Postural Function

• “To what extent posture can be distinguished from movements per se, is a question that is often raised and has not yet been answered convincingly (Massion, 1998, p. 465)”.

How is posture represented?

• Bottom-up approach.
• In this scheme, the body oscillates around the ankle joints like an inverted pendulum.
• Posture controlled as a whole entity that defines body orientation with respect to gravity.

How is posture represented?

• Top-down approach.
• Based on superimposed segments linked by sets of muscles under specific control.
• This control preserves their orientation with respect to space and each other.

Ideal Alignment in Standing

• Ear lobe.
• Tip of shoulder.
• Body C of G.
• Hip joint.
• Knee joint.
• Ankles.

Spinal Curve Development
Spinal Curve Development

• Initially there is a single 'C' curve throughout the spine.

Spinal Curve Development

• The action of gravity on the head is seen in an infant who has yet to develop head control.

• If the infant is placed in the sitting position the weight of the head drags it and the neck forward and down.

Spinal Curve Development

• Head control begins in lying and is refined in sitting.

• Development of the first 'secondary curve' the cervical lordosis.

• This is the beginning of upright posture and also gives unrestricted vision.

Spinal Curve Development

• Head control is an important milestone

• A child’s head is a greater proportion of its bodyweight than is an adults.

Spinal Curve Development

• With standing, a curve in the small of the back brings the head and upper trunk over the centre of gravity.

• Again allows for unrestricted vision.

• Some of the “natural poise” children exhibit may be in part due to the greater weight of their head relative to the rest of their body

• It is harder for them to pull it back and down
Balanced Upright Standing

Patterns During Development
• Initially a wide base of support to increase stability.
• Use arms in a ‘high-guard’ position.
• Some forward leaning, the abdomen usually bulges, and there is some flexion at the knees.

18-month-old infant (Asher, 1975).

Patterns During Development
• By two the legs have moved closer together, and child may appear flatfooted.
• The knees begin to approach each other but because a broad base is still necessary for balance, some children will appear knock-kneed. (Asher, 1975; Rosen, 2000).

Patterns During Development
• The knock-knees usually correct by around six years.
• With further growth, the abdomen becomes less prominent, and the feet begin to develop arches. (Asher, 1975)

Patterns During Development
• Often a marked forward pelvic tilt during the primary school years.
• Child may need to hyperextend their knees and brace the back (exaggerate the lumbar lordosis) at this stage to maintain balance. (Asher, 1975)

Patterns During Development
• Before puberty the limbs grow faster than the trunk.
• As the general speed of growth picks up, the trunk begins to grow faster.
• During puberty, the rate of growth between the limbs and trunk is about equal.
• Finally the limbs slow their rate of growth, but the trunk continues to grow in the postpubescent period (Asher, 1975). (Asher, 1975)
Nervous System Dynamics

Neural Tension

- Spinal canal is 5-9 cm (2-3.5 in) longer in flexion than extension (Butler, 1991).

Patterns During Development

- An exaggerated lumbar lordosis which extends the spine and shortens the canal will therefore relieve neural tension created by rapid limb growth. (Asher, 1975)

Stabilization of Patterns

- Slowly posture begins to stabilize as the growth rate settles.
- The abdominal protrusion disappears along with the exaggerated forward pelvic tilt.
- Hyperextension of the knees is no longer necessary to balance. (Asher, 1975)

What controls postural orientation?

- Vestibular information from the inner ears.
- Visual information from the eyes.
- Kinesthetic information from joints, muscles and tendons.
- Tactile information
- Graviceptors in the body cavity.
Vestibular Information

• The combined information provides a highly accurate representation of head position and movement relative to gravity in three dimensions.
• This information inputs into upright balance.
• It is also used in reflexes that stabilize visual targets during movement.

(Lackner & DiZio, 2005)

Visual Control of Postural Orientation

• In quiet stance visual cues allow us to estimate the position of our body with respect to external reference objects.
• Experimentally it has been found that reducing environmental structure increases postural sway (Kinsella-Shaw, Harrison, Colton, Semenza & Turvey, 2006).

Optic Flow Fields

• The optical flow radiates out from the point that is co-incident with the direction of motion and this point falls on the centre of the retina.

(Wade & Jones, 1997)

Kinesthesia v Proprioception

• Kinesthesia places a greater emphasis on the body's movements and motions.
• Proprioception focuses more on the body's awareness of its movements and behaviors.
• Proprioception includes the sense of equilibrium and balance, and so includes vestibular input from the inner ears.
• Additionally there is some central input.

Efference Copy

• An internal copy created with a motor command of its predicted movement and its resulting sensations.
• This enables the brain to estimate the sensory feedback from movements.
• Enables motor adaptation.
Feedforward

- This anticipated feedforward is likely related to what ‘feels right’ in our habitual ways of moving.

Proprioception includes Kinesthesia

- Information from joints, muscles and tendons provide:
  - Sense of position.
  - Sense of movement.
  - Sense of force.

Proprioceptive Chain

- There is a proprioceptive chain running from the head to the feet (Roll & Roll, 1998 in Massion 1998).
- It gives information about each segment with respect to the others and is centrally integrated.
- It is used in the organization of postural control as a whole.
- Information transmitted by the proprioceptive postural chain only operates in normal gravity.

Zero Gravity

- In zero gravity all the joints move to a midrange position of semi-flexion.

Tactile Information

- Receptors in the soles of the feet register changes in mechanical pressure as the body sways over the ankles.
- This information provides a mapping of body orientation to the upright.
Tactile Information

- Proprioceptive information combines with tactile information about hand or limb contact with the body and external objects.
- This aids in the calibration of apparent dimensions of the body and its relationship to external space.

Tendon Vibration Studies

- Vibration at a specific frequency of 120 Hz activates the muscle spindle and elicits a tonic vibration reflex.
- Restraining the limb results in apparent movement and displacement of the physically stationary limb (Lackner and Taulib, 1984).

Tendon Vibration Studies

- Vibration of the biceps tendon in the arm causes a sensation of elbow extension (lengthening of the biceps).
- If the person is holding their nose it appears to lengthen along with the change in elbow position.
**Tendon Vibration Studies**

- Vibrating the triceps muscles with arms akimbo elicits an illusion of the hands approaching each other as the waist shrinks (Lackner 1988 in Lackner and DiZio, 2005).

**Rubber Hand Illusion – Sensory Interaction**

- Vision captures the touch stimuli
- The visual-tactile correlation influences the felt position of the hand
- Results in mislocation of tactile input to spatial location of the visual input
- Vision plays a dominant role over touch and proprioception

Botvinick and Cohen (1998); Tsakiris and Haggard (2005)

**The Neck as a Sense Organ**

- Sensory information from the neck allows the CNS to differentiate between neck or whole body movement that both stimulate the inner ears.

- Neck muscle input to proprioception has a leading role in body orientation and posture regulation (Duckes, Roll, Kanounoudias & Roll, 2004).

**Tendon Vibration Studies**

- In total darkness a visual target that is fixated upon will be seen to move in the direction of apparent motion if neck muscles are vibrated.
- Vibration of the appropriate muscles will elicit apparent motion and displacement of body segments in almost any configuration. (in Lackner and DiZio, 2005)

**Visual Dominance – Illusion of Length**

- The effect of optic flow on posture began with the work of Lee and Aronson (1974).
- The authors constructed a moving room that had a stationary floor, but the walls and ceiling could move back and forward along tracks.
- Infants who were just beginning to stand independently were seen to sway and stagger when the walls moved.

‘Moving Room’ Experiments
‘Moving Room’ Experiments

(Bertenthal, Rose & Bai, 1997)

Sensory Organization

Children under 5 years exposed to moving visual fields demonstrated postural instability (Lee & Aronson, 1974).

These authors posited that visual information dominated over proprioceptive information in the postural stability of young children who had recently learned to walk.

Sensory Organization

This destabilization due to optic flow was also reported by Forssberg and Nasher (1982, cited in Steindl, Kunz, Schrott-Fischer & Scholtz, 2006).

These authors interpreted these findings as due to an inability by the children to establish context-dependent weightings of sensory input in order to process inter-sensory incongruities.

Inter-sensory conflict emerges when visual and kinesthetic inputs are incongruous, and it is here that vestibular input is critical.

Gibson and Walk (1960).

Visual Illusion of Movement

Optic and Vestibular Interactions

- Optic flow is a form of re-aффerent sensory input occurring as a result of the observer’s movement.

- Vestibular input also provides information on rotation and translational movements of the observer, and these inputs continue to be provided in darkness as well as in a lit environment.

- These two systems have differing response dynamics and this means that reliance on one or the other may vary with the situation at hand.

Steindl, Kunz, Schrott-Fischer and Scholtz (2006) tested these subsystems in seven age ranges of children and compared their performance with adults in an attempt to clarify some of the conflicting results that have been found to date.

Sensory Organization
Sensory Organization

- Concluded that the proprioceptive system was mature at 3-4 years.
  (Steindl, Kunz, Schrott-Fischer and Scholtz 2006)

- Visual input to postural control was mature by age 15-16 years.
- 15-16 year olds had mature vestibular function.
- In adolescents, all three subsystems were mature and that they should have the ability to solve inter-sensory conflict.
  (Steindl, Kunz, Schrott-Fischer and Scholtz 2006)

Integrating all the inputs

- Develop head control first.
- Head in space is important to the posture of the lower body segments with respect to the external world.
- The ‘top down’ or descending mode of postural organization, i.e. that running from the head to the feet prevails. (Massion, 1998).

- Head posture plays the role of a reference frame for movement organization in space from very early on.
- Massion (1998) suggests that ‘bottom up’ organization emerges last with “the ability to control the whole body’s posture and the distribution of the body segment masses with respect to the supporting area (p.469)”.

- There has to be an integration of the ‘top-down’ and ‘bottom-up’ modes at some point in development.
- “The reorganization of postural control that occurs at or around the age of 7 years is a last challenge to this integration process (Massion, 1998, p. 469)”.
- Other researchers have also found that this is a watershed age for development.

- There is a transition phase for the use of peripheral vision in dynamic balance control around seven. (Assiante and Ambland, 1992 cited in Nougier, Bard, Fleury & Teasdale, 1998).
- There is a transition phase around seven to eight for movement control generally (Nougier, Bard, Fleury & Teasdale, 1998).
Integrating all the inputs

- Information from all the sensory sub-systems lead to the establishment of the behavioural vertical, and uprightness is maintained by reference to it (Roberts, 1995).

- A young adult who can resolve inter-sensory conflicts has a large safety margin to ensure stability.

Young Adults

References


References


Perception of postural orientation is also affected by graviceptors in the trunk.

Research on people with and without spinal paraplegia

The input from these gravity receptors enters the spinal cord at the 11th Thoracic and 6th Cervical levels.

Bilateral kidney removal abolishes the input at 11th Thoracic level, and so it has been established that the kidneys contribute to gravity perception (Mittlestaedt, 1996).

The exact mechanism of this visceral graviception is not yet clear.

Blood in the large vessels of the body is thought to be responsible for the input at the 6th Cervical level.

The fluid mass is thought to exert inertial forces on the ligaments that support the large vessels against gravitational load.

Mechanoreceptors in the pericardium are also thought to provide input to this vascular graviception (Mittlestaedt, 1996).

Tai Chi, Qi Gong and many other disciplines recognise the importance of the kidneys and the heart in their conception of balance and energy.