Exercises for impaired balance

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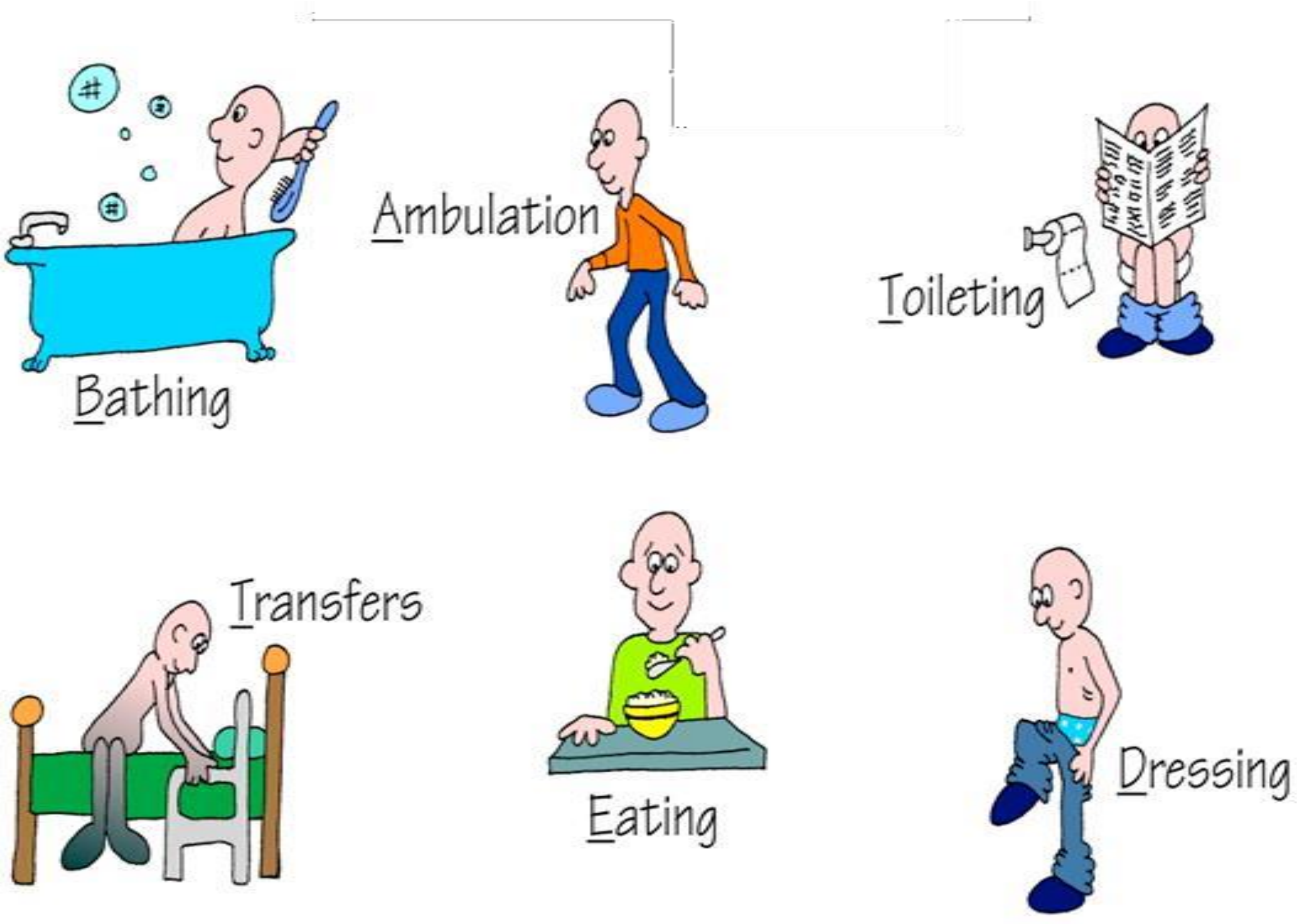
Balance: Introduction



Key terms and definitions

- **Balance or postural stability or postural control:** is a dynamic process by which the body's position is maintained in equilibrium.

Balance: Introduction

- Balance is critical for independence in functional tasks, such as sitting, standing, and walking
- Loss of balance and falling are problems that affect individuals with a wide range of diagnoses.
- The consequences of impaired balance are significant
- Physical therapists commonly evaluate balance and use balance training/exercises as either primary or secondary interventions for patients undergoing many types of rehabilitation programs.

Balance: Introduction

- Impaired Balance:
  - Loss of functional independence
  - Reduced participation in ADL
  - Increased risk for falls
  - Increased risk for mortality and morbidity

Key terms and definitions

- **Centre of mass (COM):**
  - It is a point that corresponds to the center of the total body mass
  - It is determined by finding the weighted average of the COM of each body segment
  - It is the point where the body is in perfect equilibrium
  - Balance is defined also as the ability to maintain the **center of gravity** over the **base of support**
- **line of gravity (LOG)**
  - The vertical projection of the center of mass to the ground.
  - In the anatomical position, the COG of most adult humans is located slightly anterior to the second sacral vertebra

Key terms and definitions

- **Base of support (BOS)**
  - Perimeter of the contact area between the body and its support surface
  - **Foot placement** alters the BOS and changes a person's postural stability
    - A wide BOS, such as is seen with many elderly individuals, increases stability
    - A narrow BOS, such as tandem stance or walking, reduces it.

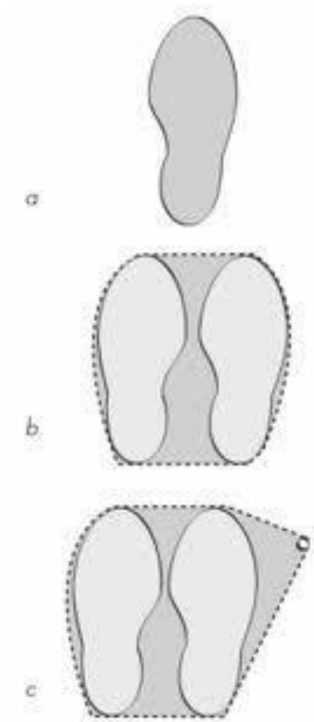
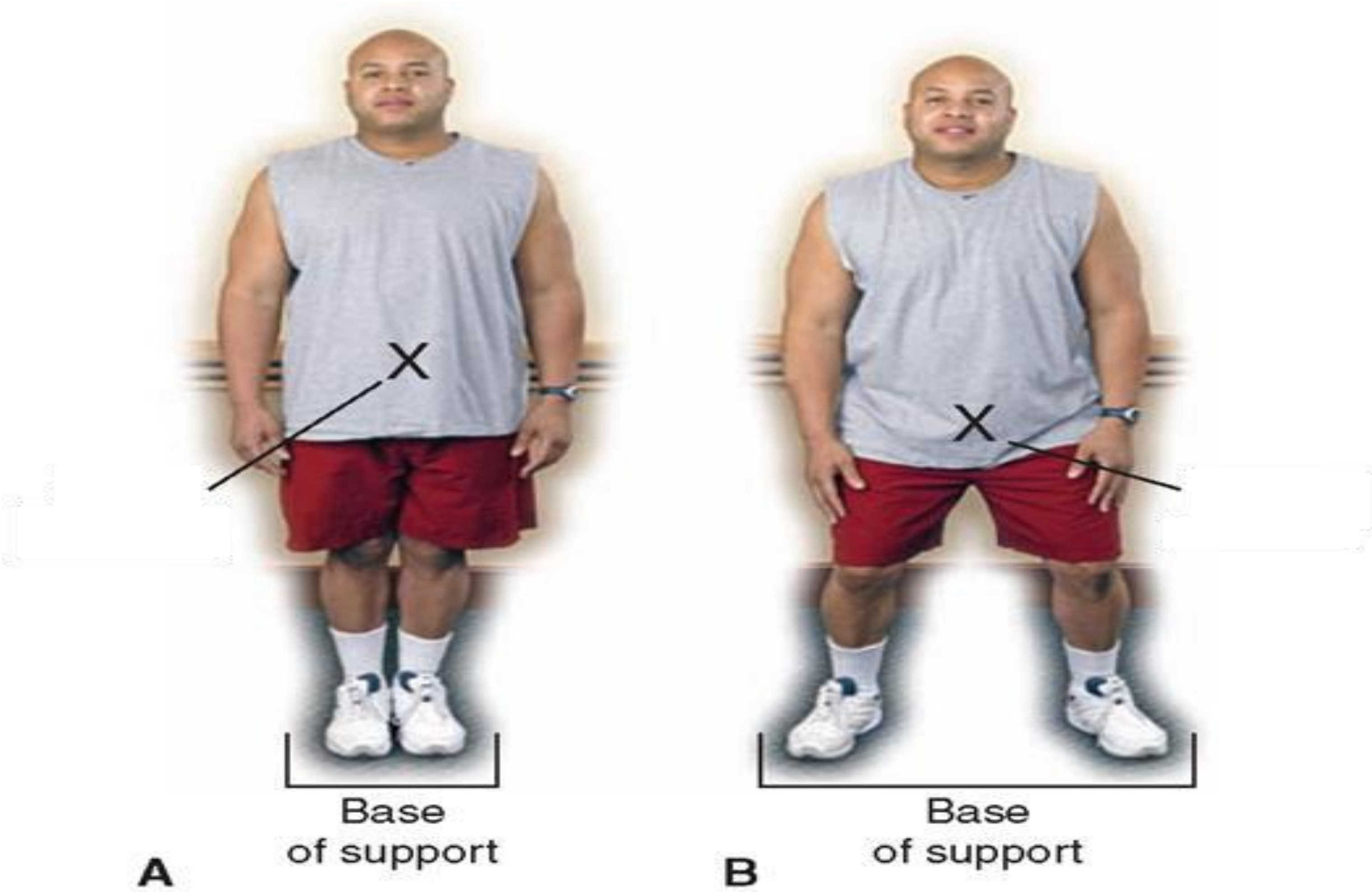


Figure 6.6 Examples of bases of support as seen from above: (a) one-legged standing, (b) two-legged standing, and (c) standing with a cane.

Key terms and definitions

- **Limits of stability (LOS)**
  - The sway boundaries in which an individual can maintain equilibrium without changing his or her BOS
  - The LOS quantifies the maximum distance a person can intentionally displace their Center of Gravity (COG), i.e. lean their body in a given direction without losing balance, stepping, or reaching for assistance.
  - These boundaries are constantly changing depending
    - The task
    - The individual's biomechanics
    - The Environment

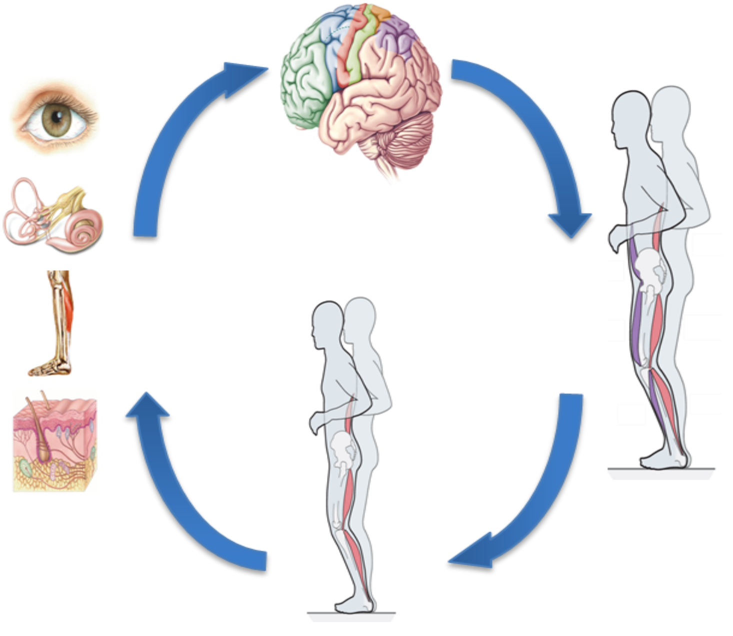
Key terms and definitions

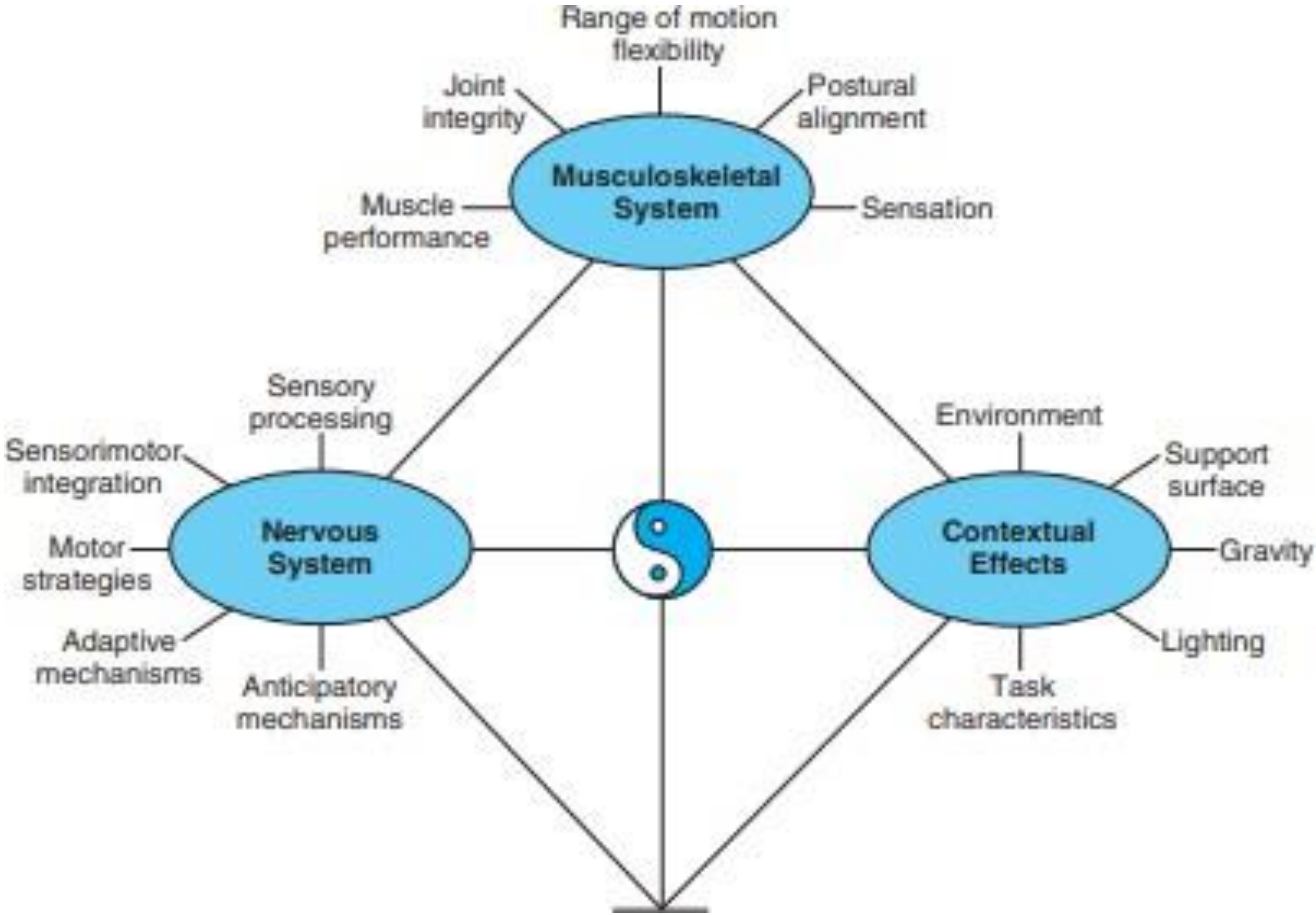


Balance control

Balance requires:

1. <u>Detection</u> of sensory information **(sensory systems)** to assess position and motion of body in space.
2. <u>Integration</u> of sensory information **(nervous system)**
3. <u>Execution</u> of appropriate musculoskeletal responses to control position **(musculosketal system)/ (motor output)**




Range of motion flexibility
Joint integrity
Postural alignment
Musculoskeletal System
Muscle performance
Sensation
Sensory processing
Sensorimotor integration
Nervous System
Motor strategies
Adaptive mechanisms
Anticipatory mechanisms
Environment
Support surface
Contextual Effects
Gravity
Lighting
Task characteristics

Sensory systems and balance control

- Perception of one's body position and movement in space require a combination of information from peripheral receptors in multiple sensory systems
  - Visual system
  - Somatosensory system (proprioceptive, joint, and cutaneous receptors)
  - Vestibular system

Sensory systems and balance control

- **Visual system**
  - Position of the head relative to the environment
  - Orientation of the head to maintain level gaze
  - Direction and speed of head movements

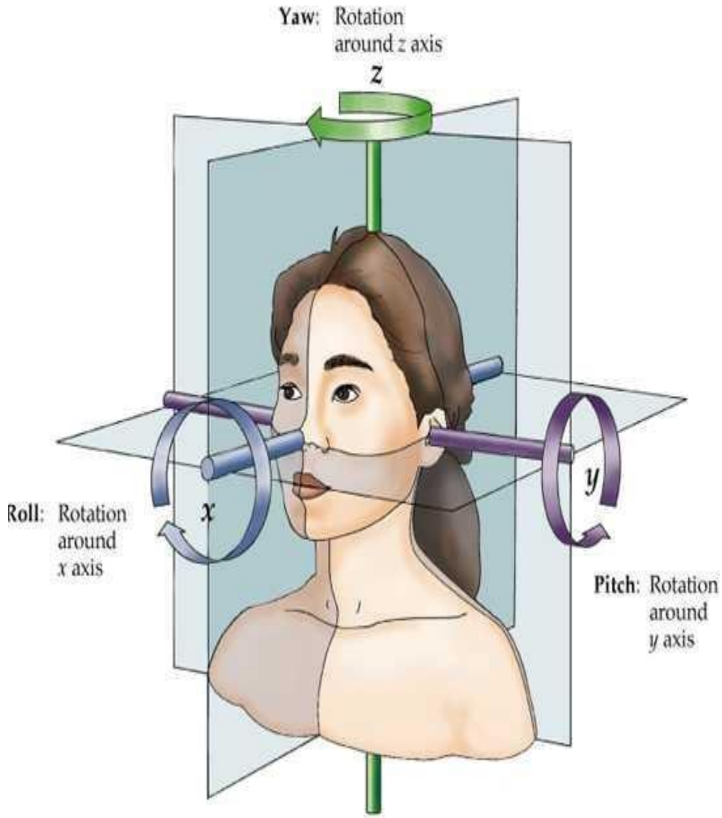
Sensory systems and balance control

- **Somatosensory information:**
  - **Skin mechanoreceptors**/ vibration, touch, deep pressure.

  - **Position and motion** of the <u>body and body parts relative to each other and the support surface</u>
    - Input derived from:
      - Information from muscle proprioceptors **when the support surface is firm, fixed, and flat**
        - **Muscle spindles** and **Golgi tendon organs**/ muscle length and tension
        - **Joint receptors**/ joint position and movement

Sensory systems and balance control

- **Vestibular system**
  - Provides information about **the position and movement of the head** <u>with</u> <u>respect to</u> <u>gravity</u>
  - Receptors in the semicircular canals (SCCs) detect angular acceleration of the head, whereas the receptors in the otoliths (utricle and saccule) detect linear acceleration and head position with respect to gravity.
  - The SCCs are particularly sensitive to fast head movements, such as during walking or during episodes of imbalance (slips, trips, stumbles), whereas the otoliths respond to slow head movements, such as during postural sway



Sensory organization for balance control

- Vestibular, visual, and somatosensory inputs are normally combined seamlessly to produce our sense of orientation and movement
- Incoming sensory information is processed and integrated into the **cerebellum, basal ganglia and supplementary motor area**
- Somatosensory information has the fastest processing time for rapid responses, followed by visual and vestibular inputs.
- When sensory inputs from one system are inaccurate due to environmental conditions or injuries that decrease the information-processing rate, the CNS must suppress the inaccurate input and select and combine the appropriate sensory inputs from the other two systems

Types of balance control

1. Static balance control
2. Dynamic balance control
3. Automatic postural reactions
    1. Feed forward (Anticipatory)
    2. Feedback (Reactive)

Types of balance control

- **Static balance control**: maintaining a stable antigravity position while at rest (e.g. standing, sitting..etc)

- **Dynamic balance control**: maintaining equilibrium when the support surface is moving or when body is moving on a stable surface (e.g. sit-to stand transfer, walking)

Types of balance control

- Automatic postural reactions
  - **Reactive balance control** is the ability to recover a stable position following an unexpected perturbation.

  - **Proactive or anticipatory balance** is the ability to activate muscles in the legs and trunk for balance control in advance of potentially destabilizing voluntary movements.

Types of balance control

- **Feed forward: is utilized** for anticipatory aspects of postural control
  - **Anticipatory control involves activation** of postural muscles in advance of performing skilled movement (e.g. planning how to navigate to avoid obstacles)
- **Feedback:** utilized for precision movements that require sensory feedback (e.g. balancing while sitting on a ball or standing on a balance beam).

Motor strategies for balance control

- To maintain balance, the body must continually:
  - Adjust its position in space to keep the COM of an individual over the
    BOS
  - Or to bring the COM back to that position after a perturbation

- Three primary movement strategies used by healthy adults to recover balance in response to sudden perturbations of the supporting surface:
  - **Ankle strategy**
  - **Hip strategy**
  - **Stepping strategy**

Suggested videos

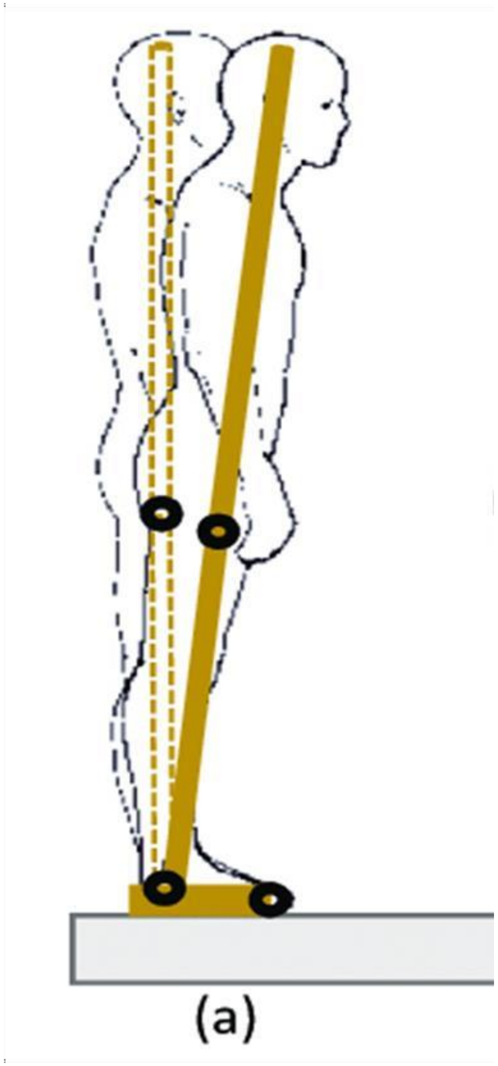
- https://www.youtube.com/watch?v=2BxJKgrByfU&list=PLAjkyo7whO0IGPtp7P5Lpi5cBGElmuj28&index=4
- https://www.youtube.com/watch?v=FoxsxcYFLsc&list=PLAjkyo7whO0IGPtp7P5Lpi5cBGElmuj28&index=5
- https://www.youtube.com/watch?v=ny-G22ZZa-Q&list=PLAjkyo7whO0IGPtp7P5Lpi5cBGElmuj28&index=6

Motor strategies for balance control

- Results of research examining the patterns of muscle activity underlying these movement strategies suggest that
  - Pre-programmed muscle **synergies** (i.e. group of muscles that they act together as a unit).
  - This to keep the COM of an individual over the BOS or to
    bring the COM back to that position after a perturbation.

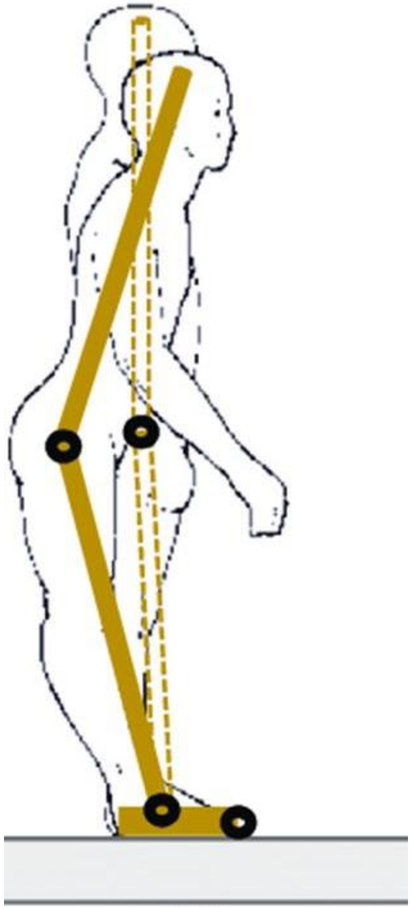
Motor strategies for balance control

- **Ankle strategy**
  - Occurs at small perturbations typically while on firm, stable surface/ **distal to proximal** muscular activation
  - **Loss of balance in forward directions:**
    - Gastrocnemius
    - Hamstrings
    - Paraspinal muscle
  - **Loss of balance in backward direction:**
    - Tibialis anterior
    - Quadriceps
    - Abdominal muscles



Motor strategies for balance control

- **Hip strategy**
  - For rapid and/or large external perturbations/COG near the limits of stability.
  - Rapid hip extension or flexion
  - **Proximal to distal activation of muscles**
  - **Loss of balance in backward direction:**
    - Abdominal muscles
    - Quadriceps
  - **Loss of balance in forward direction:**
    - Paraspinal muscles
    - Hamstrings



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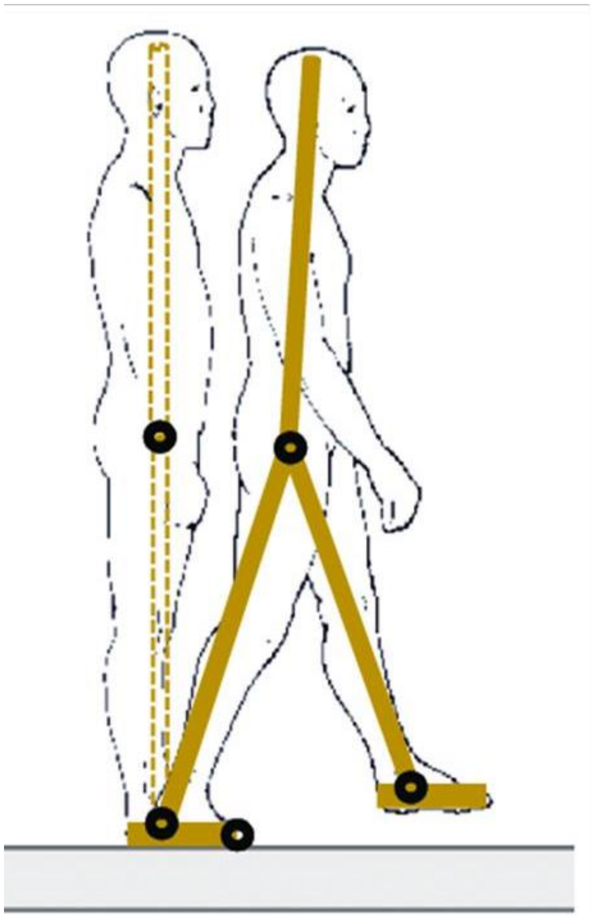
Motor strategies for balance control

- **Stepping strategy**
  - A large force displaces the COM **beyond the limits of stability**, a forward or backward step is used.
  - Enlarge BOS and regain balance control.



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- https://www.youtube.com/watch?v=Lk-mEyyXJiY

Factors influencing the selection of balance strategies

BOX 8.1 Factors Influencing Selection of Balance Strategies

- Speed and intensity of the displacing forces
- Characteristics of the support surface
- Magnitude of the displacement of the center of mass
- Subject's awareness of the disturbance
- Subject's posture at the time of perturbation
- Subject's prior experiences

Impaired Balance

- Impaired balance can be caused by <u>injury</u> or <u>disease to any structures involved in the three stages of information processing</u>
  - Sensory input
  - Sensorimotor integration
  - Motor output generation

Impaired Balance
Sensory input impairments

- Proprioceptive deficits have been implicated as contributing to balance impairments following lower extremity and trunk injuries Decreased joint position sense has been reported in individuals with:
  - Recurrent ankle sprains
  - Knee ligamentous injuries
  - Degenerative joint disease
  - Low back pain

Impaired Balance
Sensory input impairments

- Somatosensory, visual, or vestibular deficits may impair balance and mobility.
- Reduced somatosensation in the lower extremities caused by peripheral polyneuropathies in the aged and in individuals with diabetes are associated with balance deficits and an increased risk for falls. These individuals tend to rely more heavily on a hip strategy to maintain balance than do those without somatosensory deficits.

Impaired Balance
Sensory input impairments

- Visual loss or specific deficits in acuity, contrast sensitivity, peripheral field vision, and depth perception caused by disease, trauma, or aging can impair balance and lead to falls.

- Individuals with damage to the vestibular system due to viral infections, traumatic brain injury (TBI), or aging may experience vertigo (a feeling of spinning) and postural instability.

Impaired Balance
Motor output impairments

- Deficits in the motor components of balance control can be caused by:
  - Musculoskeletal impairment(i.e., poor posture, joint ROM limitations, decreased muscle performance)
  - Neuromuscular system impairment (i.e., impaired motor coordination, pain)
  - Postural malalignment, such as the typical thoracic kyphosis of the elderly, that shifts the COM away from the center of the BOS increases a person’s chance of exceeding his or her limits of stability.

Impaired Balance
Sensorimotor integration problems

- Damage to the basal ganglia, cerebellum, or supplementary motor area impair processing of incoming sensory information, resulting in difficulty adapting sensory information in response to environmental changes and in disruption of anticipatory and reactive postural adjustments.

Impaired Balance
Deficits with Aging

- Falls are common and are a major cause of morbidity, mortality, reduced functioning, and premature nursing home admissions in persons over age 65.
- Most falls by the elderly are likely due to complex interactions between multiple risk factors.

The most common risk factors associated with falls in the elderly

BOX 8.2 Most Common Risk Factors for Falls Among the Elderly

- Muscle weakness
- History of falls
- Gait deficit
- Balance deficit
- Use of assistive device
- Visual deficit
- Arthritis
- Impaired activities of daily living
- Depression
- Cognitive impairment
- Age > 80 years

From AGS Panel on Fall Prevention, 2001.[3]

Screening questions for falls

- 2 or more falls in the past 12 months
- Presence of acute falls
- Difficulty of walking or balance

Examination and evaluation of balance

- **History of falls**
  - Onset of falls: gradual or sudden
  - Frequency of falls
  - Environmental conditions
  - Activities
  - Presence of dizziness, vertigo
  - Medications
  - Visual acuity
  - **Presence of fear of falls**

Examination and evaluation of balance

- **Sensory input** (proprioceptive, visual, vestibular)
- **Sensory processing** (anticipatory and reactive balance)
- **Motor** (postural alignment, ROM, flexibility, muscle strength and endurance, pain)

Examination and evaluation of balance

- **Static balance**
  - **Observation of patient maintain different postures (vary posture/ vary sensory input/ vary support surface/ and incorporate external loads)**
    - Single-stance test
    - Romberg tests (with eyes open and eyes closed)
    - Sharpened Romberg test (eyes open and eyes closed)
    - Sharpened Romberg with cognitive loading

- **Dynamic balance**
  - **Observe patient sitting or standing on moving surface/ Transitional and locomotor activities**
    - Tinnetti performance oriented mobility test (POMA)
    - Timed Up and Go test (TUG)
    - Dynamic gait index
    - Berg balance test

Examination and evaluation of balance

- **Anticipatory (feedforward)**
  - Observe the patient catching a ball, lifting objects of different weights
  - Functional reach test
  - Multidirectional reach test
- **Reactive (feedback)**
  - Observe patient response to pushes (small or large, slow or rapid, anticipated or unanticipated)

Management of impaired balance

- **Static balance**
  - Patient maintaining different postures
  - **Vary support surface, postures, visual cues.**
  - Incorporate external loading
- **Dynamic balance**
  - Patient standing, sitting on unstable surfaces (moving support surface)
  - Move head, trunk, arms and legs
  - Transitional and locomotor activities

Management of impaired balance

- **Anticipatory (feed-forward)**
  - Reaching
  - Catching or throw
  - Lifting or kick
  - Obstacle course
- **Reactive (feedback)**
  - Ankle strategy
  - Hip strategy
  - Stepping strategy

Management of impaired balance

- **Sensory organization**
  - Reduce visual cues: Close eyes, wear prism glasses, move eyes.
  - Reduce somatosensory cues: narrow base of support, stand on foam, stand on incline board.

- **Balance during functional activities**
  - Functional activities
  - Dual or multi-task activities

Parameters of progressing balance interventions

Parameter	Progression
Upright posture	Sitting ----kneeling ----standing
Base of support	Sitting: feet on floor----feet off floor Standing: wide---narrow base (double leg stance—tandem stance---single leg stance)
Support surface	Nonmoving, firm, or flat surface (floor)--- moving, soft, uneven surface (ball, foam, wobble or slide board)
Visual cues	Eyes open----- eyes closed
Superimposed movements	Head, trunk movements Small--- large range UE or LE Un-resisted---- resisted
Perturbations	Anticipated---- unanticipated Low --- high magnitude Low ---- high speed
Functional tasks	Simple ---- complex task and single---- multiple tasks