Treatment of Balance in Aging and Neurologic Populations

Cynthia Robinson, PT, PhD
Department of Rehabilitation Medicine
University of Washington
Seattle, WA, USA

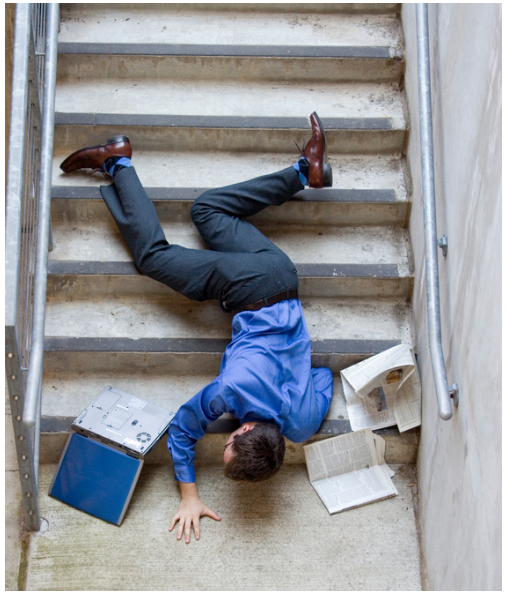
UW Medicine
DEPARTMENT OF REHABILITATION MEDICINE

Why is this an important topic?

- Falls in the elderly (per year)
  - $\geq 65\ years\ -33\%$ (Hausdorff et al., 2001; Hornbrook et al., 1994)
  - $\geq$ 80 years – 50%
- Chronic stroke(> 6 months) (Harris et al., 2005)
  - 50%
- Parkinson's Disease (Ashburn et al., 2007; Wood et al., 2002)
  - 40-70%
- Multiple Sclerosis
  (Finlayson et al., 2006; Matsuda et al., 2009; Peterson et al., 2007)
  - 50%

Consequences of Falling

- Trauma
  - Cost of medical treatment
- Loss of independence
  - Permanent disability
  - Fear of falling
  - Impact on family members



Balance

- Many definitions have been proposed.

"The ability to maintain the upright position."
(Horak and Shumway-Cook, 1987)

"A motor skill that can emerge from the interaction of multiple systems that are organized to meet functional task goals and that are constrained by environmental context."
(Horak, 1997)

Balance: Multidimensional Construct

(Horak, 1997)

- Intrinsic Factors
  - Biomechanical
  - Motor Coordination
  - Sensory Input
  - Sensory Organization
  - Cognition
  - Other
- Extrinsic Factors
  - External Environment
    - Support surface
    - Visual stimuli
  - External Perturbation
    - Nudge
    - Surface displacement

- Multidimensional interventions are most effective

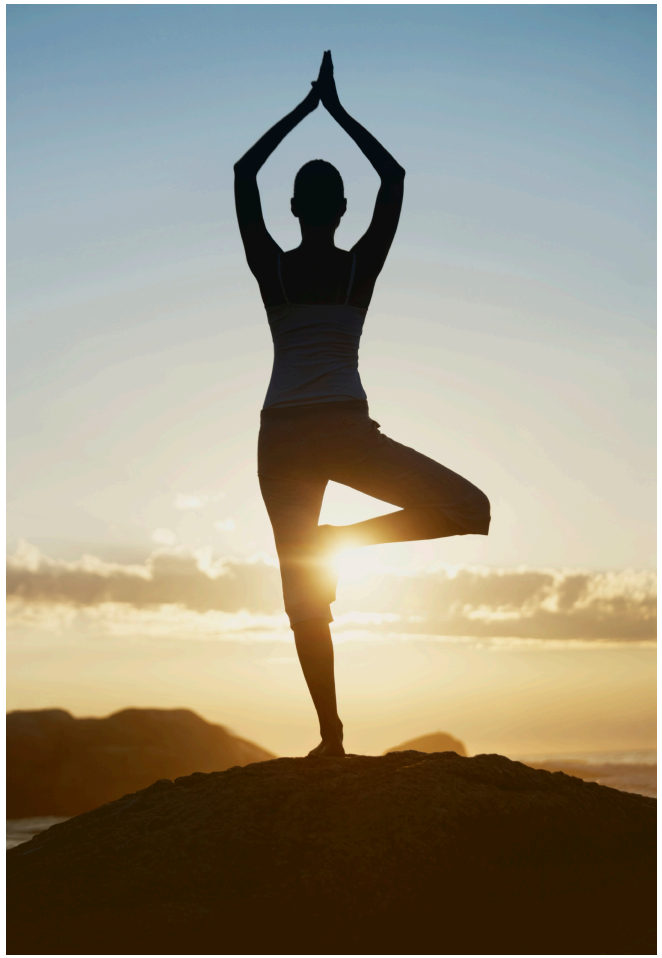
  (Howe et al., Cochrane Review, 2007; AGS/BGS, 2011)

Balance: Other

- General health of the individual
  - Endocrine system
    - Diabetes mellitus
  - Cardiopulmonary system
    - Blood pressure related to postural changes
  - Electrolyte balance
    - Dehydration
  - Medications
    - Side effects
  - Pain

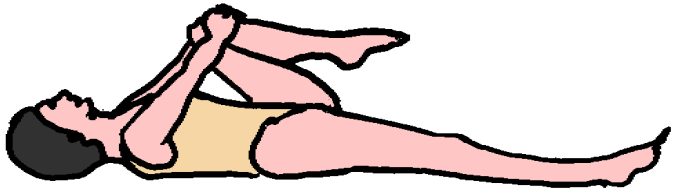
Balance: Multidimensional Construct

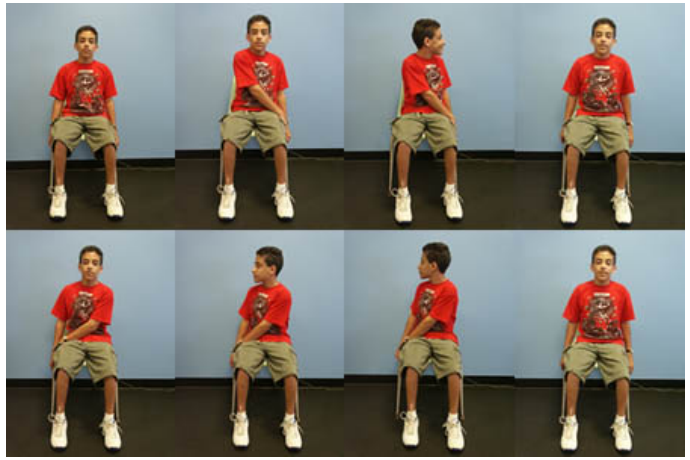
- Biomechanical
  - Joint range of motion
  - Soft tissue flexibility
  - Muscle strength
  - Postural alignment



Biomechanical: Flexibility

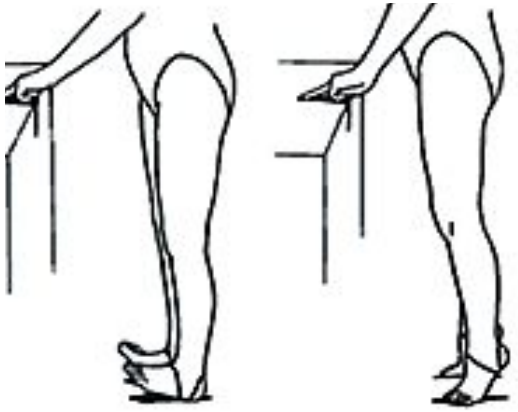
- Hamstrings
- Ankle plantar flexors
- Hip flexor stretch
- Trunk stretching



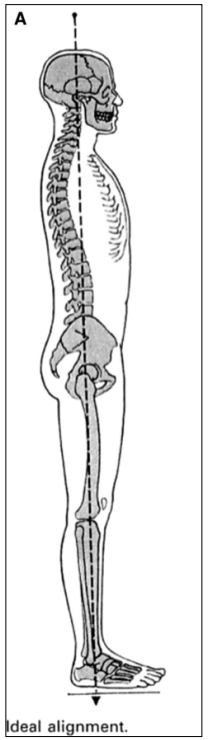


Biomechanical Factors: Muscle Strength

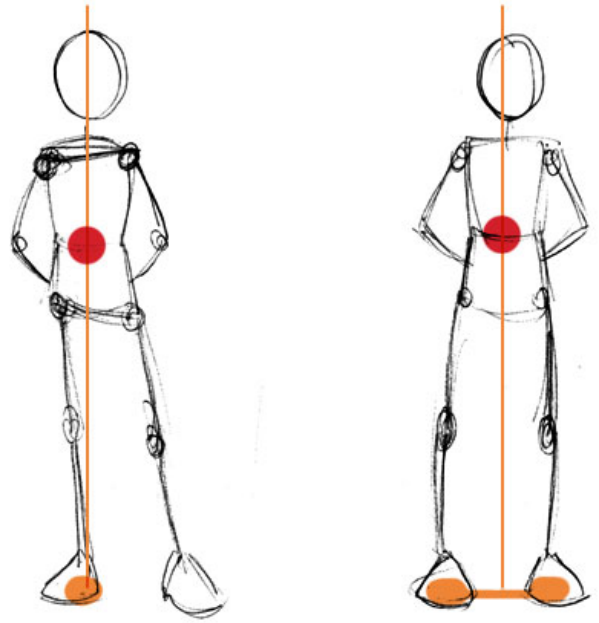
- Hip
  - Flexors (march in place)
  - Extensors (Lift leg behind)
  - Abductors (lift leg to side)
- Knee
  - Quadriceps (squats & seated knee extension)
  - Hamstrings (squats)
- Ankle
  - Dorsiflexors (toe raises)
  - Plantarflexors (heel raises)



Biomechanical: Postural Alignment

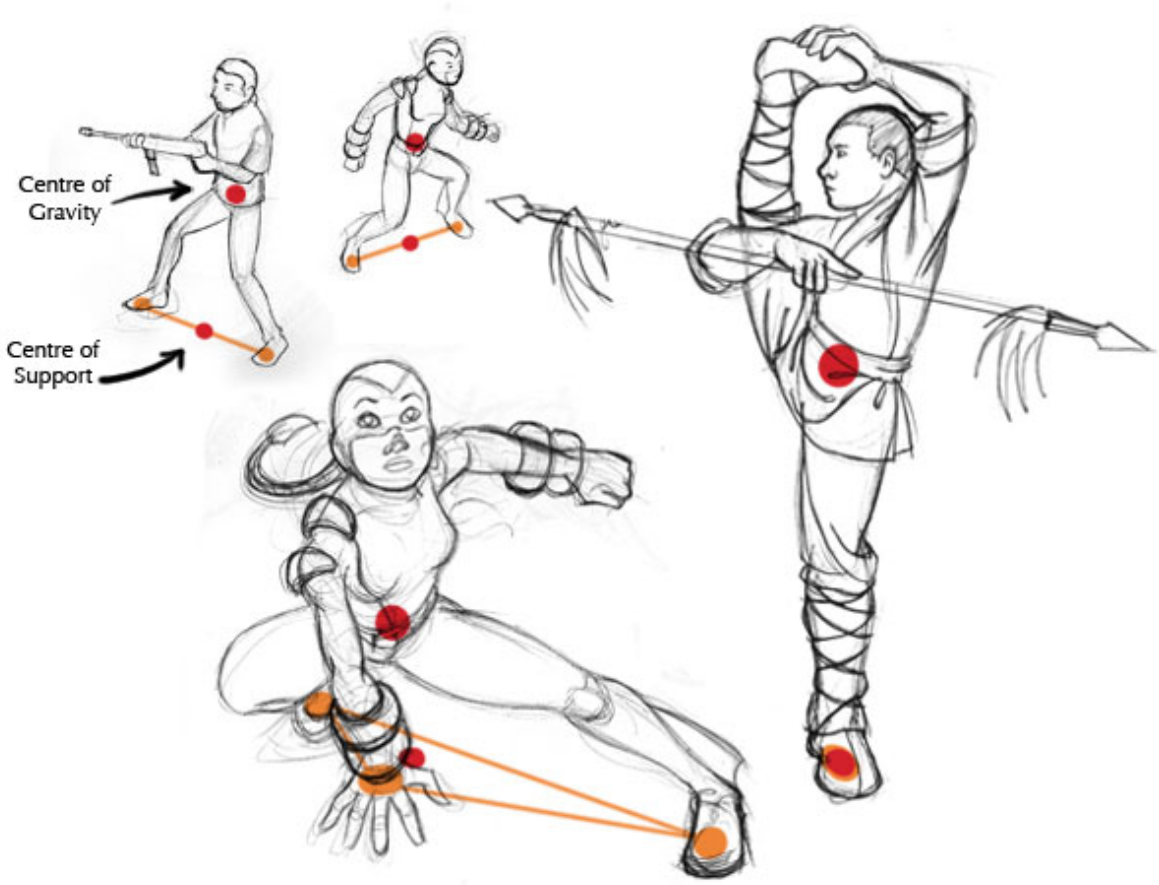


- Neutral postural alignment in sitting and standing
  - Base of support
    - On ischial tuberosities in sitting
    - Equally distributed on both legs in standing
  - Neutral alignment of the pelvis
  - Elongated thoracic spine
  - Chin tucked



Biomechanical: Postural Alignment

- Maintaining postural alignment during activities and movement
  - Conversation
  - Head turns
  - Functional activities of the upper limbs (stretching, lifting)
  - Lower limb activity



Balance: Multidimensional Construct

- Motor Coordination
  - Muscle tone
  - Spatial and temporal patterns
  - Postural strategy
  - Anticipation of voluntary movement
  - Movement and reaction time
  - Motor learning
    - Procedural- accomplished without awareness (motor learning)
    - Declarative- aware and can articulate

Motor Coordination: Proactive Balance

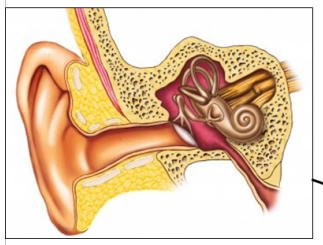
- Balance reactions in anticipation of voluntary movement
  - With practice, can be refined for optimal timing and sequence
- Practice tasks that are likely to produce instability
  - Sit and reach - Stand and reach
  - Sit to stand - Initiate walking
- Vary
  - Demands of the tasks
    - Chair height, base of support
  - Sensory conditions
    - Support surface, visual stimuli
  - Cognitive conditions
    - Single versus dual task conditions

Motor Coordination: Reactive Balance

- Balance reaction in response to a perturbation
- Practice recovery from an external stimulus that displaces the Center of Mass
- Vary
  - Stimulus
    - Manual versus tilt board
    - Speed, amplitude, and direction of stimulus
  - Sensory conditions
    - Support surface, visual stimuli
  - Cognitive demands
    - Single versus dual task

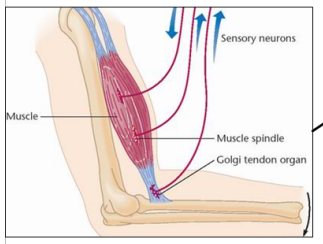
Balance: Multidimensional Construct

Vision



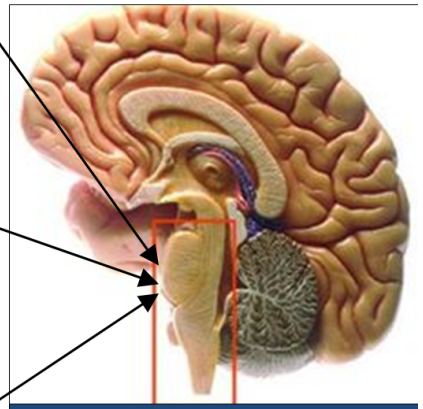
Vestibular System

(inner ear)



Proprioception

(joint & muscle movement receptors)



Vision, vestibular system and proprioceptive inputs converge onto the brainstem

- Sensory Input

Sensory Input: Somatosensory

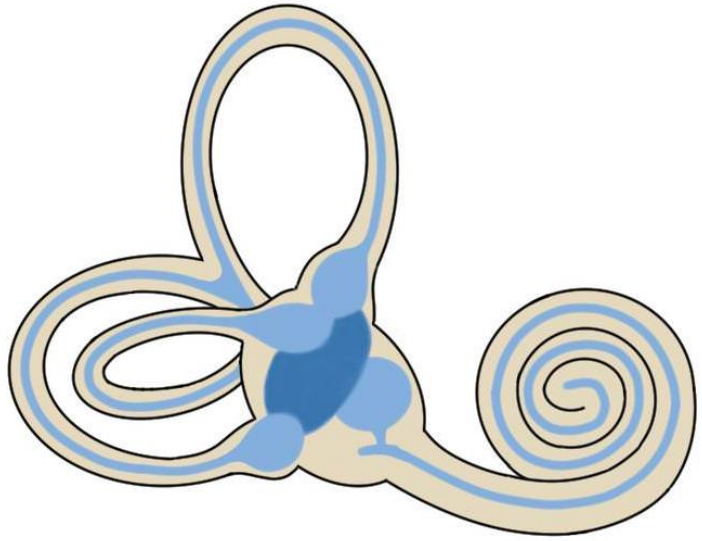
- Fastest sensory nerve conduction velocity
- Modalities contributing to balance perception
  - Pressure
  - Joint position and motion
  - Muscle length
- Test
  - Touch (5.07 monofilament)
  - Vibration (128-Hz tuning fork)
  - Joint position sense
- Primary system when on fixed, firm, predictable surface
  - Train on unstable surfaces- soft, ramp, irregular
- Impairment is significantly correlated with impaired postural control
  - Inability to use ankle strategy

Sensory Input: Visual

- Modalities
  - Focal- conscious awareness, requires light
  - Ambient- peripheral, based on motion
- Test
  - Visual acuity- at least 20/70 with or without correction
  - Peripheral vision
- Primary system used when somatosensation is reduced

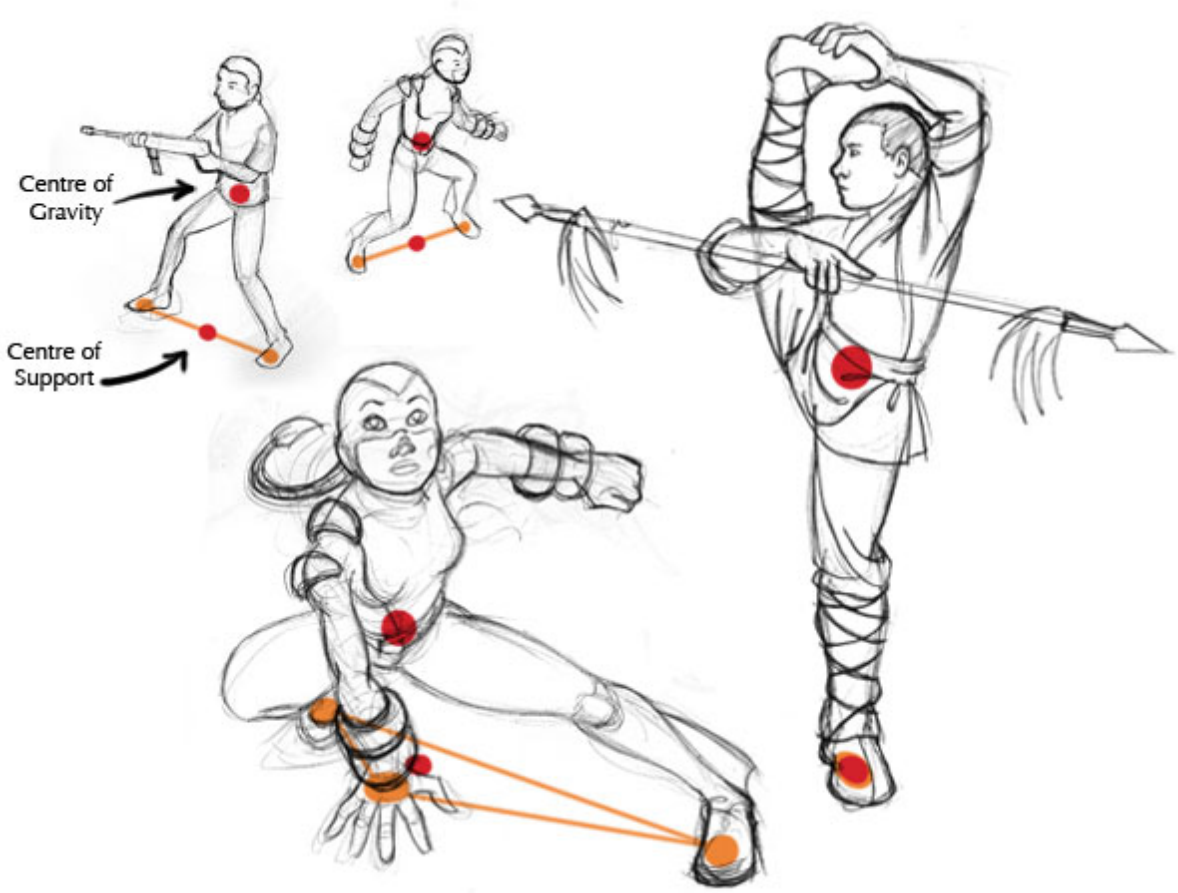
Sensory Input: Vestibular

- Perceives position and angular acceleration of the head
- Test- these can be used as treatment activities
  - Spontaneous nystagmus
  - Gaze hold- track 20-30° lateral, maintain 3 seconds
  - Smooth Pursuit- track target laterally and to 4 quadrants
  - Saccadic Eye Movement- ability to move quickly from on
- Rely on vestibular input when
  - irregular or moving support surface
  - Irregular or moving visual conditions
- Absence of input is correlated with inability to utilize a hip strategy



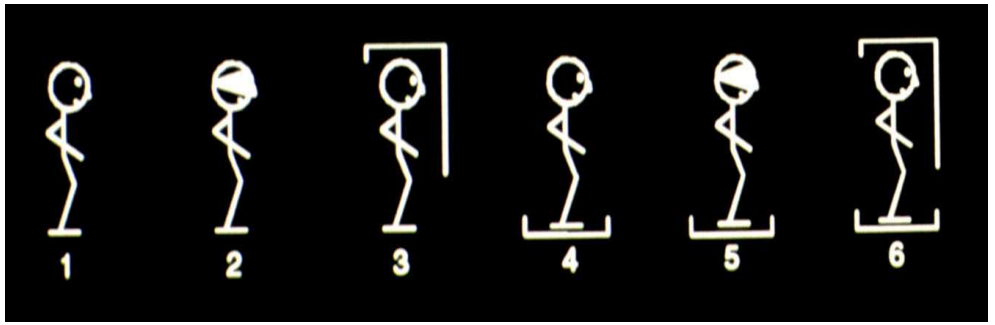
Balance: Multidimensional Construct

- Sensory Organization
  - Sensory weighting
  - Motion perception
    - self and environment
  - Perception of verticality
    - “Pusher Syndrome” after stroke
  - Limits of stability



Sensory Organization: Sensory Weighting

- Test ability to utilize input from 3 sensory systems.
- Standardized test performed in standing.
  4 conditions:
  - Condition 1- eyes open, firm surface
    - Input somatosensory, visual, and vestibular
  - Condition 2- eyes closed, firm surface
    - Input only to somatosensory and vestibular
  - Condition 3- eyes open, soft surface
    - Input to visual and vestibular, but somatosensory altered
  - Condition 4- eyes closed, soft surface
    - Input to vestibular, somatosensory altered



Sensory Organization: Sensory Weighting

EO, firm	EC, firm	EO, soft	EC, soft	interpretation
✔	✗	✗	✗	Unable to select appropriate sensory information to use for balance
✔	✔	✗	✗	Surface dependence- relies on firm, fixed surface
✔	✗	✔	✗	Visual dependence- relies on accurate visual stimuli
✔	✔	✔	✗	Vestibular input not used for balance
✗	✔	✗	✔	Aphysiologic balance

✔= intact ✗ = impaired or absent

Sensory Organization: Sensory Weighting

Interpretation	interventions
Unable to select sensory information	Begin with easy standing exercises on firm surface •Take a long blink •Increase somatosensation through upper extremity support
Surface dependence	• Static and dynamic standing activities on compliant surface • Gait over uneven surfaces, up and down ramps
Visual dependence	• Static and dynamic activities in dimly lit environment or with eyes closed
Vestibular input not used	• Static and dynamic activities with head movement dissociated from trunk movement • Gaze directed at specific visual targets

Sensory Organization: Sensory Weighting

- Sensory weighting tests can be performed with progressively challenging base of support
  - Feet shoulder width
  - Feet together
  - Step stance
  - Partial tandem
  - Tandem
  - Single leg stance

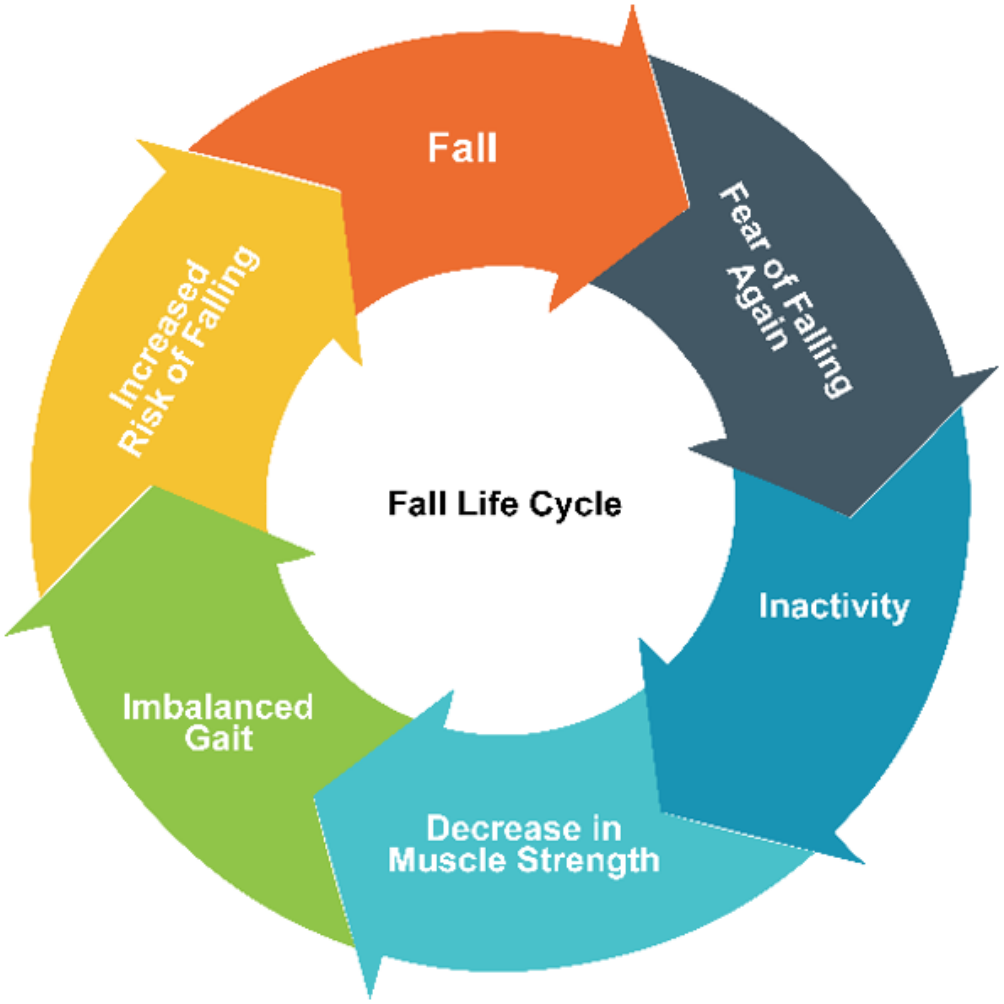
Balance: Multidimensional Construct

- Cognition
  - Dementia
  - Fear of falling
  - Attentional resources
  - Ability to learn
  - Motivation
  - Arousal

Cognition: Ability to Learn

- Two types of learning
  - Procedural- does not require conscious awareness of learning.
    - Motor learning
  - Declarative- requires conscious awareness
    - Individual aware and can express learning (i.e. verbally)
- Dementia or other cognitive impairments
  - Emphasize procedural learning- DO the task!
    - Requires repeated practice
    - Gradually vary training conditions

Cognition: Fear of Falling



- Begin with very low challenge exercises
  - Intended to increase confidence
- Group activities have proven to contribute to increases in confidence
  - Observing others achieving success
  - “Maybe I can do it too.”

Cognition: Attentional Resources

- The ability of the individual to successfully perform a motor task when distracted by a secondary motor task or a cognitive task.
- Single task versus dual task training
  - Single Task-perform only the motor task without external distraction
  - Dual Task
    - Perform simultaneous motor tasks
      - walk while carrying a glass of water
    - Perform motor task and cognitive task simultaneously
      - walk while talking or performing a mathematical calculation

Summary:
Train Multiple Aspects of Balance

- Motor coordination components
  - Alignment
  - Ability to activate and coordinate multiple muscles for reactive and proactive balance control
- Sensory Organization components
  - Ability to maintain, recover or prevent loss of stability under varying sensory conditions
- Cognitive components
  - Ability to maintain stability under multi-task conditions

Fall Prevention: What works?

- Multifactorial risk identification and reduction programs was THE most effective approach.

- Exercise was the most effective single strategy approach to fall prevention.

Rubenstein, 2006
Chang et al, 2004

Updated Clinical Practice Guideline for Prevention of Falls in Older Persons

(America and British Geriatric Societies, 2011)

- Assessment includes:
  - History of fall circumstances
    - Frequency, symptoms, and injuries
  - Checking feet and footwear
    - Traction, stability, support
  - Functional assessment
    - Activities of daily living (ADLs), use of equipment
  - Self-perception of functional ability
    - Fear of falling
  - Environmental and home safety

Balance Training

- What exercises should I do?
  - It depends!... On the individual patient

- There is no single prescription
  - Know the risk factors
  - Knowledge of underlying factors that allow balance
  - Be creative!

QUESTIONS?