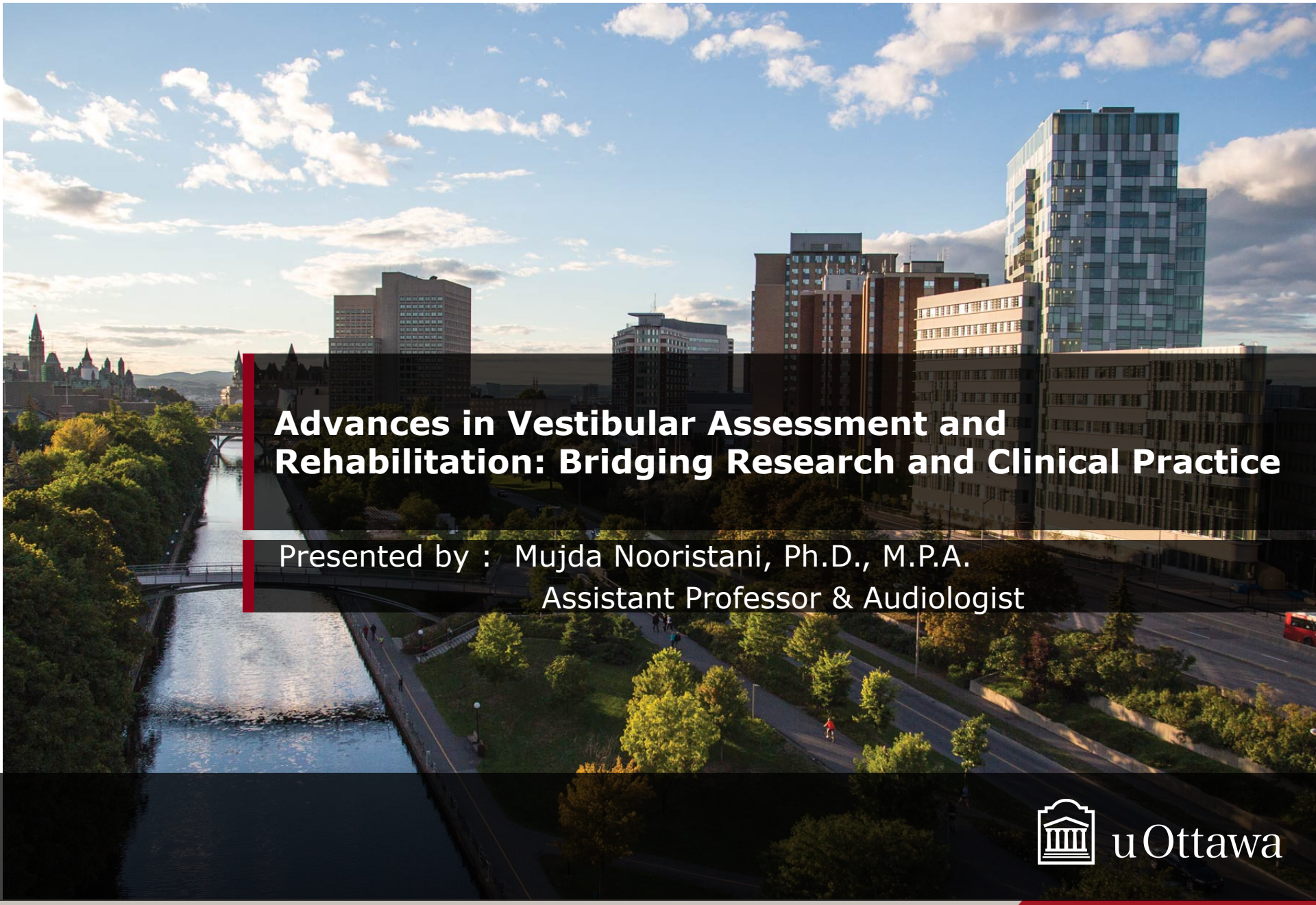


Advances in Vestibular Assessment and Rehabilitation: Bridging Research and Clinical Practice

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Presentation Outline

1. Balance and postural control
    a. Audiologist's role
    b. Vestibular System
2. Clinical assessment of Balance
3. Clinical use of Posturography
4. Interventions & Recommendations

Why Balance Matters ?

- Balance impairments are associated with:
  - Falls → death, loss of independence, increased healthcare utilization and reduced quality life
    - Adults aged 65 years and older are at greatest risk of falls
    - In 2023: 7 997 falls-related deaths in Canada (StatCan, 2025)
    - Hospitalizations : 72, 392 in 2020 (Public Health Canada, 2022)
    - In 2018, cost of falls-related injuries among adults aged of 65 years + : $5.6 billions (Parachute, 2021)

Why Does Balance Matter to Audiologists ?

Why Does Balance Matter to Audiologists ?

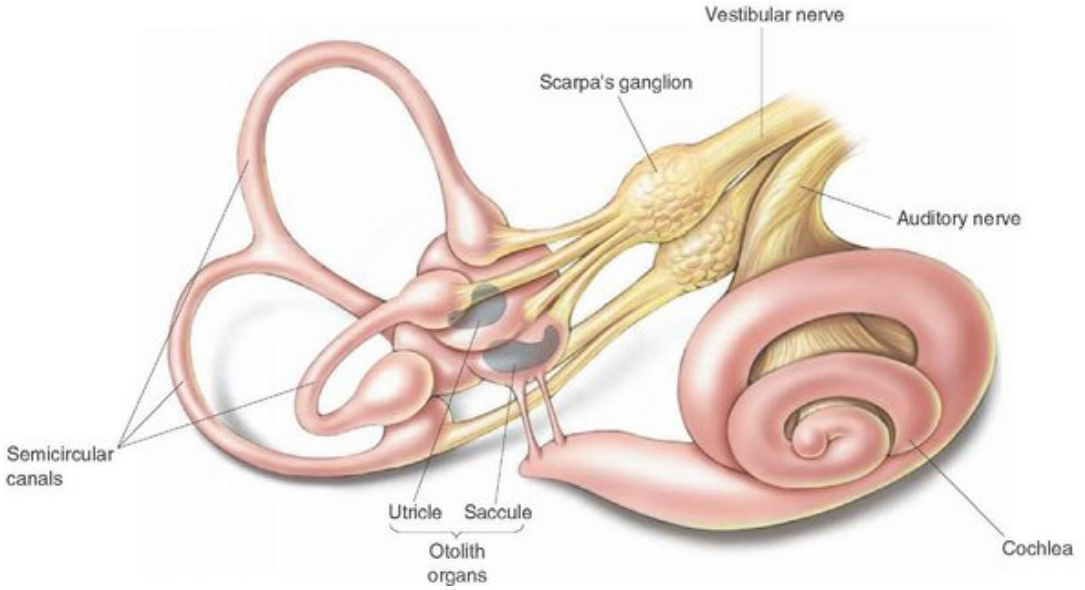
Falls are closely linked to:

- ✓ Aging:
  - Older adults represent a large proportion of our patients
- ✓ Vestibular dysfunction
  - 80% of older adults referred to a falls clinic had a vestibular impairment (Liston et al., 2014)
  - Audiologists have expertise in the vestibular domain
- ✓ Hearing loss
  - 2.39 greater odds of falling (Jiam & Agrawal, 2016)

The Vestibular System

Peripheral system

- Semicircular canals
- Otolith Organs
  - Saccule
  - Utricule
- Vestibular nerve
- Detection of head accelerations



Kingma & Van De Berg, 2016 ; Purves et al., 2015 ; Goldberg et al., 2012 ; Jacobson & Shepard, 2020

Vestibular Functions

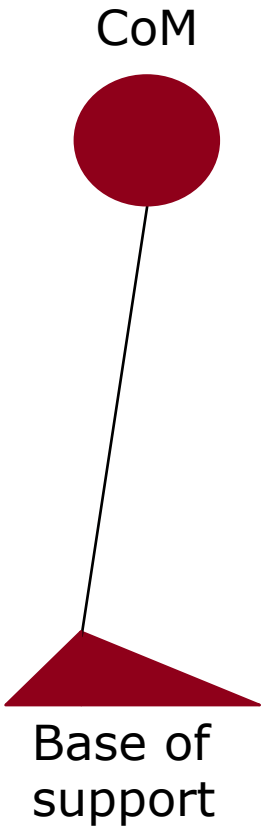
- Vestibular inputs contribute to:
  - Motion perception & Spatial orientation
  - Gaze stabilization → Vestibulo-Ocular reflex (VOR)
  - Postural control → Vestibulo-Spinal Reflex (VSR)

Kingma & Van De Berg, 2016 ; Purves et al., 2015 ; Goldberg et al., 2012 ; Jacobson & Shepard, 2020

Balance and postural control

- Upright standing is associated with continuous body sway
- Inverted pendulum model
  - Pendulum: Center of Mass (CoM)
  - Base of support : lateral, anterior, and posterior edges of the feet
- Detection of body sway by:
  - Visual System
  - Somatosensory System
  - Vestibular System

  ** Auditory input also influences body sway and contribute to motion perception



Winter et al., 1998 ; Forbes et al., 2018 ; Peterka, 2018; Shayman et al., 2020

Clinical Assessment of Balance

I. Case History

II. Hearing assessment

III. Vestibular assessment

IV. Bedside assessment

V. Posturography

Clinical Assessment of Balance
I. Case History

- Fall history
  - Identify individuals at increased risk of falls
  - Location and circumstances of falls
- Fear of falling
- Symptoms (dizziness/vertigo/imbalance)
  - The prevalence of dizziness and vertigo increases with age
  - The term imbalance is increasingly used (Piker & Jacobson, 2014)
- Medical use
  - Use of psychotropic medications
  - Four or more prescribed medications
- Medical conditions
  - Diabetes, hypertension, visual conditions

(Criter & Honaker, 2016 ; Criter & Honaker, 2017)

Clinical Assessment of Balance
I. Validated Self-reported Questionnaires

- Activities-Specific Balance Confidence scale (ABC)
  - Risk of falling <67% (Powell & Myers, 1995)
- Dizziness Handicap Inventory (DHI)

Cognitive Assessment

- Montreal Cognitive Assessment (MoCA)
  - Mild cognitive impairment → Reduced postural stability & 14x higher risk of falls (Chua et al., 2022)

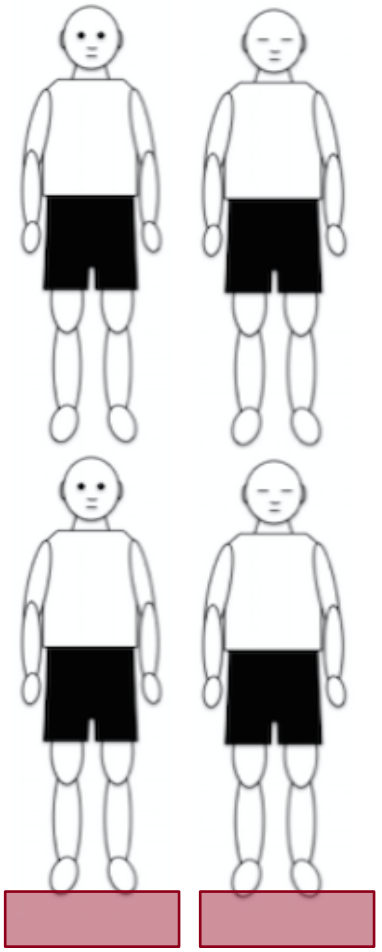
Clinical Assessment of Balance
II. Vestibular assessment

- Video Head Impulse Test (vHIT)
  - Assessment of semicircular canals & VOR
- Cervical-VEMP
  - Saccule & medial vestibulo-spinal pathway
- Ocular-VEMP
  - Utricule & vestibulo-ocular pathway
- Videonystagmography + caloric
  - Central vs peripheral origins
- Benign Paroxysmal Positional Vertigo (BPPV) assessment

Clinical Assessment of Balance
III. Bedside Assessment

Modified Clinical Test of Sensory Interaction on Balance

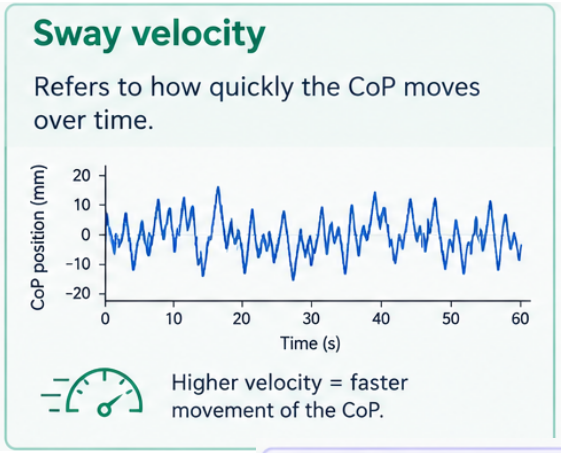
- Ability to maintain postural control during four conditions (Cohen et al., 1993)
  - Condition 1: Vision, Somatosensory, Vestibular
  - Condition 2: Somatosensory & Vestibular
  - Condition 3: Vision & Vestibular
  - Condition 4: Vestibular
- Condition 4: sensitivity of 95% and specificity of 90% in patients with complaints of dizziness and imbalance (Weber & Cass, 1993)

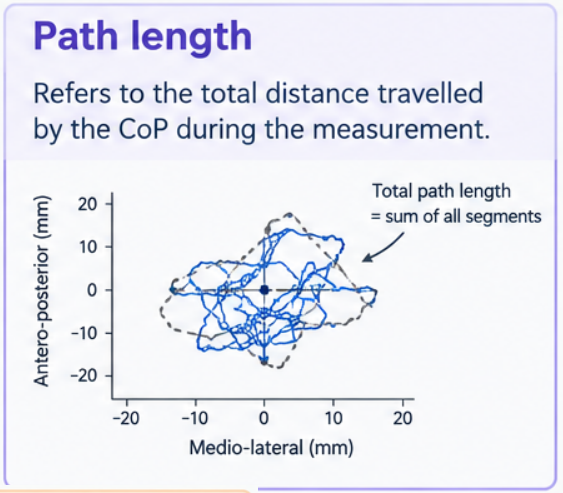


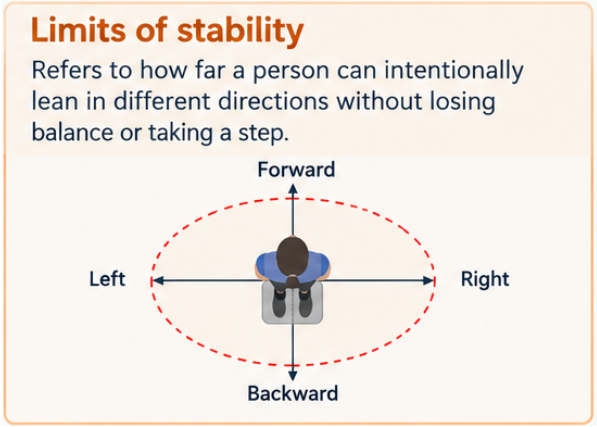
Clinical Assessment of Balance
IV. Posturography

- Force platform → assess changes in postural sway by recording the ground-reaction forces projected from the body
- Center-of-pressure (CoP)
  - Reflects trajectory of CoM
- Parameters derived from CoP data:
  - Sway velocity, amplitude, area, path length, limits of stability
  - Age norms

Palmieri et al., 2002



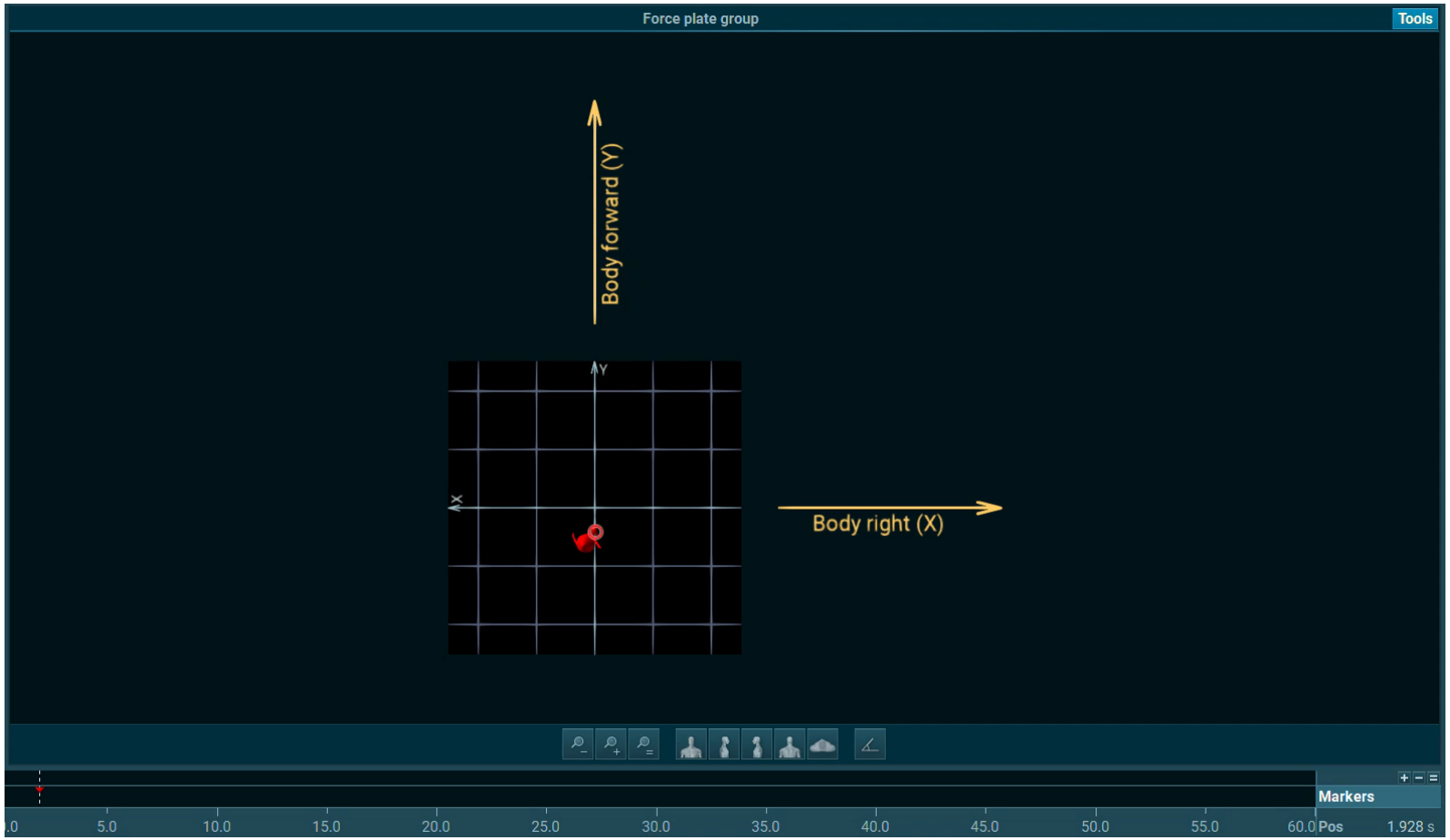




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Clinical Assessment of Balance

IV. Posturography



IV. Posturography

- Assess of contribution of sensory signals to upright balance
  - With/without visual input
  - Moving visual surround with virtual reality headset
  - Foam
  - Auditory signals
- Functional Assessment
  - Objectifying patient's symptoms of instability
- Rehabilitation monitoring
- Counseling tool

IV. Clinical application of posturography

Can Posturography Identify Older Adults at Risk of Falling?

- Current clinical tools present important limitations
- Objective tools are needed → Posturography

Posturography & Falls

- Systematic Review & Meta-Analysis (Quijoux et al., 2020)
- Objective:
  - Identify the most useful posturographic markers of fall risk in older adults
- Methods:
  - 4000 records screened
  - 44 studies included
  - 7,176 older adults

Posturography & Falls

Key Findings (Quijoux et al., 2020)

- Best Fall-Risk Markers to distinguish between a non-faller vs faller:
  - Antero-posterior mean velocity
  - Sway area per unit time
  - Radial mean velocity
- Protocol:
  - Eyes open & close
  - Longer durations of measurement
  - Repetitive trials

Posturography & Falls

Clinical Implications (Quijoux et al., 2020)

- Identifying individuals at high risk of falls
- Monitor changes over time
- Complement clinical assessment

Clinical application of posturography

- Persistent Postural-Perceptual Dizziness (PPPD)
  - Chronic functional vestibular disorder
  - Symptoms persist ≥ 3 months
  - Worse with:
    - Upright posture
    - Active or passive motion
    - Complex visual environments
- Symptoms based diagnosis
  - Formal diagnosis: 5.7 months (0-13 months)
  - Duration of PPPD symptoms: 79.5 months (8-300 months)
- No objective biomarker

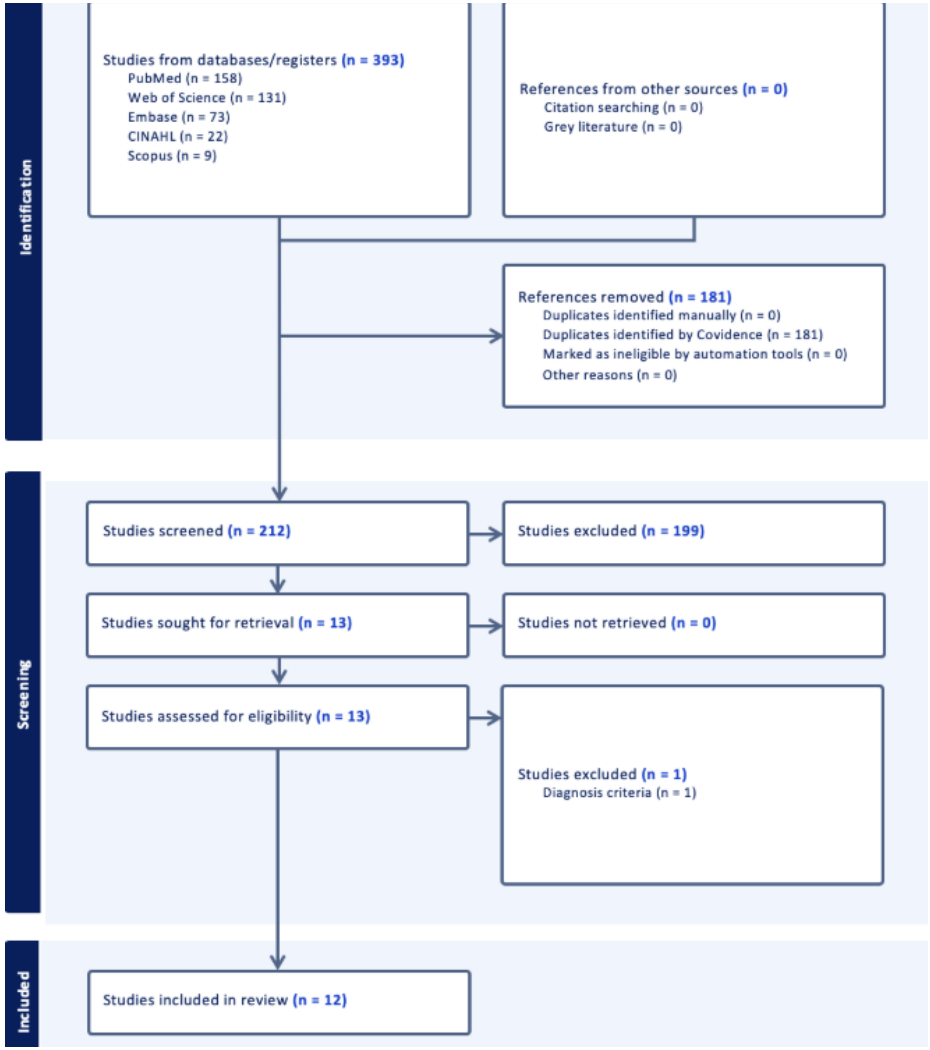
Staab (2023); Trinidade et al. (2021)

Postural control Alterations in PPPD: A Scoping review

Al Musawi & Nooristani (2026)
Under revision

- **Objective:** To map the evidence on static postural control in PPPD

Postural control Alterations in PPPD: A Scoping review



Methods

- 5 databases searched
- 392 records identified
- 12 studies included
  - Published between 2019-2026

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Postural control Alterations in PPPD: A Scoping review

Main findings

- PPPD vs Healthy Controls (n = 12)
  - CoP metrics: sway area, sway velocity & path length
  - Increased CoP sway in individuals with PPPD
  - Greater instability during sensory challenges
    - Altered visual input
    - Vestibular perturbations
- PPPD vs Other Conditions (n = 3)
  - No consistent pattern across studies
  - Visual stimulation could be promising

Postural control Alterations in PPPD: A Scoping review

Clinical Implications

- Posturography appears sensitive to detect alterations in postural control in PPPD
- Lack specificity
- Counseling Tool
  - Perceived vs Actual Postural Sway
  - Patients with PPPD perceived approximately twice as much body sway as was objectively measured (San Pedro Murillo et al., 2023)

Postural control Alterations in PPPD: A Scoping review

Future Directions

- Standardized posturography protocols
- Ecologically valid visual environments with virtual reality
- Auditory contribution to postural control
  - Broader sensory processing vulnerabilities across multiple modalities → touch, smell, and hearing (Powell et al., 2020)
  - Symptoms exacerbation in acoustically complex and sound rich environments (VeDA, 2025)

Interventions & Recommendations

- Explanation of test results to patients
- Counseling
  - Fall risk
  - Consequences
- Hearing aids (Lin & Ferrucci, 2012 ; Viljanen et al., 2009)
  - Effects of hearing loss on postural stability
  - Improvement of stability (Rumalla et al., 2015 ; Vitkovic et al., 2016 ; Negahban et al., 2017 ; Maheu et al., 2019)
  - Follow-up and adjustments to improve spatial hearing

Sakumura & Gans, 2023

Interventions & Recommendations

- BPPV repositioning maneuvres (Ganaca et al., 2010)
  - Reduction in the number of falls
  - Improved quality of life
- Vestibular rehabilitation (Jacobson & Shepard, 2020)
  - Effective in reducing dizziness and falls
  - Improved quality of life & daily functioning
  - Improving gaze stabilization
  - Improving postural control
- Muscle strengthening (Sakumura & Gans, 2023)
- Tai Chi (WHO, 2021)

Conclusion

- Audiologist play an important role in balance assessment & fall prevention
- Vestibular assessment continues to evolve
- Posturography is an interesting clinical tool
  - Assessment of balance
  - Objectifying subjective symptoms
  - Identifying patients at risk of falling
  - Rehabilitation monitoring
- Auditory contribution needs be further examined

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