2014)
  - Estimated 50% of patients not receiving care according to scientific evidence (McGlynn, 2003)
  - To promote the uptake of research findings into our clinical practice to ensure best practice
  - Change has to occur at all levels
    - Systems
    - Organizational
    - Team
    - Individual
- Knowledge translation has 2 parts (Graham, 2006)
  - Knowledge creation (Rose Marie Rine)
  - Action (my individual Clinical Action Plan—CAP)

My Clinical Action Plan (CAP)

Goals today:
- To share my individual CAP for translating knowledge to practice through an individual case study:
  - To report my knowledge adaptations for my student
  - To report my clinical outcomes
  - To identify barriers I encountered while carrying out the knowledge translation
  - To discuss what facilitated my CAP

The Inspiration for my CAP
- Lack of gross motor progress
- A sense there was something else...
- A need for answers
- Frustration!
- March 2010 New student - initial PT session
  - Minimal motor gains reported from family and teacher
  - Student described as “an observer”, “a watcher—not a doer”, & “afraid of movement”

My Challenge
- PT over 8 months time (2 months summer break)
- Total PT visits = 17
- Rx time = 98 min / month
- No clinically significant change on PDMS-II
- Participation reported at school and home very limited
CAP Phase 1
Identify available knowledge

❖ Difficult phase— you don’t know what you don’t know
❖ PubMed (NCBI, 2014) literature search— start with best guess
❖ Parameters chosen:
  Balance training, sensorineural hearing loss, pediatrics = 0 articles
  Vestibular, balance training, sensorineural hearing loss, pediatrics = 0 articles
  Physical therapy, balance training, sensorineural hearing loss, pediatrics = 0 articles

Search Parameters Revised

❖ Deaf, physical therapy, dynamic balance training = 1 article
  • No abstract
  • Free full text article not available

Positive outcome— new search terms identified
❖ Children versus pediatrics
❖ Hearing impaired versus deaf or sensorineural hearing loss

Search Parameters Revised (again)

❖ Balance, children physical therapy, hearing impaired = 9 articles
❖ 1 article relevant to my student
  • Abstract available only—full article had to be purchased

Positive outcomes
❖ Abstract confirmed child / SNHL can have concurrent vestibular impairment
❖ Study found motor skill improvement with compensatory training
❖ New search words identified: dynamic visual acuity (DVA), gaze stability and vestibular hypofunction (VH)

CAP Phase 2
Ask Relevant Questions from Available Knowledge

❖ Did my student have a true vestibular loss?
❖ Would it be central or peripheral?
❖ How do I formally test a 4 year old frightened to have his balance challenged?
❖ How do I determine if gaze stability is an issue?
❖ What is involved in the compensatory training?
CAP Phase 3
Expand Search Based on New Questions
✓ Use new search terms - locate additional knowledge
✓ Search by author — who is Rose Marie Rine?
  • Jackpot!!
    • Growing evidence for balance and vestibular problems in children (Rine 2009).
    • Evidence of progressive delay of motor development in children with sensorineural hearing loss and concurrent vestibular dysfunction (Rine et al. 2000).
    • Balance and motor skills in young children with sensorineural hearing impairment: A preliminary study (Rine et al. 1996).
    • Evidence that vestibular hypofunction affects reading acuity in children. (Braswell & Rine. 2006).
  • Reading acuity: a functional measure of gaze stability. (Braswell and Rine, 2009).
✓ Online search for additional avenues of information
  ✓ Webinars
  ✓ Continuing education courses
  ✓ Podcasts

CAP Phase 4
Identify Barriers to Obtaining Knowledge
✓ Difficulty getting full text articles
✓ Cost for obtaining information
✓ Education / training needed related to pediatric vestibular testing
✓ Cost to obtain training
✓ Time to research, read and obtain information and training
✓ Identifying correct search terms

*Identifying Correct Search terms
✓ Using Filters in PubMed can help but still did not bring up articles
  • Free full text, full text, abstracts
  • Ages
  • Species — human
✓ Difficulty determining which search words might yield results
  • Balance training, sensorineural hearing loss, pediatrics, physical therapy = 0 articles
  • Balance, hearing impaired, children, physical therapy = 9 articles
✓ How many different combinations of similar words might be used and the literature is NEVER found?
  • This alone could end knowledge translation!

CAP Phase 5
Plan to Overcome Barriers to Obtaining Knowledge
✓ Further research into Rose Marie Rine’s work
✓ Continue to search other search engines, PTNow
✓ Identified a competency based course co-sponsored by APTA
  • Pediatric Vestibular Rehabilitation: A Competency Based Course Oct 12-15 2011 Jacksonville FL.
✓ No funding from work but boss approved educational leave with pay
✓ Had to carve out time and set as priority
✓ Process can be slow
✓ 11 months from problem identification to attending conference
Knowledge Obtained
Attended competency-based training

Questions answered

- Did my student have a true vestibular loss?
  - Yes, probably. Need to test for VH and DVA

- Would it be central or peripheral?
  - Peripheral

- How do I formally test a 4 year old frightened to have his balance challenged?
  - Tests are passive

- How do I determine if gaze stability is an issue?
  - DVA testing

- What is involved in the compensatory training?
  - Strengthen vision
  - Pair vision with balance activities
  - Include somatosensory system work

CAP Phase 6
Adapt the Knowledge for the Individual

- DVA testing
  - Unable to sign letters correctly on Snellen chart (NVRI, 2014) modified by trying HOTV or LEA chart (GoodLite, 2014)
  - Metronome needed for maintaining head 120 deg/sec during testing and interventions
  - Needed helper to point to optotypes

- Intervention
  - Picture icons needed that the student recognized and could sign or say orally
  - Helper required at times to hold board and point to optotypes
  - Icons needed to be made in different sizes to allow progression of the student’s program

CAP Phase 7
Identify Barriers to Knowledge Implementation

- Support to ensure correct implementation
  - Easier to sign or say
  - Becker et al. 2002 validated for children 29-72 months for acuity testing

- Money to purchase supplies and materials
  - Boards
  - Fabric with various patterns
  - Velcro
  - LEA chart
  - Metronome
  - Laminating material for icons
CAP Phase 8
Plan to Overcome Barriers to Knowledge Implementation

- Contacted Rose Marie via email after course and asked for help.
- Used other sources for donations
  - Asked fabric stores for remnants
  - Contacted other departments at school
  - Low vision for LEA Symbols board
  - Speech therapy for Boardmaker® Software (Mayer-Johnson, 2014)
  - Shop for cutting boards
  - Copy / media for lamination
- Set aside time for fabricating boards and making icons
- Able to go through the department budget to purchase supplies I could not obtain other ways
  - Velcro
  - Metronome

CAP Phase 9
Implement Knowledge

- Pre-testing to determine DVA problem exists
  - Head Thrust Test
  - Gaze Stability Test
- Pre-testing motor / balance
  - PDMS-II Retested
  - Pediatric Balance Scale (PBS)

Pre-vestibular Rehabilitation Testing

- Head Thrust Test (HTT) Qualitative also known as Head Impulse Test (HIT)
  - Identification of hypofunction in adults 84% sensitivity bilateral and 71% sensitivity unilateral and specificity 82% (Schubert et al. 2004)
  - HTT is a useful reference test, non-expert (Jorns-Haderli et al. 2007)
  - Clinical experience - sensitive in pediatric population (Rine R, 2011)
  - Test with forward head tip 30 degrees and unexpected, quick head turn; HTT evaluates each ear individually so results could be unilateral or bilateral

Pre-vestibular Rehabilitation Testing

- Gaze Stability: Dynamic Visual Acuity (DVA) Test (Peterson et al. 2013)
  - Abnormal test results = A decline of more than 2 lines between SVA and DVA scores (Fife et al. 2000; Rine et al. 2003).

What is happening?

- The VOR cannot stabilize the gaze (tested in HTT) and movements are too fast for smooth pursuit to keep eyes on target = decreased visual acuity when head moving.
- The disruption of gaze stability due to VH contributes to reading difficulties in children and intervention needs to be provided to minimize reading problems (Braswell et al. 2006; 2009)
Pre-vestibular Rehabilitation Testing

- Student’s Head Thrust results:
  - Positive bilaterally
  - VOR not keeping eyes on target
  - Indicates bilateral vestibular hypofunction

- Student’s DVA results:
  - Positive
  - SVA 20/32
  - DVA 20/200
  - 6 line difference

Vestibular Rehabilitation — 2 times per week

- Individual pull-out physical therapy
  - Physical therapy during his centers time 1 time per week ranging from 30 to 45 minutes depending upon stamina
  - Obstacle courses, balance games
  - Paired vision with motor activity
  - Somatosensory system work

- Health aide continued with visual board work 20 minutes per week for average of 3 weeks per month (additional 60 min / week vision)
  - Straddled on peanut ball, independently bouncing, while aide pointed to icons
  - PT monitored and progressed board and icons monthly

Pre-vestibular Rehabilitation Testing

Gross Motor Results:
- March 2010: 1st Percentile
- November 2010: 2nd Percentile
- November 2011: 3rd Percentile

- 60 visits total over 10 months
- Rx increased to 2x/week 1 pull-out & 1 class group
- 214 min / month of contact
- 116 min more per month than previous test period
- Gross motor progress still limited
- Participation with movement activities & balance guarded at school
- Parents still reporting limited participation with activity at home as well

Vestibular Rehabilitation

- Intervention — Exercise improves gaze stability (Braswell et al. 2006)
  - Strengthen use of vision
  - Visual boards included in therapy and used an additional session by health aide just to bounce on peanut ball and call out icons.
  - Pair vision and balance
  - Sitting T-stool with balloon, bean bag toss to target, catching soft ball
  - Progress to standing, feet together, tandem, on balance beam
  - Add movement walking, bouncing on peanut ball, trampoline, sit and spin slow
  - Somatosensory system work
  - Walking path
  - Boxes with colored bottoms to step into.
Overview of variations made

- Head movements (passive or active)
  - Horizontal
  - Vertical
- Target
  - Fixed
  - Moving
- Body position
  - Seated
  - Standing
  - Marching
  - Jumping (tramp)
  - Walking
- Feet
  - Shoulders width apart
  - Together
  - Tandem
  - Single leg stance

- Arms
  - Outstretched
  - Quiet down at sides
  - Crossed over chest
- Support surface
  - Hard
  - Soft—thin mat
  - Foam
  - Rocker board / t-stool
- Support surface width
  - Wide
  - Narrow

Post-vestibular Rehabilitation Testing

- Pediatric Balance Scale (PBS)
  - A criterion-referenced screening for children 3 to 6 years
  - Screens functional balance in everyday tasks
  - Guidelines developed for age and gender based on 641 children typically developing.
  - Use a 95% confidence interval of mean as an indicator that performance may warrant further investigation (Franjoine et al. 2010).
  - High test-retest and interrater reliability in testing balance for children 5-15 years with mild to moderate motor impairment (Franjoine et al. 2003).

Pediatric Balance Scale Results

- Pre-score 47/56
  - S2 lower Confidence interval (CI) cut off
  - Results indicated further investigation warranted
- Post-score 52/56
  - S2 lower Confidence interval (CI)
  - Improvement to lower limit

Gross Motor Results:

- March 2010: 1st Percentile
- November 2010: 2nd Percentile
- November 2011: 3rd Percentile
- April 2012: 8th Percentile

- 35 visits over 5 months 2x/week (1 pull out and 1 vision session with aide)
- 228 min / month (14 min more per month than previous test period)
- Gross motor progress clinically significant
- Participation with movement activities much improved, jumping, running and playing with peers at school. Parents very happy with results!
Post-vestibular Rehabilitation Testing

Dynamic Visual Acuity Results
- Clinically meaningful change found
- The criteria for clinically meaningful change mean plus two SD of the difference between test one and test two (Braswell et al. 2006; Rine et al. 2003)

CAP Phase 10
Evaluate Outcomes of Knowledge Use
- Pediatric balance test scores improved 5 points
- PDMS-II percentile scores improved 5 percent
- Significant for motor improvement
- Dynamic visual acuity scores moved into the normal range
- DVA was .3 LogMARs and SVA .2 LogMARs
- Improved participation at school and home
  - running, jumping, climbing and enjoying playground
  - not sitting on steps to descend
  - not crying when placed on movable surface (bridge, foam wedge)
  - Classroom behavior more focused and starting to identify his written name as well as write his name with a model
- Student transferred back to less restrictive environment (home district) for start of new school year secondary to such great progress

CAP Review—11 Steps
Obtaining Knowledge
1. Identify available knowledge
2. Ask relevant questions from available knowledge
3. Expand search based on new questions
4. Identify barriers to obtaining additional knowledge
5. Plan to overcome barriers to obtaining knowledge

Implementing Knowledge
6. Adapt the knowledge for the individual student
7. Identify barriers to knowledge implementation
8. Plan to overcome barriers to knowledge implementation
9. Implement new knowledge
10. Evaluate outcomes of knowledge use
11. Share and continue use of newly acquired knowledge

CAP Facilitators:
- Personal determination
- Member of APTA
  - Reduced cost for class
  - Access to PTNow (APTA, 2014)
- Administrative support at school
- Flexibility in service delivery in school-based program
- Access to student throughout the year(s).
- Family support
- Researcher’s willingness to create a partnership—Rose Marie Rine—thank you!
Final Thoughts

- You are not alone!
- The loan wolf has a pack...
- Create partnerships—it is possible!
- Develop your own CAP
- Promote best practice in our profession

Thank you!!

KT- Vestibular Related Impairments in Children

- Research & synthesis –
  - Established
  - tests: DVA, SVV, norms for SOT
  - VED affects gaze stability, balance and motor development in children
  - Efficacy of intervention
  - Reviews – evaluation and treatment
- Dissemination –
  - Articles, conference and continuing ed
  - VEDA articles
  - Here today!
- Exchange –
  - Meetings, teleconferencing, emails
- Application –
  - Establishing centers
  - Clinical work with a specific patient

What are Difficulties and possibilities?

Difficulties
- Conflicting roles
  - Researcher
  - Academician
  - Clinician
- Access to research articles
- Time
  - Clinician & researcher

Possibilities
- Collaboration
- Pub-Med
  - Open access journals
  - APTA access
  - VEDA
- Dedication & collaboration
  - SIG?
  - Website – linked in, Research Gate

KT – Pediatric Vestibular

- What facilitates KT for you?
- What are the roadblocks that you see?
- Questions?
- Discussion?
References—cont.