THE RELATIONSHIP OF VISION, POSTURE AND MOBILITY

Teresa Plummer, PhD, TR, ATP
Assistant Professor: School of Occupational Therapy
Belmont University
Nashville, TN USA

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OBJECTIVES:

1. Identify anatomical considerations of posture and mobility
2. Review visual development as it relates to mobility.
Postural control: center of mass over base of support

Proprioceptive input leads to motor output for balance

Oculomotor and vestibular system

Proximal stability-reaching

Weight bearing – use contact surface as source of sensory information
SKILLS EVALUATION

- **Reflexes** for the neurologically involved client
- Physical skills
  - Orthopedic- resulting from neuromuscular factors
  - Neuromotor factors
- Respiratory and Circulatory
- Sensory Skills - **Visual Skills**
- Cognitive / Behavioral
  - Safety Awareness
  - Motivation
- Functional Skills
ANATOMICAL CONSIDERATIONS OF POSTURE AND MOVEMENT
IMPLICATIONS OF ABNORMAL REFLEXES – OPTICAL RIGHTING- ONE TO BE CONSIDERED FOR CHILD

- Tip body in all directions and head will always orient to vertical position
- If abnormal, in upright sitting, child will not orient head to upright/midline position. During tilting in w/c, child will not make attempts to maintain head vertical and therefore will lose line of vision
- If present in the context of other abnormal development, during tilting in w/c, child will be working to orient head to vertical position to maintain line of vision
LIMITATIONS: ORTHOPEDIC

- Limit the movement patterns, quality and sensory input into the CNS

Sensory input = Motor output.
KINESIOLOGICAL PRINCIPLES OF SEATING AND POSTURE: POSTURAL CONTROL
PROCESSES FOR POSTURAL CONTROL

- **Motor processes**
  - Emergence of neuromuscular response synergies to maintain stability of neck, trunk and legs

- **Sensory Processes**
  - Maturation of visual, vestibular and somatosensory systems as well as central sensory strategies of limb orientation

- **Musculoskeletal Components**
  - Structural, soft tissue, muscle strength and range of motion (Westcott, & Burtner, 2004)
DEVELOPMENT OF SITTING

- 3-5 months: (pre-sitting) single postural muscles activated
- 5-6 months: able to sit with arm support
- 7-10 months: activation of leg, trunk and neck muscles to cooperate in sitting
- 9 months- 3 yrs: good modulation of pelvic muscles as base of support
TRUNK STABILITY

• Must have proximal stability before distal mobility
• Pelvis is the base of support
• True ability to move is to translate movement over a stable pelvis
• Look at patients functional reach if in doubt.
• Must understand musculoskeletal components of anterior –posterior pelvic tilt, lateral weight shift and interaction of upper trunk and lower trunk
TRUNK

- Critical site for development of abnormal movement patterns because trunk movements form the basis for postural control
  - Patients assume a slumped posture with weight bearing behind the Ischial tuberosities
  - Lateral flexion or retraction occurs on the involved side, or may be bilateral
Proprioception first described in 1906 (Sherrington) sensations arising from deep areas of the body which contribute to conscious sensations, postural equilibrium and joint stability. Currently referred to as sensorimotor function. (Haggert, Person, Werner, Ljung, 2009)
ERECTOR SPINAES MUSCLES

http://www.realbodywork.com/learn/torso/erector.htm
TRUNK STABILITY

- Hierarchically:
  - Trunk stability
  - Trunk extension with head extension
    - Move center of gravity in front of IT
    - Must have neutral pelvic tilt
  - Lateral weight shifts and upper extremity movement with scapular protraction
VISUAL DEVELOPMENT RELATED TO MOBILITY
HOW DOES THE VISUAL SYSTEM CONTRIBUTE TO MOBILITY?
POSTURAL CONTROL

- All parts of the nervous system are involved in the control of posture (Dietz, 1992 as cited in Hadders-Algra, 2005)
- Involves the orientation of the body in space for stability as well as orientation to the task within the context of the environment
- Pyramidal system transmits “action plans” to the motor cortex
  - Controls complex posture and movement of arms, hands and fingers (Rosenblum & Jossman, 2003)
- Defined simply as the ability to control one’s center of mass (COM) over the base of support (BOS) (Westcott & Burtner, 2004)
POSTURAL CONTROL

- Balance (COM over BOS)
- Orientation: head in vertical alignment
- Sensory Input
  - Somatosensory and proprioception
  - Weight bearing
  - Kinesthesia
  - Vision: cues to head alignment
  - Vestibular: movement and response to gravity
MOVEMENT

- Prime movement
- Postural control
VISION

Visual skills that are necessary for mobility include visual processing, object identification, and depth perception / binocularity.

“The amount of information that an infant can acquire from moving objects depends, in part, with his ability to follow objects” (Ruff, 1980, page 983).
OCULOMOTOR

- Fixation- eyes fixed on target
- Saccades- move eyes from one stationary target to another
- Smooth Pursuits- follow moving target
- Vestibular- eyes still, head moves
- Optokinetic- eyes move, head still
  - (reflexive, develops at 6 months of age)
- Vergence- equal position of both eyes
OCULOMOTOR SYSTEM

- Dependent upon proximal control
- Developmentally linked
- Neurological insults influence the function
- Practice or training results in changes from reliance on visual input to reliance on proprioception during unperturbed stance (Mesure, Amblard, & Cremieux, 1999 as cited in Westcott & Burtner, 2006)
  - Cranial Nerve III, IV, VI
    - About 40% of TBI (Scheiman, 2001)
VESTIBULAR SYSTEM

- Contributes to balance and spatial orientation
- Provides the dominate input about movement and equilibroception
- Vestibular system send signals to neural structures that control our eye movement and to our postural muscles
  - Provide anatomical basis for vestibulo-ocular reflex (Highstein, Faye, Popper, 2004)
VESTIBULO-OCULAR REFLEX

1. Detection of rotation

2. Inhibition of extraocular muscles on one side.

2. Excitation of extraocular muscles on the other side

3. Compensating eye movement

Wikipedia.org
“Beyond the primary visual cortex, the visual system can be divided into two major processing streams” (Neuringer & Jeffrey, 2003, p. S93). The analysis of motion and spatial relationships, visual motor control and the control of visuospatial attention are the result of the projections of the dorsal stream into the superior temporal and posterior parietal cortex. The ventral stream projects in the occipital lobe to analyze specific aspects of the stimuli such as orientation, shape and color and then sends this information to the inferior temporal lobe where synthesis of the information occurs. The two processing streams have been labeled the “where” and “what” systems. It has been proposed that the dorsal stream is more vulnerable to a variety of developmental insults (Neuringer & Jeffrey, 2003).
Direction specific postural movement is accompanied visually locating item, successful grasp pattern and adequate posture for confronting gravity (Henderson & Pehoski, 2006; Hadders-Algra, 2005).

Contributes to body scheme and position in space
Visual information leads to direction specific movements.

Postural stability leads to distal mobility and is motivated by reaching. First gain control of shoulders, elbows, wrist, then hands (Rosenblum, & Jossman, 2003).

The relationship between vision, hand function and posture is apparent. (Henderson & Pehoski, 2006; Hadders-Algra, 2005).
VISION RELATED TO DEVELOPMENT

- 2 months
  - relies on visual input for head control
- Birth to 1 yr
  - visual preference for postural orientation in sitting and standing
- 13-16 months
  - visual preference for independent standing and walking
- Birth-death
THIRD TRIMESTER
(WEEKS 27-40 GESTATIONAL AGE)

- beginning of organized sleep states occurs during this trimester between 28 to 30 weeks gestation.
- brain waves that occur during these sleep cycles are necessary for proper development of the visual cortex.

2014, Plummer
**BIRTH**

- Light activates the newborn's visual system
- Vision is not fully developed at this time and myelination of the optic nerve is incomplete.
- Visual acuity is estimated to be about 20/400.
- The infant is only able to focus at a distance between 10-12 inches.
- The newborn's visual field is limited.

3-4 day old infants show activation of neck muscles to visual flow patterns
• Preference for reliance on visual input for head control at two months (Westcott & Burtner, 2004)

• For the visual system to continue to develop, visual stimulation must be present.

• During the first month, the infant’s eyes may wonder randomly or occasionally cross, while he or she is learning how to control the eyes together.

• Postural activity
  • 1-3 month old infants generate direction-specific postural adjustments based on multiple sources of sensory information (vision, vestibular and proprioception)
  • At 5 months direction-specific muscle activity is generated by pelvis rotation (stretch-sensitive mechanoreceptors in the buttock region (Hadders-Algra, 2005)
There is a critical period for development of these columns after which vision cannot be restored.

Visual experience is necessary for ocular dominance columns to form in the visual cortex.

The bottom picture shows what happens in the absence of visual stimulation. Note that the left eye, in absence of stimulation, has not formed full ocular dominance patterns.
2-3 MONTHS

- May demonstrate brief visual fixation
- Eyes begin to move with less associate head movement
- Follows vertical stimuli more than horizontal
- Sees the color red
- Note- at one month infant generates direction specific movement (Hadders-Algra, 2005)

Photo (c) Paulus Rusyanto
SIGNIFICANT AGE

- Symbiotic relationship between posture and reaching is illustrated by attainment of head stabilization on trunk
  - Given that postural control develops in cranial-caudal direction... reaching at 6 months is dependent upon infant’s ability to stabilize lower trunk and pelvis as well as long muscles of the trunk (van Wulfften Palthe & Hopkins, 1993 as cited in Hopkins & Ronnqvist, 2001)

- Providing hip and pelvis support improved reaching and head stability (Hopkins & Ronnqvist, 2001)
THREE MONTHS

- Functional activity in the basal ganglia, cerebellum, and parietal, temporal and occipital lobe increases substantially (Rubenstein, et al., 1989)
- Age of major neurodevelopmental transition (Pretchl, 1984)
- Goal directed arm movement emerges (Hadders-Algra, 2005)
• Lumbar lordosis with successful prone lying at 4 months and independent sitting at 6 months (Sweeney, & Gutierrez, 2002)

• Can begin to see near and far
• Has the ability to converge
• Estimated distance of fixation is 3 feet
• Begins to develop 3D and depth perception
• Goal directed reaching results in successful grasp (Hadders-Algra, 2005)
6 MONTHS

Visual system

- Can see 20/200
- Smooth Pursuits
- Increased Hand-Eye Coordination
- Particular interest in falling objects
- Can recognize faces at 6 feet

Postural Activity

- Begins to develop stabilization of head in space
- The capacity to adapt postural activity emerges
- Development of independent sitting – must have the ability to generate direction-specific postural adjustments (Brogen & Hadders-Algra, 2005)
- The development of secondary spinal curves of cervical and lumbar lordosis and thoracic and sacrococcygeal kyphosis become more pronounced with gross motor skill development in later infancy (Sweeny & Gutierrez, 2002)
**Nine Months**

- Antagonistic co-activation in sitting tasks emerges around 9 months and continues until 18 months (Van der Fitts, et al., 1999 as cited in Hadders-Algra, 2006)
- Fine tune postural muscle contraction at 9-10 months
- Linked to increase in functional activity in parietal and frontal cortices (Rubenstein, et al., 1989 as cited in Hadders-Algra, 2006)
- Reflects important changes in social-cognitive abilities (Carpenter, et al., as cited in Hadders-Algra, 2006)
VISUAL PERCEPTION

Synthesize stimuli which leads to construction of visual representation

- Used to navigate, and identify objects in space (Ganis, Thompson, Mast, & Kosslyn, 2003).
- Visual imagery / visual memory stored information to make reference to environment
- Smooth pursuits dependent upon vestibular input
DEPTH PERCEPTION

“Although infants can perceive depth by six weeks of age, only after they have been locomoting independently for 2-6 weeks does the perception of depth become linked with emotion of wariness”

(Bertenthal, Campos & Kermoian, 1992 as cited in Kermoian 1997)
MOBILITY BEGINS WITH TURNING TO STIMULI
HAPTIC PERCEPTION

“recognition of objects and object properties by the hand without the use of vision” (Henderson & Pehoski, 2006)

Leads to object identification
In hand manipulation typically develops from 1-7 years of age (Rosenblum, & Jossman, 2003)
NEONATES AND INFANTS

- Learn first by oral interaction
- Later, learning occurs through hand function
- Learning also occurs through vision
- Learning: the process of acquiring information about features of the environment (texture, object weight, size)
- NOT ONLY ACQUIRED BY VISION
Visual information guides hand positions
“Due to visual projection to the cerebellar vermis and cortex it could be assumed that a lack of input leads to a delay in cerebellar control of balance in the sitting position and hence leads to a very prolonged period of instability, expressed as ataxia” (Pretchl, et al., 2001, p. 200).
**VISUAL IMPAIRMENTS**

- Infants with blindness display of visual motor delays. (Prechtl, Cioni, Einspieler, Bos and Ferrari, 2001)

- Not apparent until third month

- “delay in vestibular function due to the lack of visual calibration of the labyrinthine functions” (Prechtl, Cioni, Einspieler, Bos and Ferrari, 2001, pg. 199)
VISUAL FIXATION AND POSTURAL STABILITY

- Relationship between posture and movement is an inclusive subset of relationship between perception and action.
- Head stabilization is fundamental to locomotion (Wade & Jones, 1997).
VISUAL INATTENTION OR NEGLECT

- Unilateral spatial neglect
  - RCVA 82%
  - LCVA 65%
  - Decreased ability to attend to objects
  - Scanning may be disorganized
  - The side of the body ignored
  - Right hemisphere- plays a role in global attention, spatial awareness and topographical orientation
  - Left hemisphere attends to detailed information (Wolter & Preda, 2006)
Types of Visual Deficits

- **Visual Field Deficit (VFD)**
  - Hemianopsia: visual loss on one side is detected in 36% of R CVA, and 25% with L CVA
  - Clients may not be aware that they have a VFD
  - Visual System related to power mobility
  - Clients describe difficulty with mobility or ADLs (Wolter & Preda, 2006).
TREATMENT

- Varied environments
- Scan environment
- Community activities are essential
- Expose client to dynamic less predictable environment for to enhance generalizability (Wolter & Preda, 2006)
- Why power mobility (driving)?
- Wayfinding- life / activity space
  - Maneuvering in space is essential for rehabilitation (Antonakos, Giordani, Ashton-Miller, 2004)
Driving / Mobility

- Primarily a visual task: 90-95% of the input to the driver is visual
  - Essential component of rehabilitation (Wolter & Prada, 2006)
  - Increased head movements can compensate for the deficit
  - Depth perception can be reacquired but incorporating other environment cues
**Power Wheelchair as a Modality**

- How are power wheelchairs traditionally used?
  - Typically for MRADLs, getting from point A to point B, (mobility related tasks)
- Can powered mobility be beneficial as an adjunct treatment tool for visual/perceptual deficits in patients with cerebral vascular accidents?
- In return, how will powered mobility as a treatment tool impact clinical decision making for wheelchair selection.
VISUAL SYSTEM RELATED TO POWER MOBILITY

- Visual system develops through movement as it relies on the vestibular and somatosensory systems.
- Early intervention is crucial for development
  - There is correlation between how children and adults develop visual/perceptual skills
  - Learning vs relearning visual/perceptual skills
- Movement is the catalyst for developing visual/perceptual skills
Previous planar seating system
Video??
MEDIAL SCAPULAR SUPPORT
CUSTOM MOLDING PROCESS
Final Seating System
REFERENCES/ RESOURCES

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