NIH Toolbox
Assessment of Neurological and Behavioral Function

Vestibular

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NIH Blueprint

For more information, please visit www.nihtoolbox.org
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Vestibular – Balance Team

- Rose Marie Rine, University of North Florida
- Susan Whitney, University of Pittsburgh
- Michael Schubert, Johns Hopkins University
- John Carey, Johns Hopkins University
- Neil Shepard, Mayo Clinic Rochester
- Gary Jacobsen, Vanderbilt University
- Diane Wrisley, University of Buffalo

Representative of clinicians (PT, audiology, MD) and academician/researchers

Charge: Define & Develop

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

**Definition determines measures to be used

Vestibular Definition

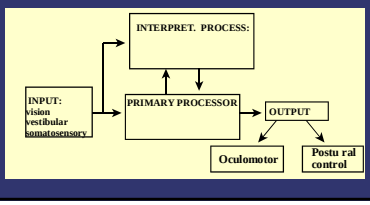
- Physiological
  - Canals and otoliths of inner ear
  - Diagnostic tests
- Functional
  - Vestibular ocular reflex (VOR) – gaze stabilization
    - Correct retinal slip
  - Vestibulospinal (Vsp) – postural control/balance

distinct end organ input to gaze and 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

Development of Balance test:
lead: Susan Whitney, Ph.D. (Mark Redfern)

- 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

Accelerometer

INPUT Postural Sway Data

Custom GUI (LabVIEW)

Accelerometer
- Attached to posterior pelvis

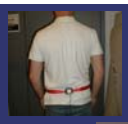
Current Configuration
- Laptop Computer
- Wired connections
- USB-based data acquisition

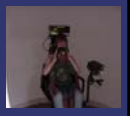
Eliminate the Wires – Bluetooth eliminate the tether wires between the accelerometer and the computer -

- 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 = 10; 11-17 y.o. n = 10; 21-35 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





Progress/plan for Vestibular Team

- 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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