

# Pathology Related to Balance



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Thomas Geriatric Symposium:  
Balance and Fall Prevention in the Elderly  
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## Presentation Overview

- Introduction
  - The Big Picture
  - Balance and Aging
- Components Required for Balance
  - Pathologies Affecting Each Component
    - Implications of Pathology
  - Pathologies Affecting Multiple Components
- Additional Factors that Increase Fall Risk
- Implications for Reducing Fall Risk

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## The Big Picture

- Control of Balance and Prevention of Falls
  - Multiple components
  - Multiple sources for increased fall risk
  - Intrinsic and extrinsic factors
- Elderly More at Risk
  - Combined effects
    - Normal aging
    - Accumulated pathologies
    - Medication effects
  - Higher risk for injurious falls



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## Balance and Aging

- Balance Declines with Increased Age<sup>B,A</sup>
  - Reduced balance leads to:
    - Increased fall risk<sup>1,2</sup>
    - Falls increase morbidity<sup>1,2,3</sup>
    - Falls increase mortality<sup>1,2,3</sup>
    - Falls decreased quality of life
    - Falls increased expenses<sup>2,3</sup>
      - health care costs
      - reduced independence
- Role of Health Care Professionals

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## Components Required for Balance

- Many systems contribute to maintaining balance
  - Sensory systems
  - Vestibular system
  - Musculoskeletal system
  - Cardiovascular system

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## Components of Balance: Sensory Systems

- Vision



- Touch



- Proprioception

- location in space



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**Components of Balance:**  
**Sensory Systems (continued)**

■ **Vision**

- Acuity
- Contrast Sensitivity
- Horizon
- Environment
  - Light
  - Dark
- Visual Attention<sup>4</sup>
- Visual Dominance



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**Components of Balance:**  
**Sensory Systems (continued)**

■ **Proprioception**

- Awareness of Body/Limb Position
- Ankle Sway
- Counterbalance
  - head
  - trunk
  - arms



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**Components of Balance:**  
**Sensory Systems (continued)**

■ **Touch**

- Pressure on soles of feet
  - changes in pressure
- Arms/Hands
  - Additional Point of Input
  - Comparisons



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**Components of Balance:**  
**Sensory Systems (continued)**

- **Review**
  - **Sensory systems contribute to maintaining balance**
    - seeing the environment
    - feeling the body's position in the environment
    - feeling the body interacting with the environment
      - hands and or feet
    - Detecting **CHANGES** between body and environment

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**Pathology of the Sensory Systems:**  
**Consequences**

- Reduced visual acuity and/or attention
  - Increases postural instability<sup>5</sup>
  - Self-restricted activity level<sup>6</sup>
    - disuse weakness
  - Increases fall risk<sup>5-7</sup>
- Reduced proprioceptive/touch/pressure input<sup>2</sup>
  - Reduced postural control
  - Increased sway
  - Delayed reaction time to perturbations

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**Pathologies Affecting**  
**Visual Function**

- Cataracts
  - increase postural instability<sup>5</sup>
  - improves following cataract surgery<sup>3</sup>
- Glaucoma<sup>7</sup>
- Macular Degeneration<sup>8</sup>
- Smoking Related Visual Loss<sup>7</sup>
- Medication Effects<sup>7</sup>

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### Pathologies Affecting Proprioceptive Function

- Peripheral Neuropathy
  - nerve compression
  - ischemia (less oxygen)
- Joint/Nerve Damage
  - Sprained ankles
  - Knee/ankle/foot surgery

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### Pathologies Affecting Touch/Pressure Sensation

- Peripheral Neuropathy
- Nerve Damage
  - central
  - peripheral

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### Components of Balance

- Many systems contribute to maintaining balance
  - Sensory systems
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  - Musculoskeletal system
  - Cardiovascular system

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## Components of Balance:

### Vestibular System

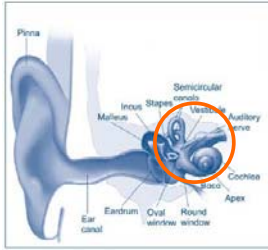


Image adapted from:  
[http://www.healthyeating.com/management/uploads/news/071008\\_atbalance.jpg](http://www.healthyeating.com/management/uploads/news/071008_atbalance.jpg)

- Inner ear
  - fluid filled chamber
  - responds to changes in movement
    - horizontally
    - vertically
    - angular
- Left and Right Vestibular Systems
  - Nervous System
    - communication
    - integration

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## Components of Balance:

### Vestibular System (continued)

#### ■ Vestibular System

- Left and Right Sides
- Interpret **changes** in body movement
  - head turning/nodding
  - body moving through space
    - elevator
    - car/plane
- Reflex connections
  - neck
  - trunk
  - legs

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## Pathology of the Vestibular System: Consequences

- Unilateral Pathology<sup>9</sup>
  - Flawed integration of left and right sides
    - spinning sensation
    - dizziness
    - nausea
    - imbalance
- Bilateral Pathology
  - Rely exclusively on vision/proprioception
  - Initial difficulties with eye control
- Increased Fall Risk<sup>10</sup>

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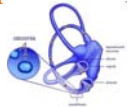
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## Pathologies Affecting the Vestibular System

### ■ Unilateral

- **Benign Positional Vertigo (BPV)**
  - OR Benign Paroxysmal Positional Vertigo (BPPV)
  - Object in the fluid-filled cavity (otoconia)
- **Acoustic Neuromas**
  - Tumor of the support cells of Cranial Nerve VIII
    - Hearing and vestibular function involved
- **Labyrinthitis**
  - Inflammation of the membranous labyrinth
  - Typically viral
  - Elderly
    - May be lack of blood supply
- **Head Trauma**



<http://www.micro-medic-usa.com/products/szytfx/images/bppv1.gif>

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## Components of Balance

- Many systems contribute to maintaining balance
  - Sensory systems
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  - Musculoskeletal system
  - Cardiovascular system

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## Components of Balance: Musculoskeletal System

### ■ Muscles

- Active contraction
  - Hips, knees and/or ankles
  - Timing of contraction
    - Anticipatory
    - Compensatory
- Static balance
  - Maintain a posture
- Dynamic balance
  - Changes during movement



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**Components of Balance:**  
**Musculoskeletal System (continued)**

■ **Bones and Joints**

- **Range of Motion**
  - Amount of joint movement available
  - Hips, knees and/or ankles
- **Allow movement**
  - Slow and/or fast
  - Flexibility
- **Efficient movements**



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**Pathology of the Musculoskeletal System:**  
**Consequences**

- **Reduced range available to respond**
  - ankles, hips, knees
  - alters balance strategies available
- **Reduced strength to respond to changes**
  - alters balance strategies available
  - changes functional task strategies
    - self-restricted activities
    - leads to disuse and further weakness
- **Delayed reaction time**
  - further from stable base before correcting
- **Pain**
  - alters reactions
  - alters balance strategies available
  - self-restricted activities
- **Increased Fall Risk**

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**Pathologies Affecting the Musculoskeletal System**

- **Arthritis**
  - Reduces joint range of motion
    - less flexibility
    - stiff
  - Joint pain
- **Osteoporosis**
  - weak bones
  - fracture **BEFORE** the fall
- **Amyotrophic Lateral Sclerosis (ALS)**
  - loss of nerve supply to the muscle
    - weakness
- **Disuse**
  - **NOT A DISEASE**
    - more sedentary
    - muscle weakness

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## Components of Balance

- Many systems contribute to maintaining balance
  - Sensory systems
  - Vestibular system
  - Musculoskeletal system
  - **Cardiovascular system**

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## Components of Balance: Cardiovascular System

- Adequate blood supply to the brain
  - pumped against gravity in standing
- Adequate blood supply to the arms and legs



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## Pathology of the Cardiovascular System: Consequences

- May not keep brain adequately supplied
  - Changes in position
    - sitting up from laying down
    - sit to stand
  - dizziness
    - unsteady, insecure
  - syncope
    - falls
- Peripheral Supply
  - tissue ischemia distally
  - reduced sensation in feet and ankles

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## Pathologies Affecting the Cardiovascular System

### Postural Hypotension<sup>11</sup>

- Changing positions
  - lying down to sitting OR standing
  - Blood pressure drops
  - Dizzy, light headed, or may pass out
- May be influenced by medications
- Peripheral Vascular Disease
  - Sensory nerves to the feet and ankles
  - Reduced proprioception and pressure sensation

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## Components of Balance

- Many systems contribute to maintaining balance
  - Sensory systems
  - Vestibular system
  - Musculoskeletal system
  - Cardiovascular system
- Many elderly people have more than one system affected

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## Some Pathologies Affect More than One System

- Diabetes<sup>12</sup>
  - Sensory System
    - damages nerves
      - vision (retinopathy)<sup>7</sup>
      - proprioception
      - pressure on the sole of the foot
      - reduces reaction time
  - Musculoskeletal
    - muscle metabolism
    - weakness
  - Cardiovascular
    - peripheral vascular disease
    - stocking-glove sensory loss
      - hands and feet

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## Some Pathologies Affect More than One System (continued)

### ■ Cancer

- Specific to form of cancer
  - Location of the tumor(s)
    - Sensory System
    - Vestibular System
    - Musculoskeletal System
- Cancer Treatment
  - Radiation and/or Chemotherapy
    - Sensory System
    - Musculoskeletal System

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## Some Pathologies Affect More than One System (continued)

### ■ Stroke (Cerebrovascular Accident)

- Typically one side of the body
  - Sensory System
    - vision
      - lose ½ field of vision
      - double vision
    - proprioception
    - touch
  - Musculoskeletal System
    - reduced motor control of arm and leg on affected side
  - Vestibular System
    - Brain Stem location

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## Additional Factors that Increase Fall Risk

### ■ Normal Changes with Aging<sup>2</sup>

- Changes within the proprioceptive receptors
- Fewer touch receptors
- Slowed nerve conduction velocity

### ■ Changes in Cognitive Ability

- Dementia<sup>11,13,14</sup>
  - Alzheimer's Disease
- Age-associated changes<sup>15,16</sup>
- Reduced ability to make safe decisions<sup>13,17</sup>
- May not interpret environment adequately

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## Additional Factors that Increase Fall Risk (continued)

- Taking Multiple Medications
  - 4 or more medications<sup>10</sup>
  - ? interaction OR more systems involved
- Fear of Falling<sup>18-20</sup>
- Footwear<sup>11,21,22</sup>
- Changes in Walking Ability
  - Gait<sup>11,19</sup>
    - Most likely linked to other system changes
      - Sensory
      - Musculoskeletal

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## Implications for Reducing Fall Risk

- Screen to Identify Those at Risk<sup>16</sup>
- Understand the Pathologies
  - Treat to Restore Losses
    - Medication
    - Flexibility/Strength/Endurance Programs
  - Compensate for Impaired Balance Systems
    - Assistive devices (cane, walker)
- Understand Additional Factors
  - Intrinsic and Extrinsic
- Education to Promote Safe Behavior
  - Who?
    - Elderly People
    - Care Providers
  - What?
    - Fall Prevention
    - Home/Community Safety

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## Summary

- Many Body Systems and Factors Influence Balance
- Pathology or One or More Systems May Reduce Balance
- Reduced Balance Increases the Risk for Falls
- Other Factors Also Increase Risk for Falls
- Comprehensive Screening and Intervention Needed
- Further Research is Needed

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## Cited References

1. Lee HKM, Scudds RJ. Comparison of balance in older people with and without visual impairment. *Age And Ageing*. 2003;32(6):643-649.
2. Shaffer SW, Harrison AL. Aging of the somatosensory system: a translational perspective. *Physical Therapy*. 2007;87(2):193-207.
3. Schwartz S, Segal O, Barkana Y, Schwesig R, Avni I, Morad Y. The effect of cataract surgery on postural control. *Investigative Ophthalmology & Visual Science*. 2005;46(3):920-924.
4. Owsley C, McGwin G, Jr. Association between visual attention and mobility in older adults. *Journal Of The American Geriatrics Society*. 2004;52(11):1901-1906.
5. Anand V, Buckley JG, Scally A, Elliott DB. Postural stability changes in the elderly with cataract simulation and refractive blur. *Investigative Ophthalmology & Visual Science*. 2003;44(11):4670-4675.
6. Ray CT, Wolf SL. Review of intrinsic factors related to fall risk in individuals with visual impairments. *Journal of Rehabilitation Research & Development*. 2008;45(8):1117-1124.
7. Pelletier AL, Thomas J, Shaw FR. Vision loss in older persons. *American Family Physician*. 2009;79(11):963-970.
8. Lord SR, Menz HB, Tiedemann A. A physiological profile approach to falls risk assessment and prevention. *Physical Therapy*. 2003;83(3):237-252.
9. Vidal P, Huijbregts P. Dizziness in orthopaedic physical therapy practice: history and physical examination. *Journal of Manual & Manipulative Therapy*. 2005;13(14):221-250.
10. Jacobson GP, McCaslin DL, Grantham SL, Piker EG. Significant vestibular system impairment is common in a cohort of elderly patients referred for assessment of falls risk. *Journal of the American Academy of Audiology*. 2008;19(10):799-807.
11. Lin JT, Lane JM. Falls in the elderly population. *Physical Medicine And Rehabilitation Clinics Of North America*. 2005;16(1):109-128.

## Cited References (continued)

12. Lu F-P, Lin K-P, Kuo H-K. Diabetes and the risk of multi-system aging phenotypes: a systematic review and meta-analysis. *Plos One*. 2009;4(1):e4144-e4144.
13. Vassallo M, Mallela SK, Williams A, Kwan J, Allen S, Sharma JC. Fall risk factors in elderly patients with cognitive impairment on rehabilitation wards. *Geriatrics & Gerontology International*. 2009;9(1):41-46.
14. Das CP, Joseph S. Falls in elderly. *Journal Of The Indian Medical Association*. 2005;103(3):136.
15. Anstey KJ, Wood J, Kerr G, Caldwell H, Lord SR. Different cognitive profiles for single compared with recurrent fallers without dementia. *Neuropsychology*. 2009;23(4):500-508.
16. Shumway-Cook A, Ciol MA, Hoffman J, Dudgeon BJ, Yorkston K, Chan L. Falls in the Medicare population: incidence, associated factors, and impact on health care. *Physical Therapy*. 2009;89(4):324-332.
17. Liu-Ambrose TY, Ashe MC, Graf P, Beattie BL, Khan KM. Increased risk of falling in older community-dwelling women with mild cognitive impairment. *Physical Therapy*. 2008;88(12):1482-1491.
18. Boyd R, Stevens JA. Falls and fear of falling: burden, beliefs and behaviours. *Age And Ageing*. 2009;38(4):423-428.
19. Delbaere K, Stumieks DL, Crombez G, Lord SR. Concern about falls elicits changes in gait parameters in conditions of postural threat in older people. *The Journals Of Gerontology, Series A, Biological Sciences And Medical Sciences*. 2009;64(2):237-242.
20. Deshpande N, Metter EJ, Bandinelli S, Lauretani F, Windham BG, Ferrucci L. Psychological, physical, and sensory correlates of fear of falling and consequent activity restriction in the elderly: the InCHIANTI study. *American Journal of Physical Medicine & Rehabilitation*. 2008;87(5):354-362.
21. Menant JC, Steele JR, Menz HB, Munro BJ, Lord SR. Optimizing footwear for older people at risk of falls. *Journal of Rehabilitation Research & Development*. 2008;45(8):1167-1181.
22. Berry SD, Miller RR. Falls: epidemiology, pathophysiology, and relationship to fracture. *Current Osteoporosis Reports*. 2008;6(4):149-154.