**Vestibular**

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**Vestibular – Balance Team**

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- Susan Whitney, University of Pittsburgh
- Michael Schubert, Johns Hopkins University
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- Neil Shepard, Mayo Clinic Rochester
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Representative of clinicians (PT, audiology, MD) and academician/researchers

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**Charge: Define & Develop**

- **Define**
  - Physiological, Functional, Multi-modal interdependence
  - Test review and selection (lifespan, quick, easy)
- **Develop**

  "Definition determines measures to be used"
**Physiological**
- Canals and otoliths of inner ear
- Diagnostic tests

**Functional**
- Vestibular ocular reflex (VOR) – gaze stabilization
- Correct retinal slip
- Vestibulospinal (Vsp) – postural control/balance

*Vestibular Definition (continued)*

**Multi-modal dependency for function**
- Vestibular, vision and somatosensation
- Central processing of information
- Motor system required

**Vestibular Defined**
- The vestibular system transduces and processes
  - Angular and linear acceleration and deceleration of head
  - Enables balance, locomotor control and gaze stability
- An inertial guidance system
  - Integrated into a complex multi-sensory interplay between the central nervous system, eye, inner ear and somatosensory inputs

Measure must include VOR and Vsp, with control for other contributions. Measure should consider central processing.
Identification of Measures

- 33 tests identified and reviewed
  - 6 screened out due to:
    - Self report, high cost, expertise required
- In-depth review of 27 tests
  - Categorized by VOR vs. Vsp
  - Eliminated for lack of reliability, sensitivity, or cost
- Selected
  - Dynamic visual acuity – tests VOR
  - Vestibular and sensory interaction for balance – tests Vsp
  - VOR suppression – central test

Dynamic Visual Acuity (DVA)

- DVA - quantify acuity change with head stable vs. moving
  - Typically the same, unless vestibular deficit
- Test requirements:
  - Optotype visible > 80 msec
  - Visual contribution controlled (via head movement rate)
- Computerized version optimal: reduce training and assure requirements
- NO PEDIATRIC VERSION developed to date

Vestibular & Sensory Interaction for Balance

- Quantify sway in varying vision and support surface conditions, to differentiate roles of sensory inputs
  - Must control for other inputs
  - Posturography = gold standard: costly, skill
- Current clinical versions
  - Sway not measured, require training and skill
  - Consistent method for use with children and adults NOT available
Development:

- Coordination with vision and motor teams
  - 1 tool, 2 measures achieved
  - Static acuity and balance
- Development phases:
  - I: develop tool (in progress)
  - II: determine reliability and validity (November - Feb)
  - III: develop instructions for use in Toolbox (Dec - March)

DVA Development
lead = M Schubert, Ph.D. (Dale Roberts)

- Computerized version
  - Minimize cost and language and cultural effects
- Software and hardware
  - Subject to identify optotype with head stable and moving @ specified rate
  - Progressively smaller size
- Compare:
  - Symbol vs. letter results
  - Test for young child and others
- Reliability and validity
- Instructions

Computerized DVA

- Test/retest: 110 subjects
  - without pathology:
    - 3-7 y.o. n = 20
    - 7.1-15 y.o. n = 30
    - 20-79 y.o. n = 10 in each decade
- Test subjects with pathology (rotary testing): 10 each children, adults
  - Test with letter & symbols (all with pathology; typical n = 10 8-15 y.o.; n = 20 adults)
- Compare to previous versions

DVA score = static - active, in LogMAR
Coordination with motor team
- 1 tool, 2 measures achieved

Development phases:
- I: develop tool (in progress)
- II: determine reliability and validity (November – March 2009)
- III: develop instructions for use in Toolbox and report

Balance Test Development
- Quantify sway under varying sensory conditions across life span
  - Foam, SLS/DLS, EO/EC
- Establish validity with gold standard of test for sensory integration for balance (posturography)

Balance Development:
Vestibular and Sensory Interaction for Balance Test
- Phase 1:
  - Hardware/software
  - Accelerometers (how, where to attach)
  - Data acquisition and processing methods, software user interface
  - Subject to stand, up to 30 sec, in 4 sensory conditions (EO/EC, foam/floor), for each of 2 support conditions (DLS, SLS)
MOBILE POSTURAL TESTING SYSTEM
Schematic Diagram of General Instrumentation Setup

HARDWARE

Software

Current Configuration:
- Laptop Computer
- Wired connections
- USB-based data acquisition

Custom GUI (LabVIEW)

Postural Sway Data

Accelerometer
- Attached to posterior pelvis

Eliminate the Wires – Bluetooth eliminate the tether wires between the accelerometer and the computer -

- Wireless DAQ
  - ~$300
  - High power Bluetooth Radio (100m range)
  - 8 channel / 16-bit ADC
  - Selectable capture rate from 1Hz to 3kHz
  - 6-12V input Dimensions: 1.6x3.0x0.9”

- Bluetooth receiver
  - USB dongle
  - ~$30

Vestibular & Sensory Interaction for Balance Test

- Phase 2: feasible, reliable, valid
  - Testing of 3 and > 75 y.o.?
  - Test-retest 80 subjects, no pathology, validate w/posturography scores: 3-3.9 y.o. n = 10; 4-6 y.o. n = 10; 7-10 y.o. n = 30; 11-17 y.o. n = 20; 22-35 n = 10; 36-55 n = 10; 56-65 n = 10; 66-75 n = 10
  - Sensitivity and specificity (to rotary and VEMP tests): 10 each child and adult

- Instructions
October 2008 – March 2009 (Phases I and II)
- Complete test protocol, hardware and software development
- Complete testing of all subjects to establish feasibility, reliability and validity
- Preliminary analysis of data

February – May (Phase III)
- Development of tool completed, reports done, ready for norming
- Training materials completed

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