



**Vanderbilt Bill Wilkerson Center for Otolaryngology  
and Communication Sciences**

# **The Assessment of Falls Risk in the Elderly**

**Gary P. Jacobson, Ph.D.  
Vanderbilt Bill Wilkerson  
Center**

# Risk of Falls in the Elderly

**HEALTH & FITNESS**



**Falls present a significant threat to senior citizens**

BY RENÉE SKOGLUND  
STAFF WRITER  
rskoglund@oe.homecomm.net

sustain a hip fracture from a fall will die within a year; another 20 percent will be moved to an inpatient long-term care center, and of

Disease, osteoporosis and depression to balance impairment, vision problems and the cumulative effect of multiple medications

Gary P. Jacobson

## Buzz in shoes may help seniors stay on their feet

By EMMA ROSS  
Associated Press

**LONDON** — A buzz in the soles may keep elderly people on their toes and reduce the risk of debilitating falls, preliminary research suggests.

The experiment, outlined this week in *The Lancet* medical journal, found that elderly people showed signs of better balance when they stood on a pair of battery-operated, randomly vibrating insoles.

Although users are not conscious of the subtle buzz, the idea is that the vibrations amplify balance-related signals between the feet and the brain that become dulled with age or

illness.

Experts said the research shows promise but scientists need to see if the technique improves balance when people walk, turn or reach, which is when they are most vulnerable to a fall.

When a person leans or sways to one side, the pressure on the sole of that side increases.

Normally, the nervous system senses the change in pressure and sends a message to the brain so the posture can be adjusted.

However, those messages can be blunted by age, stroke or conditions such as diabetes.

"I think the vibrating insole

holds promise and is definitely worth studying," said Dr. Mary Tinetti, chief of geriatrics at Yale University School of Medicine, who was not connected with the study.

The research, funded by the U.S. National Institutes of Health, was conducted by scientists at Boston University and Harvard Medical School.

They recruited 27 healthy volunteers — 15 people in their 20s and 12 elderly people — to stand on the gel-based insoles, which were placed on the floor for the experiment.

The volunteers were told to keep their eyes closed and their arms by their sides. The insoles

were connected to a large battery pack and each was implanted with three small vibrating discs.

The intensity of vibration was set individually so that it was just below the threshold that could be felt. The scientists conducted before and after tests on various tasks involved in balance control.

The young volunteers showed some improvement with the vibrating insoles, but the elderly people showed more improvement, said James Collins, a professor of biomedical engineering at Boston University who directed the project.

"The improvements we are

seeing in the elderly — that is, we move them down to, or close to, the level in the young — we view as being very positive and suggestive that this technology may in fact be able to improve elderly balance to the point where we could significantly reduce the risk of falls," Collins said.

Collins plans to test the insoles in studies that involve walking and turning.

Providing those work out, the biggest challenge will be to design a practical pair of shoes, or insoles that can be worn inside any pair of shoes, Collins said.

No such insoles are currently commercially available. ■



**Vanderbilt Bill Wilkerson Center**

# S. 1531 - “Keeping Senior Safe From Falls Act of 2005”

II

109TH CONGRESS  
1ST SESSION

## S. 1531

To direct the Secretary of Health and Human Services to expand and intensify programs with respect to research and related activities concerning elder falls.

---

IN THE SENATE OF THE UNITED STATES

JULY 28, 2005

Mr. ENZI (for himself, Ms. MIKULSKI, Mr. COCHRAN, Mr. BAUCUS, Mr. GRASSLEY, Mrs. MURRAY, and Mrs. DOLE) introduced the following bill, which was read twice and referred to the Committee on Health, Education, Labor, and Pensions

---

### A BILL

To direct the Secretary of Health and Human Services to expand and intensify programs with respect to research and related activities concerning elder falls.

1 *Be it enacted by the Senate and House of Representa-*  
2 *tives of the United States of America in Congress assembled,*

3 **SECTION 1. SHORT TITLE.**

4 This Act may be cited as the “Keeping Seniors Safe  
5 From Falls Act of 2005”.

6 **SEC. 2. FINDINGS.**

7 Congress finds the following:



Vanderbilt Bill Wilkerson Center

# S. 1531 - “Keeping Senior Safe From Falls Act of 2005”

- Develop effective public education strategies...to reduce falls among older adults
- Conduct research to determine the most effective approaches to preventing and treating falls among older adults
- Require the Secretary to elevate the effect of falls on health care costs, the potential for reducing falls, and the most effective strategies for reducing health care costs associated with falls



# S. 1531 - “Keeping Senior Safe From Falls Act of 2005”

1 Secretary in conducting the review under paragraph  
2 (1).

3 “(f) AUTHORIZATION OF APPROPRIATIONS.—In  
4 order to carry out this section, there are authorized to be  
5 appropriated—

6 “(1) to carry out the national public education  
7 provisions described in subsection (b)(1), \$3,000,000  
8 for each of fiscal years 2007 through 2009;

9 “(2) to carry out the State public education  
10 campaign provisions of subsection (b)(2),  
11 \$5,000,000 for each of fiscal years 2007 through  
12 2009;

13 “(3) to carry out research projects described in  
14 subsection (c), \$8,000,000 for each of fiscal years  
15 2007 through 2009;

16 “(4) to carry out the demonstration projects de-  
17 scribed in subsection (d)(1), \$4,000,000 for each of  
18 fiscal years 2007 through 2009; and

19 “(5) to carry out the demonstration and re-  
20 search projects described in subsection (d)(2),  
21 \$5,000,000 for each of fiscal years 2007 through  
22 2009.”.



Copyrighted Material

# FALLS in older people

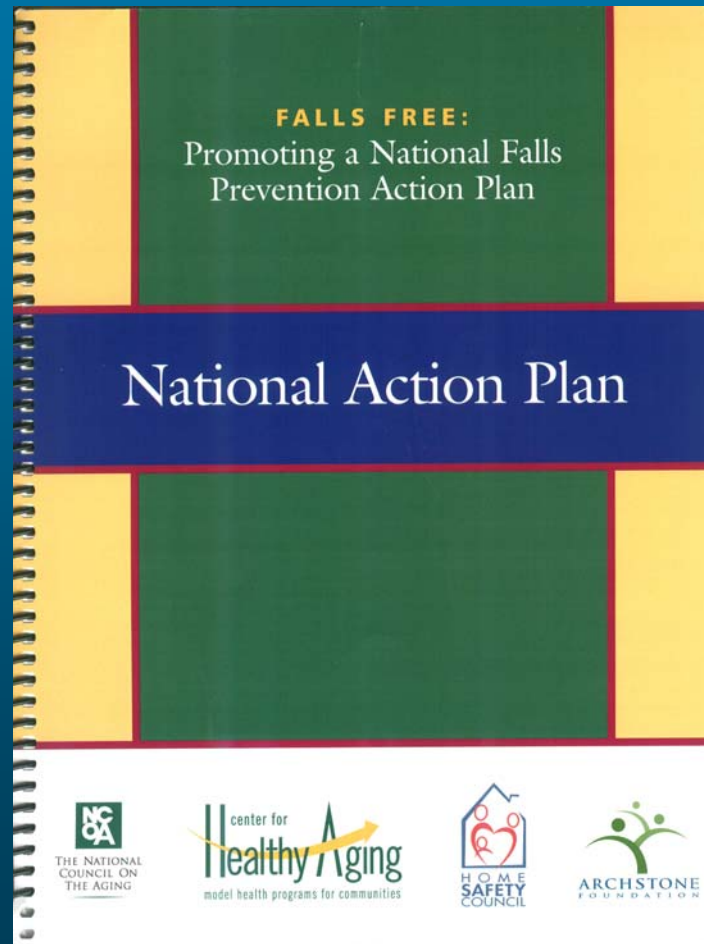
Risk factors and  
strategies for prevention

Stephen R. Lord  
Catherine Sherrington  
Hylton B. Menz



**Vanderbilt Bill Wilkerson Center**

# Falls Free Coalition



**Vanderbilt Bill Wilkerson Center**

# Falls Free Coalition

## I. Executive Summary

Falls and fall-related injuries impose an enormous burden on individuals, society, and the nation's health care systems. And as the population of the United States ages, the negative impact of falls continues to increase. Yet many falls, and fall-related injuries, can be prevented with existing knowledge and technology.

In response to escalating concerns related to falls and fall-related injuries among the aging population, and to address the challenges and barriers related to a national falls prevention initiative, *The National Council on the Aging* (NCOA), with support from the *Archstone Foundation* and the *Home Safety Council*, is spearheading an initiative entitled *Falls Free: Promoting a National Falls Prevention Action Plan*.

The overarching vision and goal statements for this initiative are:

Vision: Older adults will have fewer falls and fall-related injuries, maximizing their independence and quality of life.

Goal: To launch a *National Action Plan* with specific goals and strategies to effect sustained initiatives that reduce falls among older adults.

Evidence strongly suggests that falls result from multiple factors that can be both intrinsic to the individual, and within the environment. While recognizing that falls prevention requires integrated assessment and management of the full range of causative factors, this plan is organized around four primary risk factors, as well as issues that cut across multiple concerns (cross-cutting issues).

The involvement and collaboration of multiple and diverse groups including, but not limited to, consumers, health care providers, policy makers, aging services professionals, representatives of building and construction industries, and community health professionals will be required in order to successfully implement this plan.

Thirty-six strategies are proposed, based on input from the *Falls Free Summit* participants. The strategies are organized under goals within each risk factor. It is important to note that the strategies and action steps are not prioritized in this document.





# Falls Free Coalition

Elvy Iekowicz  
**American Geriatrics Society**  
The Empire State Building  
350 Fifth Avenue, Suite 801  
New York, NY 10118  
Phone: 212-308-1414, ext. 320  
Fax: 212-832-8646  
Email: [eickowicz@americangeriatrics.org](mailto:eickowicz@americangeriatrics.org)

Gary P. Jacobson, Ph.D.  
**American Academy of Audiology**  
Vanderbilt Bill Wilkerson Center  
1114 19<sup>th</sup> Avenue, South  
Nashville, TN 37212-2197  
Phone: 615-322-4568  
Fax: 615-343-0872  
Email: [gary.jacobson@vanderbilt.edu](mailto:gary.jacobson@vanderbilt.edu)

Gavin Kennedy, M.S.  
**US Department of Health & Human Services,  
Office of the Assistant Secretary for Planning and  
Evaluation (ASPE)**  
200 Independence Avenue, 405F  
Washington, D.C. 20201  
Phone: 202-690-6443  
Fax: 202-401-7733  
Email: [gavin.kennedy@hhs.gov](mailto:gavin.kennedy@hhs.gov)

Gary Kodaseet  
**National Indian Council on Aging**  
10501 Montgomery Blvd. NE, Suite 210  
Albuquerque, NM 87111  
Phone: 505-292-2001  
Fax: 505-292-1922  
Email: [gary@nicoa.org](mailto:gary@nicoa.org)

Carol Kratz, M.P.A.  
**Virginia G. Piper Charitable Trust**  
6720 North Scottsdale Road, Suite 350  
Scottsdale, AZ 85253  
Phone: 480-556-7123  
Fax: 480-348-1316  
Email: [ckratz@pipertrust.org](mailto:ckratz@pipertrust.org)

Pauline Lapin, M.H.S.  
**Centers for Medicare & Medicaid Services**  
7500 Security Blvd.  
Room S3-06-24, Mail Stop S3-02-01  
Baltimore, MD 21244-1850  
Phone: 410-786-6883  
Fax: 410-786-4005  
Email: [Pauline.lapin@cms.hhs.gov](mailto:Pauline.lapin@cms.hhs.gov)

Greg Link  
**National Association of State Units on Aging**  
1201 15th Street, NW, Suite 350  
Washington, D.C. 20005  
Phone: 202-898-2578, x134  
Fax: 202-898-2583  
Email: [glink@nasua.org](mailto:glink@nasua.org)

Lorna Lynn, M.D.  
**American Board of Internal Medicine**  
510 Walnut Street, Suite 1700  
Philadelphia, PA 19106  
Phone: 215-446-3465  
Fax: 215-446-3473  
Email: [llynn@abim.org](mailto:llynn@abim.org)

Pamela Macfarlane, Ph.D.  
**American Association for Active Lifestyles  
and Fitness**  
1525 Rogers Court  
DeKalb, IL 60115  
Phone: 815-753-3909  
Fax: 815-753-1413  
Email: [PMacfarl@niu.edu](mailto:PMacfarl@niu.edu)

William Marton, Ph.D.  
**US Department of Health & Human Services,  
Office of the Assistant Secretary for Planning  
& Evaluation (ASPE)**  
200 Independence Avenue, 405F  
Washington, D.C. 20201  
Phone: 202-690-6443  
Fax: 202-401-7733  
Email: [William.marton@hhs.gov](mailto:William.marton@hhs.gov)



**Vanderbilt Bill Wilkerson Center**

# American Geriatrics Society Lauds "Welcome" Proposals for Preventive Services Under Medicare

- “The AGS is excited that the proposed benefit includes several of the components of a geriatric assessment...” (including)
- ...review of the individual's functional ability...
- ...level of safety, including factors e.g....
  - hearing impairment
  - activities of daily living,
  - **falls risk and home safety** based on the use of an "appropriate screening instrument" as determined by the physician or other qualified provider.



# Epidemiology of Falls in the Elderly: How Big is the Problem?

- 30% to 50% of patients over age 65 yrs will fall next year (~ 7 million falls annually)
  - 33% of falls will occur at home
  - 45-70% of falls will occur in nursing homes

Coogler, C.E. (1992)



# Epidemiology of Falls in the Elderly: How Big is the Problem?

- 10% of those who fall will fall again
  - 50% of these patients will die within the next year



# Epidemiology of Falls in the Elderly: How Big is the Problem?

- Of those elderly who fall, 5% will sustain a hip fracture
  - 20% of patients will die within the next year
  - 20% of patients will be moved to a nursing home for the first time

American Academy of Orthopedic Surgeons  
(1998)



# Epidemiology of Falls in the Elderly: How Big is the Problem?

- 350,000 hip fractures were predicted in 2000
- Cost of repairing hip fractures.
  - \$35,000 per patient.

American Academy of Orthopedic Surgeons  
(1998)

Nyburg et al. (1996)



# Epidemiology of Falls in the Elderly: How Big is the Problem?

- Cost of caring for elderly who fall in the United States is est. to be:
  - \$20.2 billion/year
- Falls are associated with significant **morbidity** and **mortality** and **expense** to our health care system



# Goals of the Risk of Falls Assessment Clinic

- To prevent potentially injurious falls.
- To identify elderly at greatest risk for falling through an assessment of factors known to be associated with highest risk
- To provide recommendations to the referring physician for decreasing the risk of falls





# Sources of Postural Instability in the Elderly

**Distorted or undistorted**

**Vision**

**Proprioception**

**Vestibular**

**Distorted or undistorted**

**Central processor for sensory inputs and formulator of motor commands for eye movements and via spinal cord for postural changes**

**Distorted or undistorted**

**Nerves and muscles in the eye movement system**

**Nerves and muscles for postural control**



# Sources of Postural Instability in the Elderly

<b>Distorted or undistorted</b>	<b>Distorted or undistorted</b>	<b>Distorted or undistorted</b>
<b>Vision</b>	<b>Central processor for sensory inputs and formulator of motor commands for eye movements and via spinal cord for postural changes</b>	<b>Nerves and muscles in the eye movement system</b>
<b>Proprioception</b>		<b>Nerves and muscles for postural control</b>
<b>Vestibular</b>		

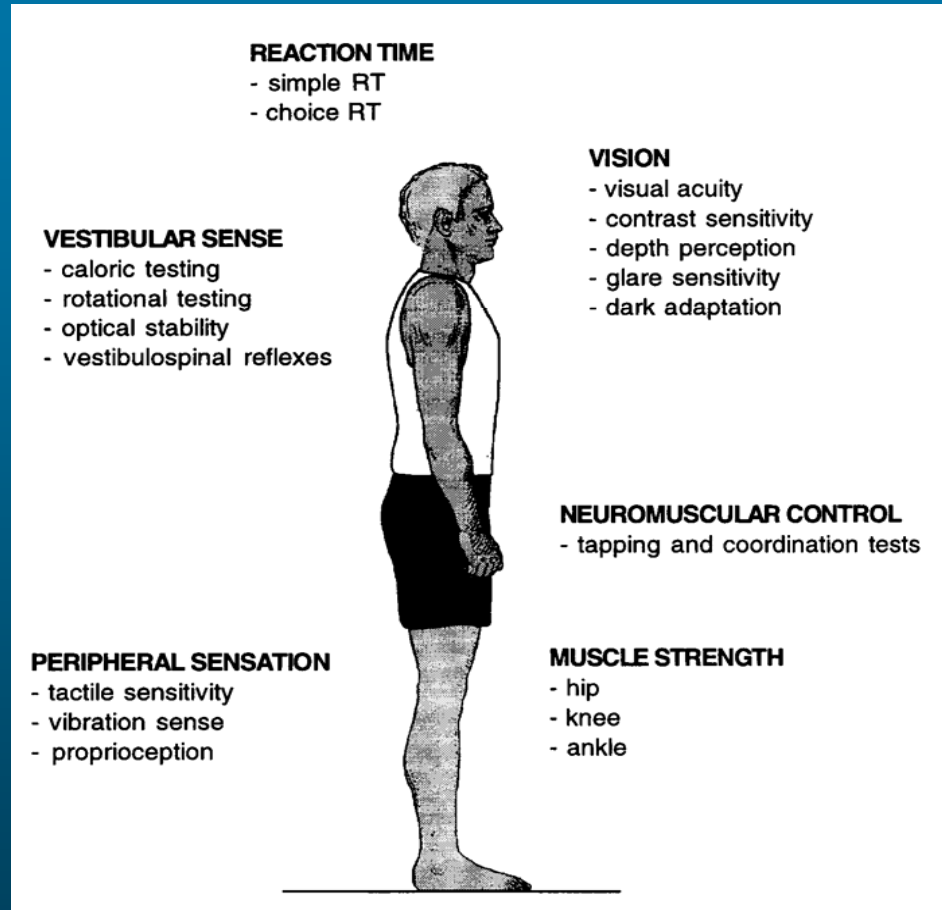


# Sources of Postural Instability in the Elderly

<b>Distorted or undistorted</b>	<b>Distorted or undistorted</b>	<b>Distorted or undistorted</b>
<b>Vision</b>	<b>Central processor for sensory inputs and formulator of motor commands for eye movements and via spinal cord for postural changes</b>	<b>Nerves and muscles in the eye movement system</b>
<b>Proprioception</b>		<b>Nerves and muscles for postural control</b>
<b>Vestibular</b>		



# Complexity of the Problem



# Assessment of Falls Risk (3 hours)

- Focused history
- Cognitive function
- Depression
- Reaction time
- Postural hypotension
- Postural stability
- Gait
- Vestibular function
- Visual function
- Somesthesia (e.g. proprioception, vibration sense)



# Focused History



Vanderbilt Bill Wilkerson Center

# Focused History

- History of major illnesses
- Medication history
- History of gait problems or weakness
- History of dizziness/LOC
- History of previous falls
- Environmental risks



# Risk Factors Associated with Falls in the Elderly (endogenous)

- **Prescription medications** (Tinetti et al., 1988; Richardson, 2002)
  - e.g. minor tranquilizers (increase comfort but reduce vigilance).
  - In a recent study of risk factors, **age** and **prescription medications** were found to be strong predictors of falls.





# Risk factors associated with falls in the elderly (endogenous)

- **Diseases:** e.g. Parkinson's d., osteoporosis, cardiac disease (arrhythmias, atherosclerotic d.), diabetes, cerebrovascular diseases including stroke.
- **General risk factors:** impaired somesthesia (e.g. proprioception), vision, & balance function, postural hypotension, use of anxiolytic or sedative meds., **use of 4 or more prescription meds.**



# **Risk factors associated with falls in the elderly (exogenous)**

**Environmental factors including:** poor lighting, loose rugs, power cords, unstable furniture, stairs with poor railings or poorly visualized edges, low beds and toilets.



# Cognitive Function



Vanderbilt Bill Wilkerson Center

# Assessment of Cognitive Function

(Odds ratios = 1.4-3.5)

- **Mini-mental Status Examination (MMSE)- Folstein et al., 1975)**
  - 11 sections, total score = 30 pts,  $\leq$  23 pts = abnormal



# Effect of Decreased Cognitive Function

- Dementia affects 6-10% of community-dwelling elderly
- Demented elderly are 3X more likely to die within 6 mos. of hip fractures than non-demented elderly
- Demented patients are less aware of their environment (e.g. environmental hazards)



# Mini-mental Status Examination- Folstein et al. 1975

Folstein Mental Status Examination			
Task	Instructions	Scoring	
Date Orientation	"Tell me the date?" Ask for omitted items.	One point each for year, season, date, day of week, and month	5
Place Orientation	"Where are you?" Ask for omitted items.	One point each for state, county, town, building, and floor or room	5
Register 3 Objects	Name three objects slowly and clearly. Ask the patient to repeat them.	One point for each item correctly repeated	3
Serial Sevens	Ask the patient to count backwards from 100 by 7. Stop after five answers. (Or ask them to spell "world" backwards.)	One point for each correct answer (or letter)	5
Recall 3 Objects	Ask the patient to recall the objects mentioned above.	One point for each item correctly remembered	3
Naming	Point to your watch and ask the patient "what is this?" Repeat with a pencil.	One point for each correct answer	2
Repeating a Phrase	Ask the patient to say "no ifs, ands, or buts."	One point if successful on first try	1
Verbal Commands	Give the patient a plain piece of paper and say "Take this paper in your right hand, fold it in half, and put it on the floor."	One point for each correct action	3
Written Commands	Show the patient a piece of paper with "CLOSE YOUR EYES" printed on it.	One point if the patient's eyes close	1
Writing	Ask the patient to write a sentence.	One point if sentence has a subject, a verb, and makes sense	1
Drawing	Ask the patient to copy a pair of intersecting pentagons onto a piece of paper.	One point if the figure has ten corners and two intersecting lines	1
<b>Scoring</b>	A score of 24 or above is considered normal.		<b>30</b>



# Depression



Vanderbilt Bill Wilkerson Center

# Effects of Depression

- Clinical depression is associated with:
  - use of antidepressant meds (**risk factor**)
  - lower levels of physical activity (deconditioning) resulting in reduced strength, coordination and balance (**risk factor**)
  - altered gait patterns (**risk factor**)





# Assessment of Depression

(Odds ratios for meds to treat depression = 1.4-7.5)

- **Geriatric Depression Scale- GDS**  
(Yesavage et al. 1983)
  - 30 items answered in “yes” and “no” format
  - Cut-off score of 11 pts.
    - Yields 84% sensitivity and 95% specificity



# Sample Items

## Geriatric Depression Scale

(Yesavage et al. 1983)

### Mood Assessment Scale (Geriatric Depression Scale - Yesavage et al. 1983)

1. Are you basically satisfied with your life ?	Yes	No
2. Have you dropped many of your activities and interests?	Yes	No
3. Do you feel that your life is empty?	Yes	No
4. Do you often get bored?	Yes	No
5. Are you hopeful about the future?	Yes	No
6. Are you bothered by thoughts you can't get out of your head?	Yes	No
7. Are you in good spirits most of the time?	Yes	No
8. Are you afraid that something bad is going to happen to you?	Yes	No
9. Do you feel happy most of the time ?	Yes	No
10. Do you often feel helpless ?	Yes	No



# Reaction Time



Vanderbilt Bill Wilkerson Center

# Effect of Increased Reaction Times

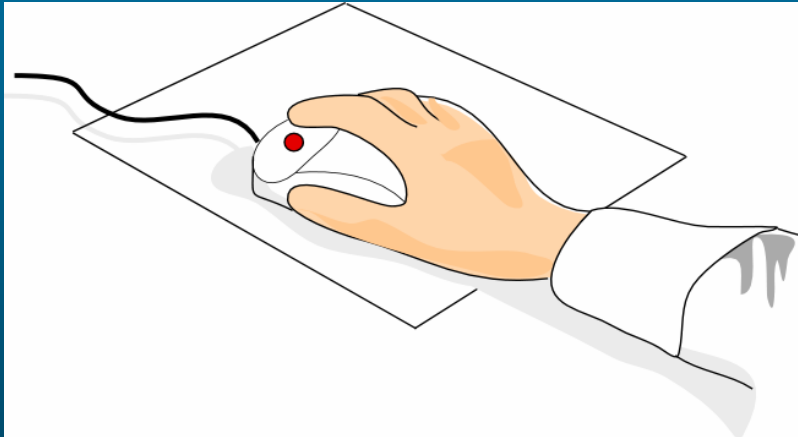
- Reaction time
  - Independent risk factor for falls
  - Fallers show longer simple and choice RTs than non-fallers
  - Increased RTs are associated with delayed responses to changes in postural stability & increased body sway with eyes closed on a compliant surface (Lord et al. 1991)



# Reaction Times (upper)



# Assessment of Reaction Time (msec) Hand



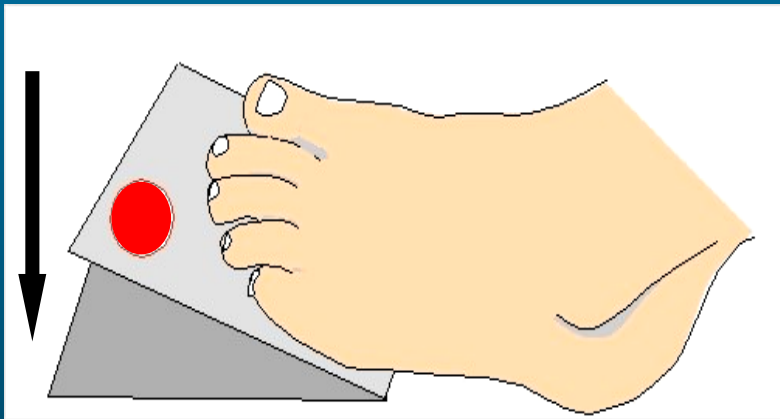
- Hand
  - Excellent = < 200 msec
  - Good = 200-250 msec
  - Fair = 250-300
  - Poor = 300 + msec



# Reaction Times (lower)



# Assessment of Reaction Time (msec) Foot



- **Foot**
  - Excellent =
    - < 250 msec
  - Good = 250-300 msec
  - Fair = 300-350
  - Poor = 350+ msec





# Orthostatic Hypotension



Vanderbilt Bill Wilkerson Center

# Postural Hypotension



# Assessment of Orthostatic Hypotension

(Odds ratio = 1.3)

- Defined as decrease in systolic blood pressure on standing...
  - ✓ by  $\geq 20$  mm Hg, or,
  - ✓ to  $< 90$  mm Hg



# Effects of Orthostatic Hypotension

- OH- affects 6% of community dwelling elderly when confounding factors are controlled (e.g. medications known to cause OH)
- OH- can be symptomatic or asymptomatic
- OH- can be post-prandial



# Somesthesia



Vanderbilt Bill Wilkerson Center

# Assessment of Somesthesia

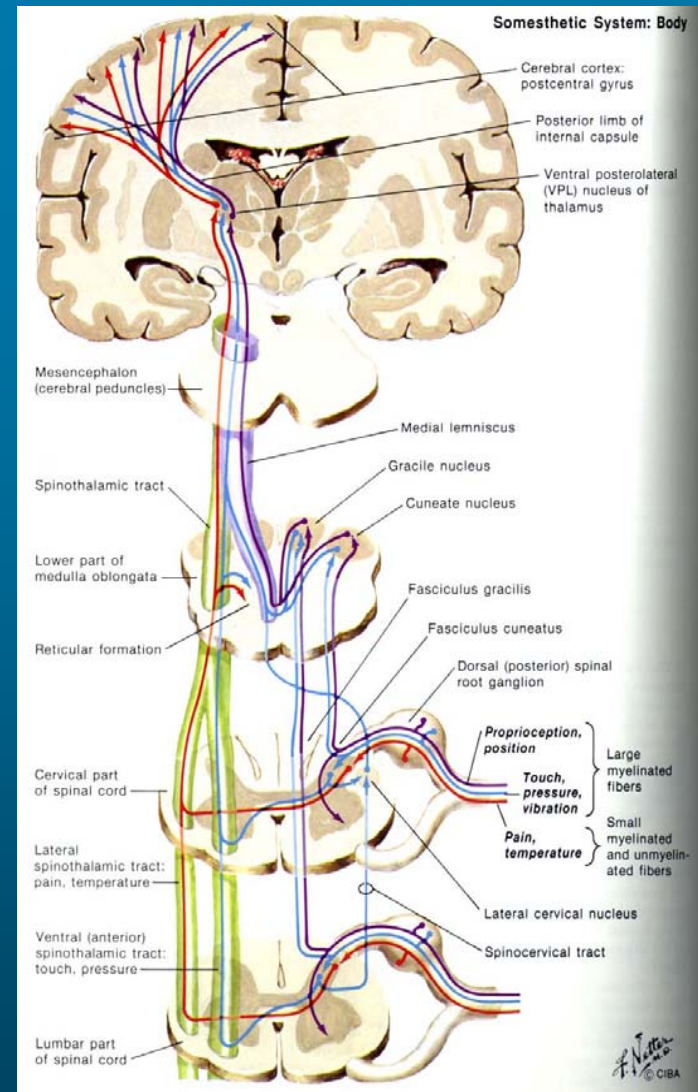
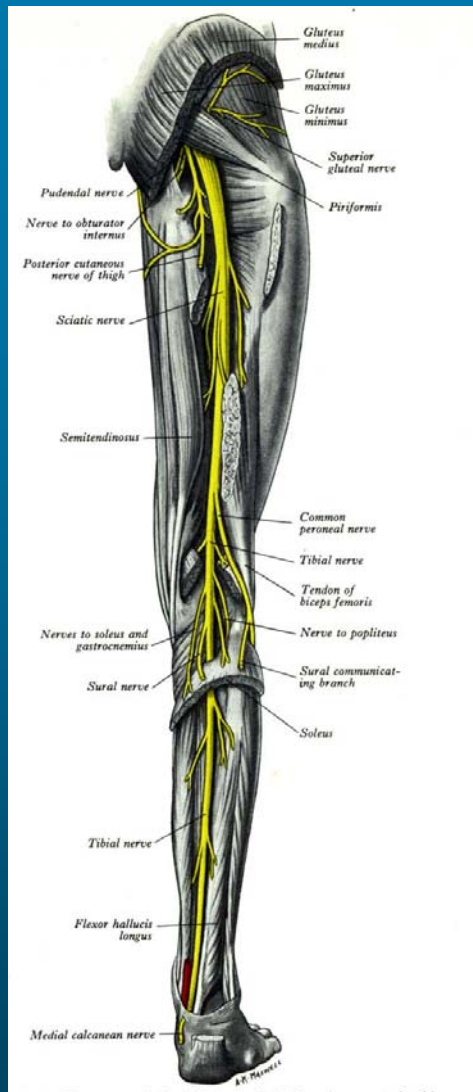
- Proprioception
- Vibration Sense



# Assessment of Somesthesia in the Elderly

- Age results in decreased ability to detect passive movement of the foot (direction and position).
- Associated with disorders causing distal peripheral neuropathies
  - e.g. diabetes







# Effects of Impaired Somesthesia

Lord et al. (1991)

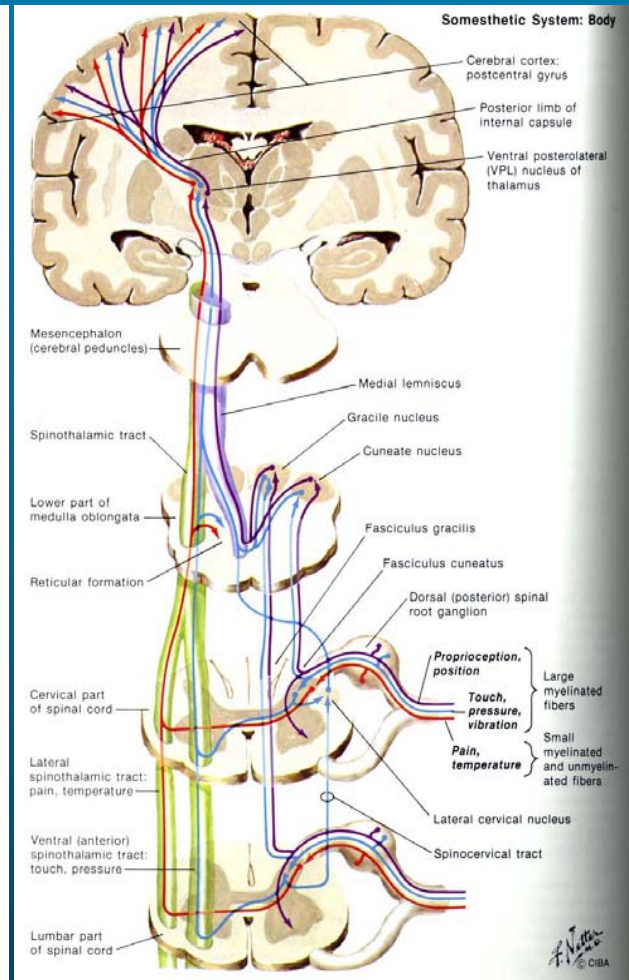
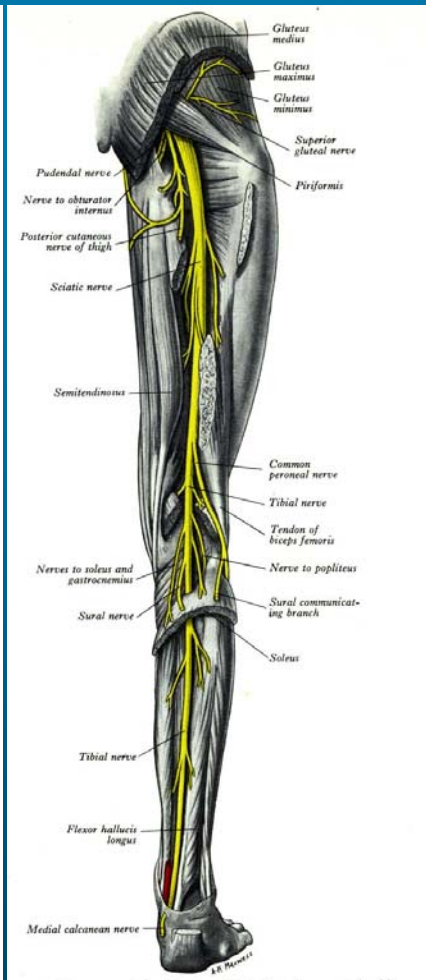
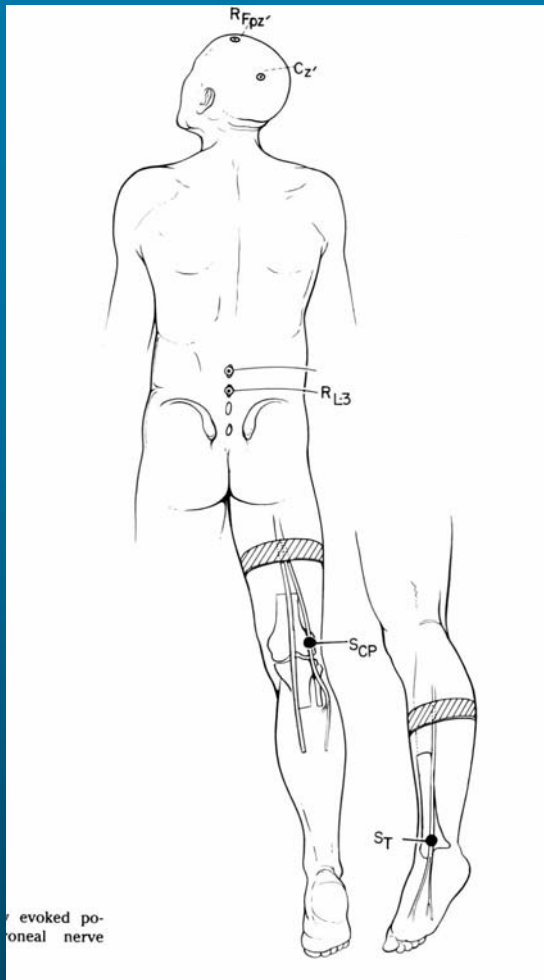
- Somesthesia is the most important sensory system for **static postural stability**
- Increased body sway with eyes open is associated with:
  - Decreased tactile sensitivity
  - **Decreased joint position sense**
  - **Decreased vibration sense**



# Assessment of Proprioception (Somatosensory EPs)

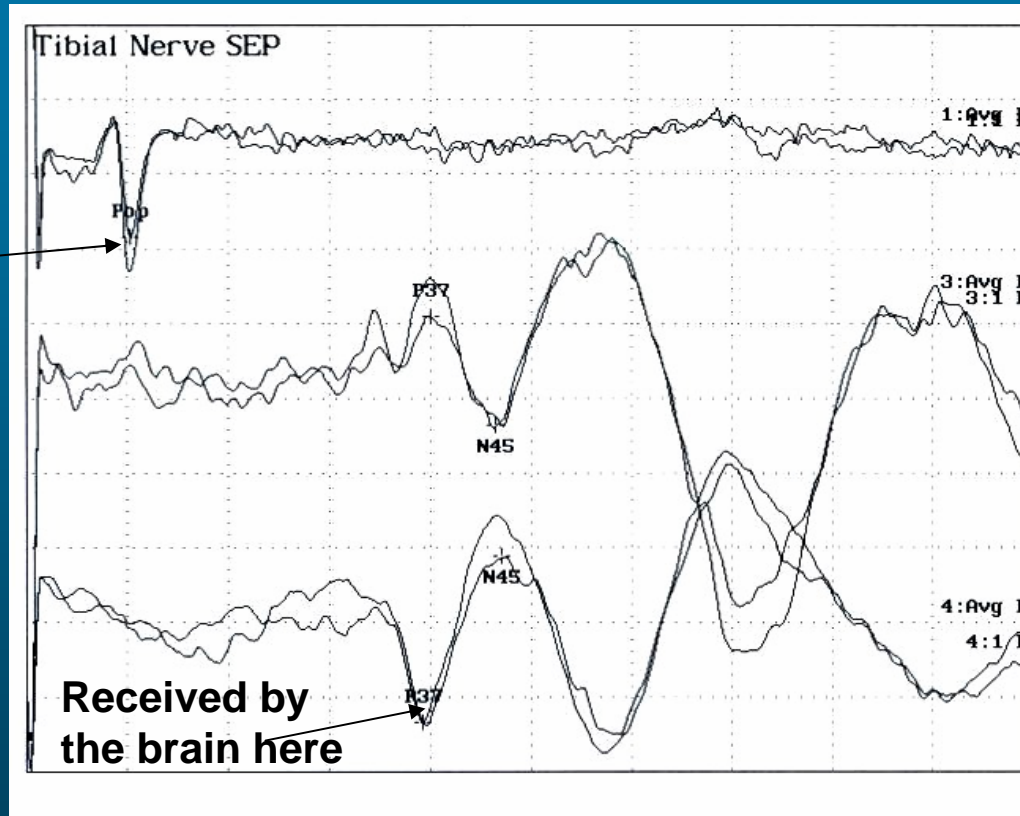
- **Tibial nerve Somatosensory Evoked Potentials (SEP)**
  - Permits as assessment of neural conduction through the neuraxis
    - Assessment of:
      - Distal sensory nerve conduction
      - Conduction in dorsal columns (proprioception), and
      - Central somesthetic pwy rostral to dorsal column nuclei





# Normal Tibial n. SEP

Passing through  
the knee here



Time →

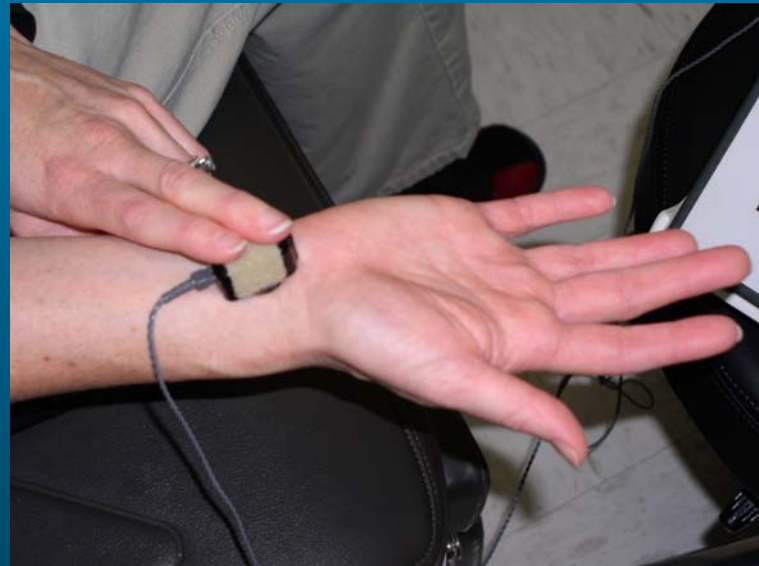
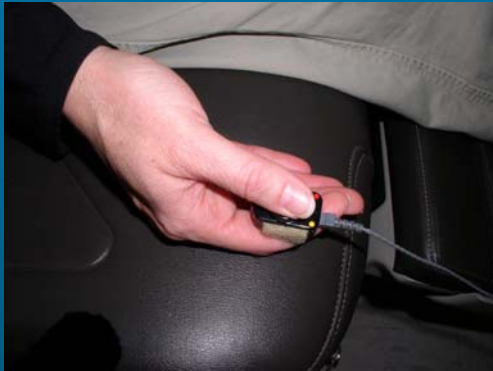


# Assessment of Vibration Sense

- Bone vibrator is placed at the great toe, ankle, and tibial tuberosity (lower) and thumb, wrist, and elbow (upper).
- A threshold is obtained in 5dB steps (ascending).
- This procedure is repeated six times



# Assessment of Vibration Sense



# Assessment of Vibration Sense



# Vestibulo-ocular Reflex



Vanderbilt Bill Wilkerson Center



# Effects of Impaired VOR in Elderly

- Age reduces numbers of hair cells and vestibular neurons
- VOR gain decreases by 35% when pts < 40 yrs are compared to  $\geq 40$  yrs for high velocity signals
- Causes progressive bilateral deficit
- Results in retinal slip and poor visual acuity during head movements



# Assessment of VOR

(Odds ratios = 1.09-6.0)

- **Electronystagmography (ENG)**
- **Rotary Chair testing**



# Assessment of VOR

## ENG

- **Electronystagmography (ENG)/(VNG)**
  - “Gold-standard” for identification of canal paresis (unilateral, bilateral)
  - Assesses function of vestibular system at ~ 0.003 Hz
  - Provides a means of identification of disorders of ocular motility

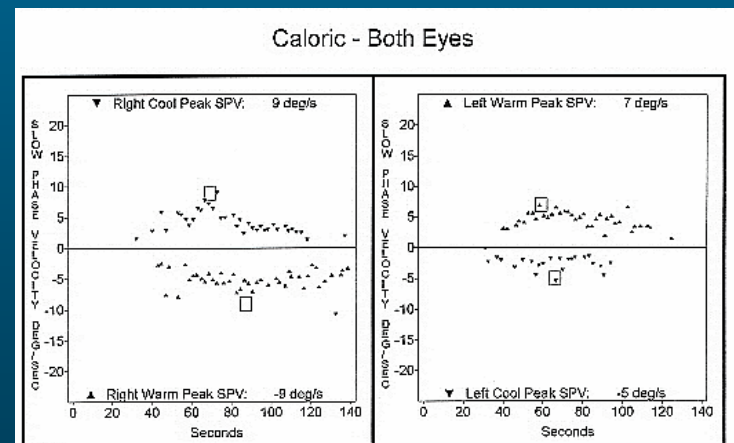
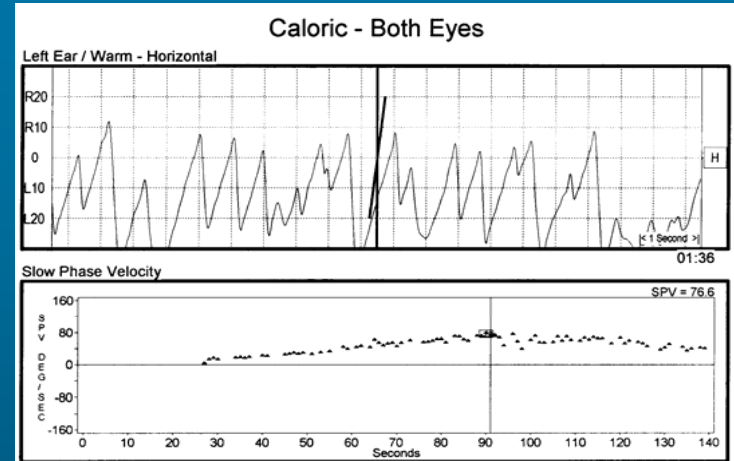
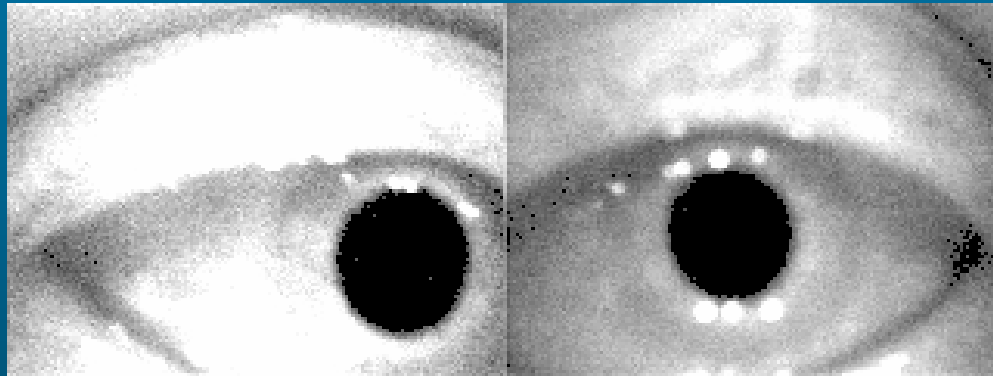


# VNG



**Vanderbilt Bill Wilkerson Center**

# Electronystagmography: Bithermal Caloric Test



Caloric Weakness: 20% in the left ear



# Assessment of VOR

## Rotary Chair Testing

- Permits an assessment of the VOR over a broader area of its operating range (.01-.64 Hz), and can document:
  - ...central compensation for unilateral peripheral deficits
  - ...bilateral reductions in peripheral vestibular system function.

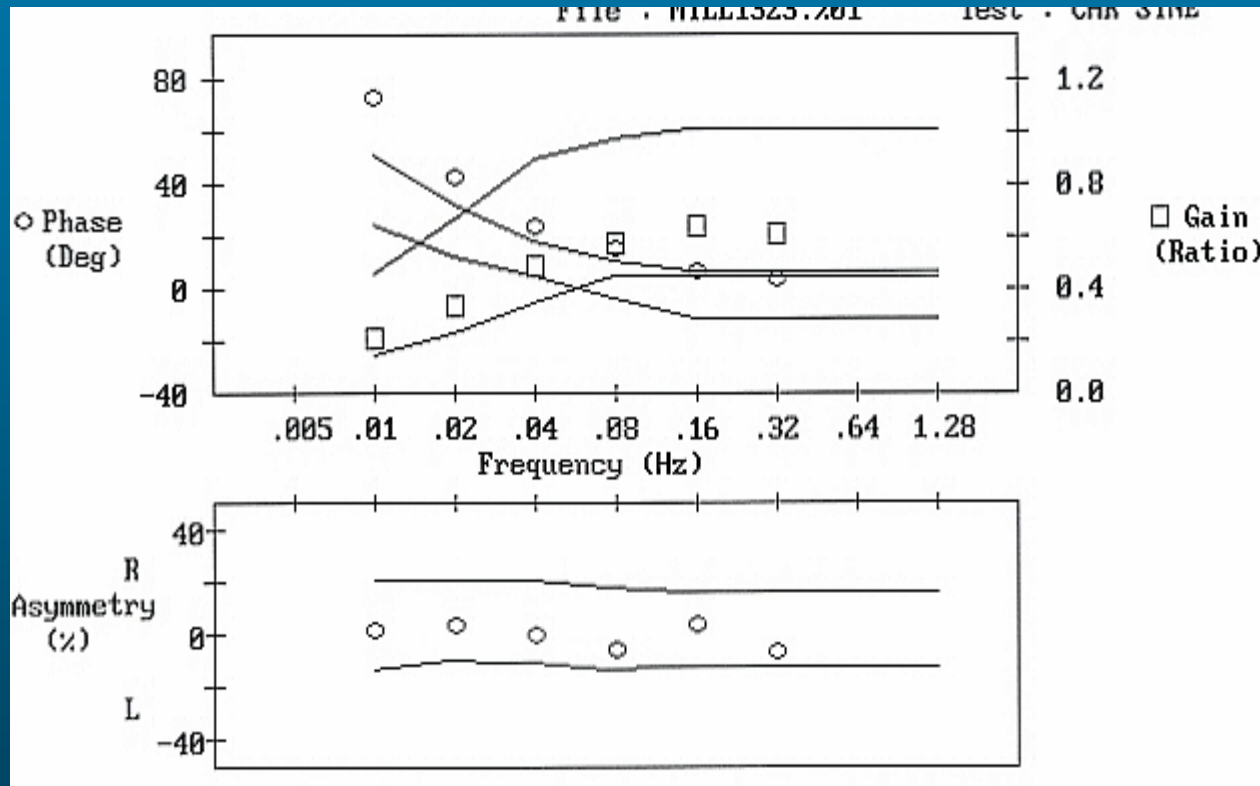


# Rotational Chair System



**Vanderbilt Bill Wilkerson Center**

# Rotary Chair Report





# **Assessment of Postural Stability**

**(Odds ratio = 1.4-8.0 depending on disease causing instability)**

- **Computerized Dynamic Posturography (CDP)**
  - **Measure of ability of patient to make use of vestibular, visual, and proprioceptive inputs to remain upright**



# Computerized Dynamic Posturography (CDP)



Vanderbilt Bill Wilkerson Center

# Sway-referenced Platform and Surround

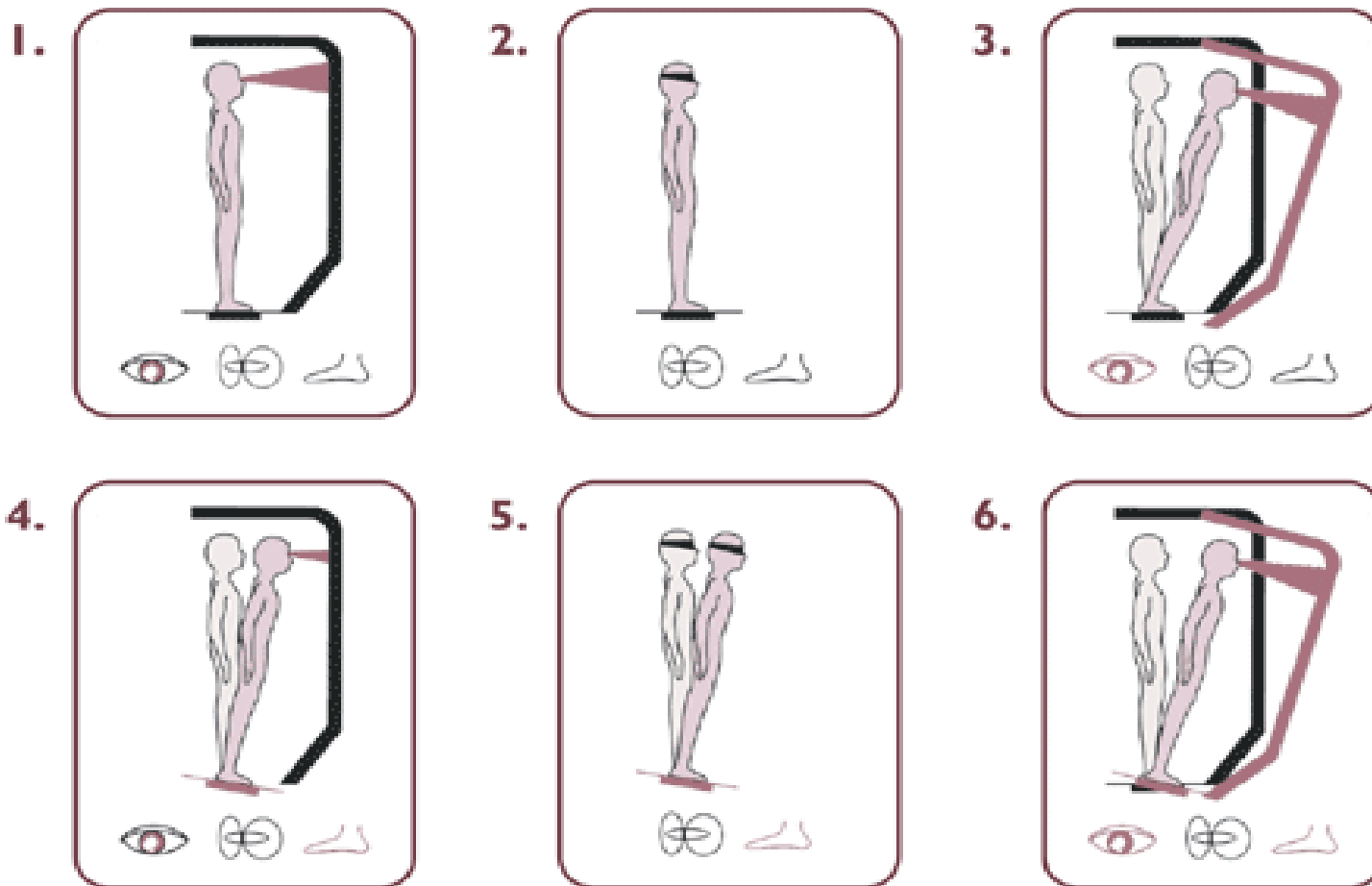
Condition 3



Condition 4

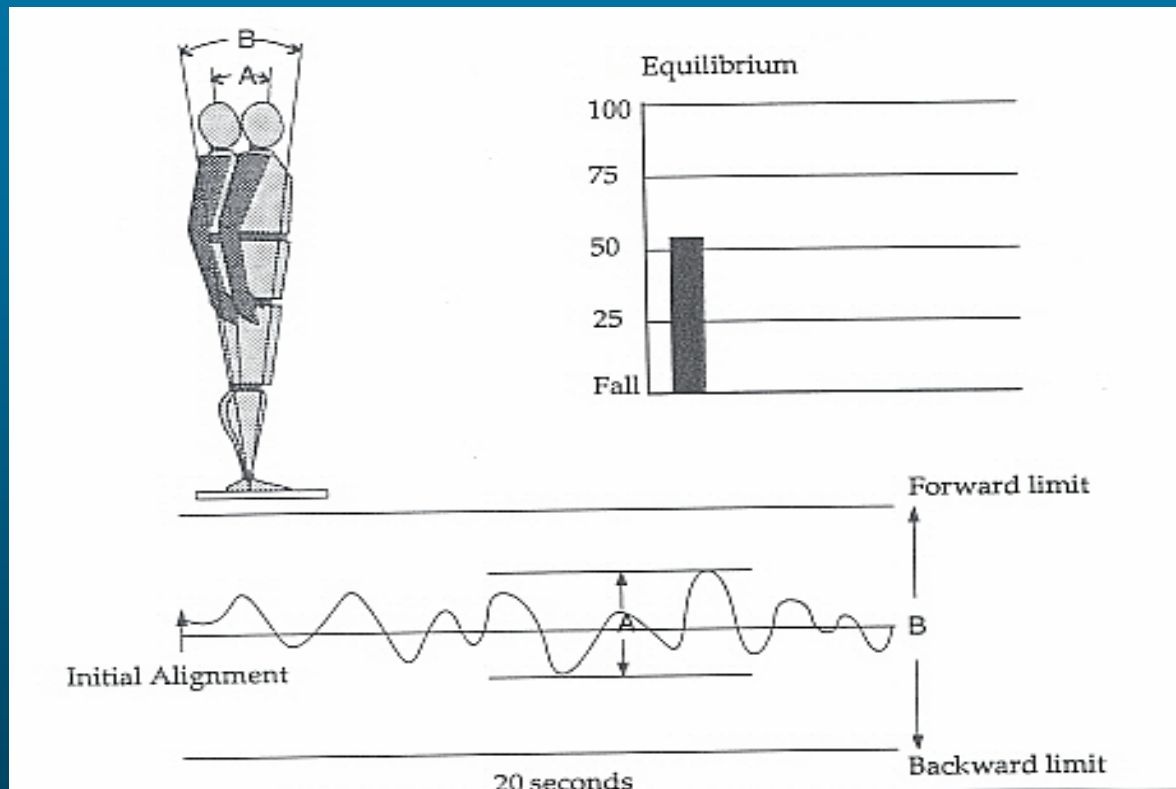


# Sensory Organization Subtest Equitest Protocol



Sensory Organization Test

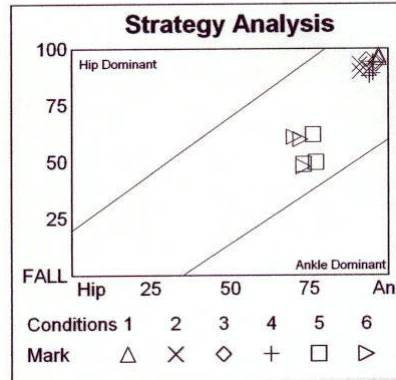
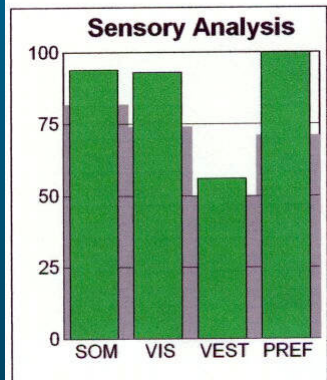
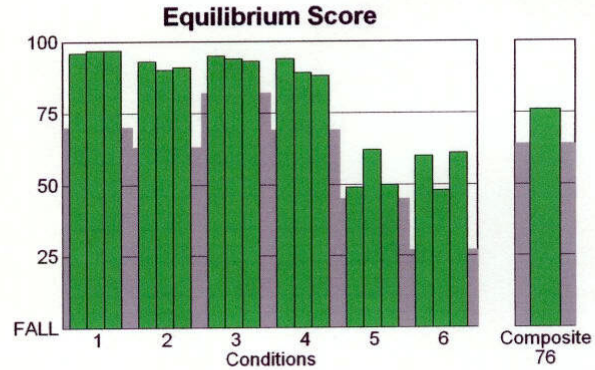
# SOT – Schematic Representation of Condition 1



# SOT Normal Examination

## Sensory Organization Test

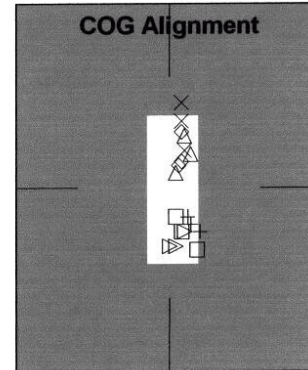
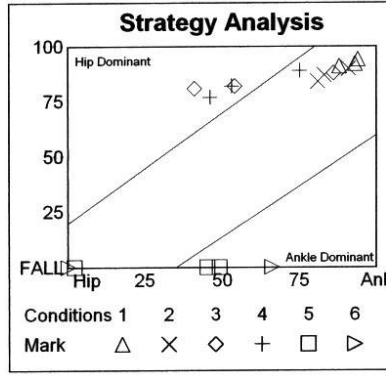
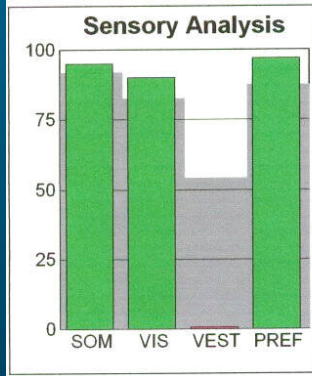
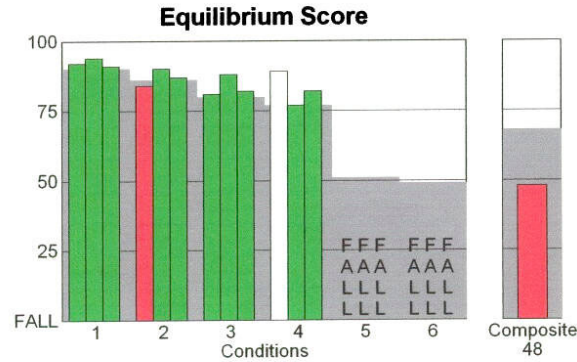
(Sway Referenced Gain: 1.0)



# SOT Bilateral Vestibular End Organ Paresis

## Sensory Organization Test

(Sway Referenced Gain: 1.0)



# Functional Assessment of Gait and Balance

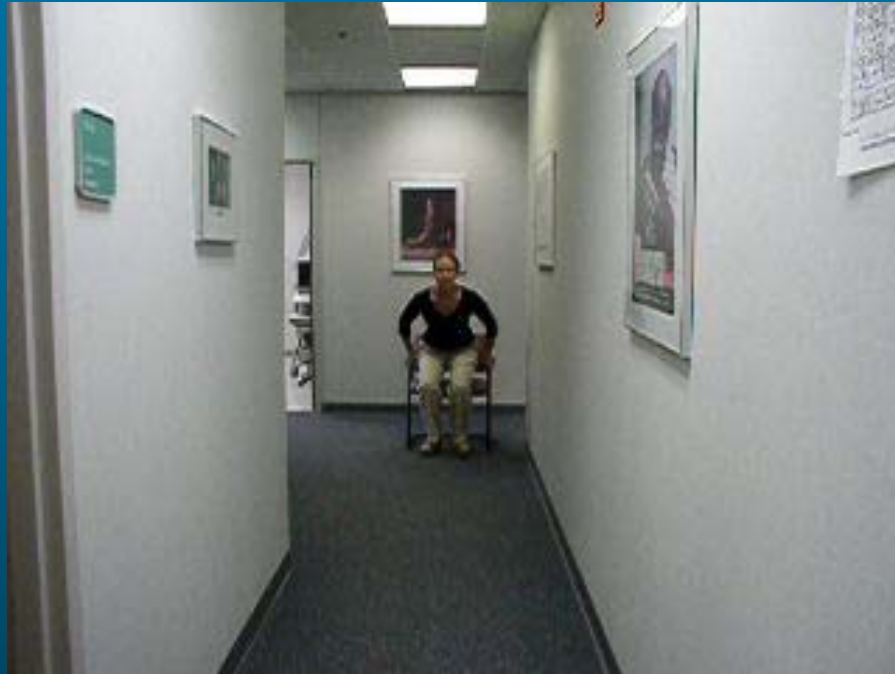
## Timed “Up and Go” Test (Podsiadlo and Richardson, 1991)

- Simple functional measure that is predictive of falls
- “Get up out of a chair, walk 3 meters as quickly and safely as possible, cross a line marked on the floor, turn around, walk back, sit down.”





# Timed “Up and Go” Test



Vanderbilt Bill Wilkerson Center

# Common Factors Affecting Gait

- **Neurological diseases** (e.g. stroke, Parkinson's D.)
- **Osteoarthritis**
- **Peripheral neuropathies** (e.g. diabetic, traumatic)
- **Periventricular white matter disease** (“white matter signal abnormality” T2 weighted MRI; e.g. Masdeu et al. 1989; Benson et al. 2002)



# Vision



Vanderbilt Bill Wilkerson Center

# Assessment of Visual Function

(Odds ratio = .73-5.5)

- **Corneo-retinal potential** (derived indirectly from ENG)
- **Ocular motility** (obtained from ENG examination)
- **Visual acuity (Snellen)**
- **More recently = Contrast Sensitivity (Melbourne Edge Test)**



# Assessment of Vision in the Elderly

- **Visual functions that normally change in elderly:** visual acuity, darkness adaptation, smooth pursuit
- **Diseases affecting vision:** cataracts, glaucoma & macular degeneration
- **Impairments:** cloudy vision, impaired peripheral vision and impaired central vision





**Vanderbilt Bill Wilkerson Center for Otolaryngology  
and Communication Disorders**

# **Simulations of Visual Impairments**

**Gary P. Jacobson, Ph.D.  
Division of Audiology**

# Near-sighted (myopia)/Far-sighted



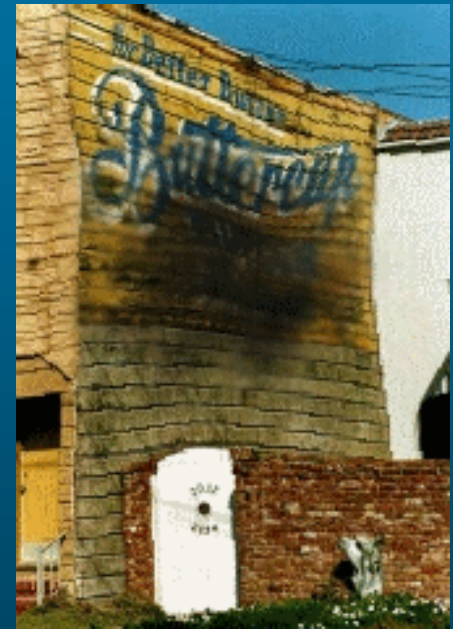
# Cataract



**Vanderbilt Bill Wilkerson Center**



# Macular Degeneration



# Astigmatism

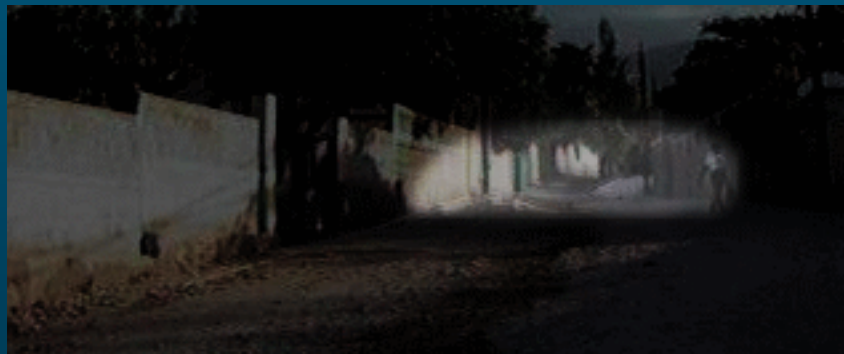


# Macular Degeneration

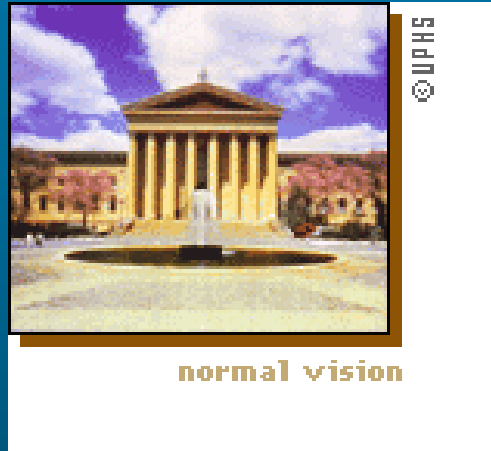


**Vanderbilt Bill Wilkerson Center**

# Glaucoma



# Cataract and Diplopia



# Corneo-retinal potential (Derived indirectly from ENG)

- CRP provides “indirect” information about the strength of the eye “battery”
- Direct measure = electroretinography (ERG)



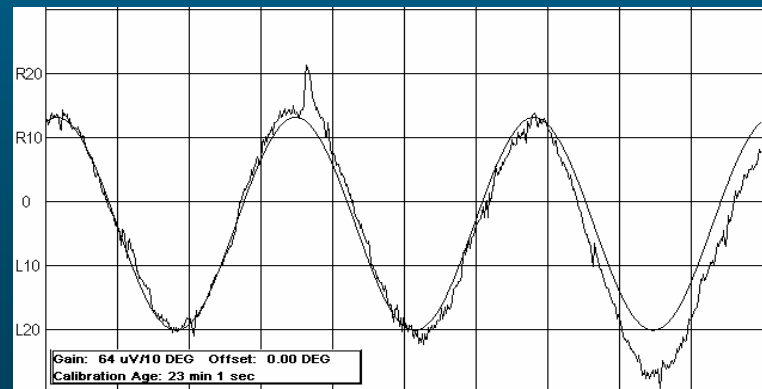
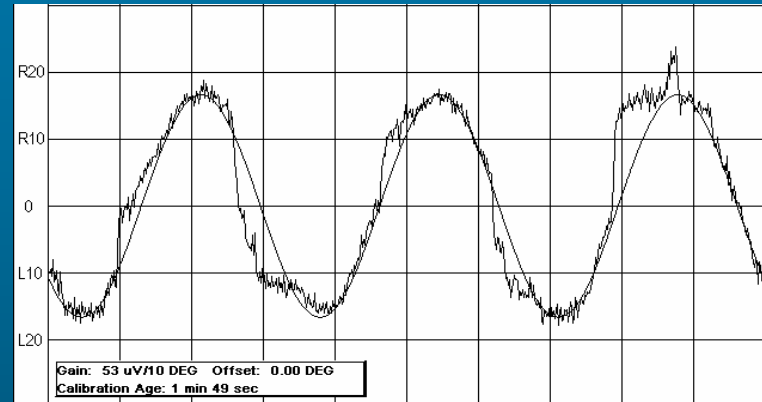
# CRP (uV/deg) Percentiles

Sex	1 <sup>st</sup>	5 <sup>th</sup>	10 <sup>th</sup>	15 <sup>th</sup>	20 <sup>th</sup>	50 <sup>th</sup>	80 <sup>th</sup>	85 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	99 <sup>th</sup> h
M	7.1	8.2	9.2	9.5	10.4	13.8	17.3	19.1	19.9	21.8	25.8
F	9.0	10.8	11.4	13.0	13.2	17.2	21.7	22.2	24.5	27.3	28.2



# Examples of Patients with Reductions in CRP

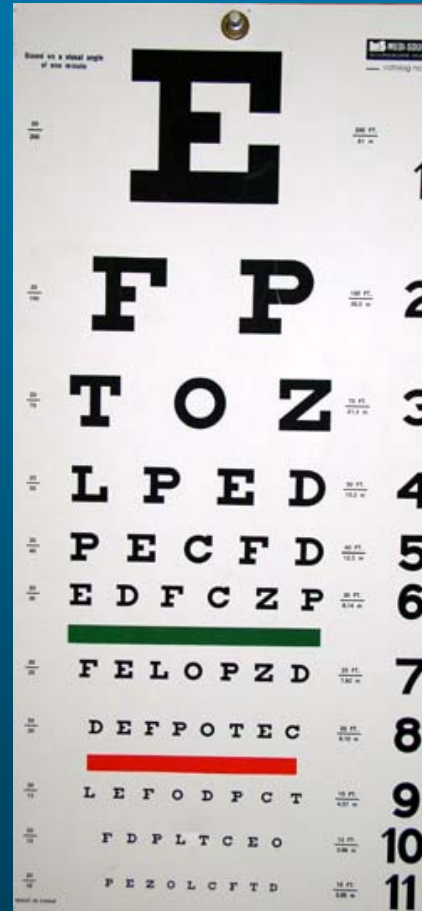
- **Top:** 80 yo F with dx of advanced glaucoma with hypertensive retinopathy (5.3 uV/deg)
- **Bottom:** 69 yo M patient with diabetic retinopathy (6.4 uV/deg)



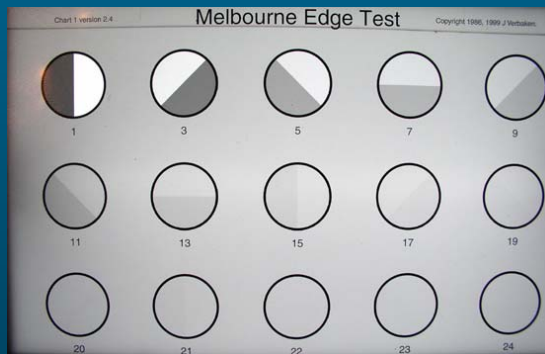


# Assessment of Visual Acuity

- Snellen Chart
- Patient stands 20' away
- Vision tested monocular and binocular, uncorrected and “best corrected”



# Edge Contrast Sensitivity (Melbourne Edge Test)



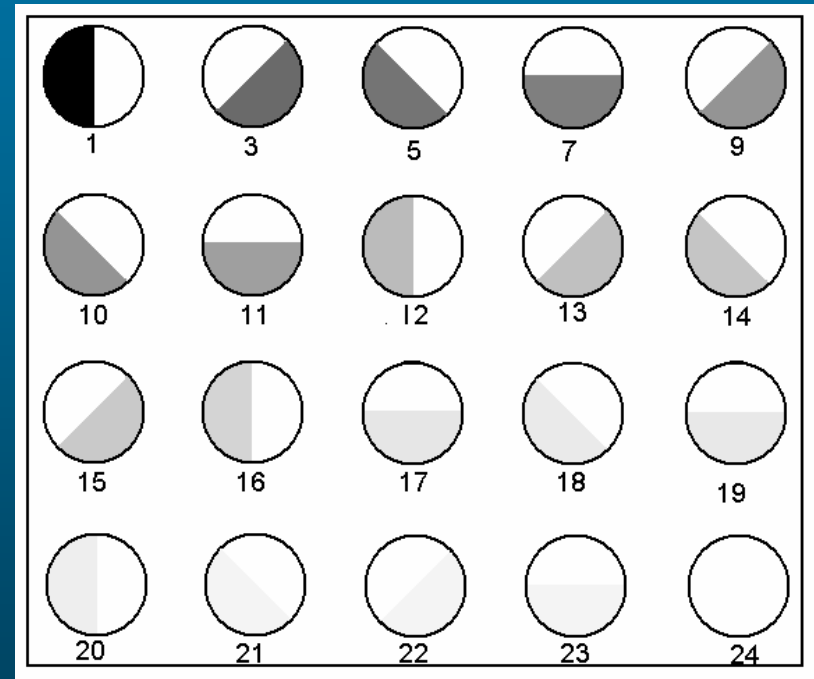
# Melbourne Edge Test Scoring

Excellent contrast vision – 24

Good contrast vision – 20-23

Fair contrast vision – 16-19

Poor contrast vision – 1-15



# Effect of Impaired Vision

- **Asymmetric acuity** (e.g. following unilateral cataract removal) is associated with impaired depth perception
- **Impaired contrast sensitivity** results in difficulty perceiving edges (steps, tree roots, gutters etc)





**Vanderbilt Bill Wilkerson Center for Otolaryngology  
and Communication Sciences**

# **Assessment of Falls Risk in a Cohort of 76 Elderly Patients**

**Gary P. Jacobson, Ph.D.  
Devin L. McCaslin, Ph.D.  
Vanderbilt Bill Wilkerson Center**

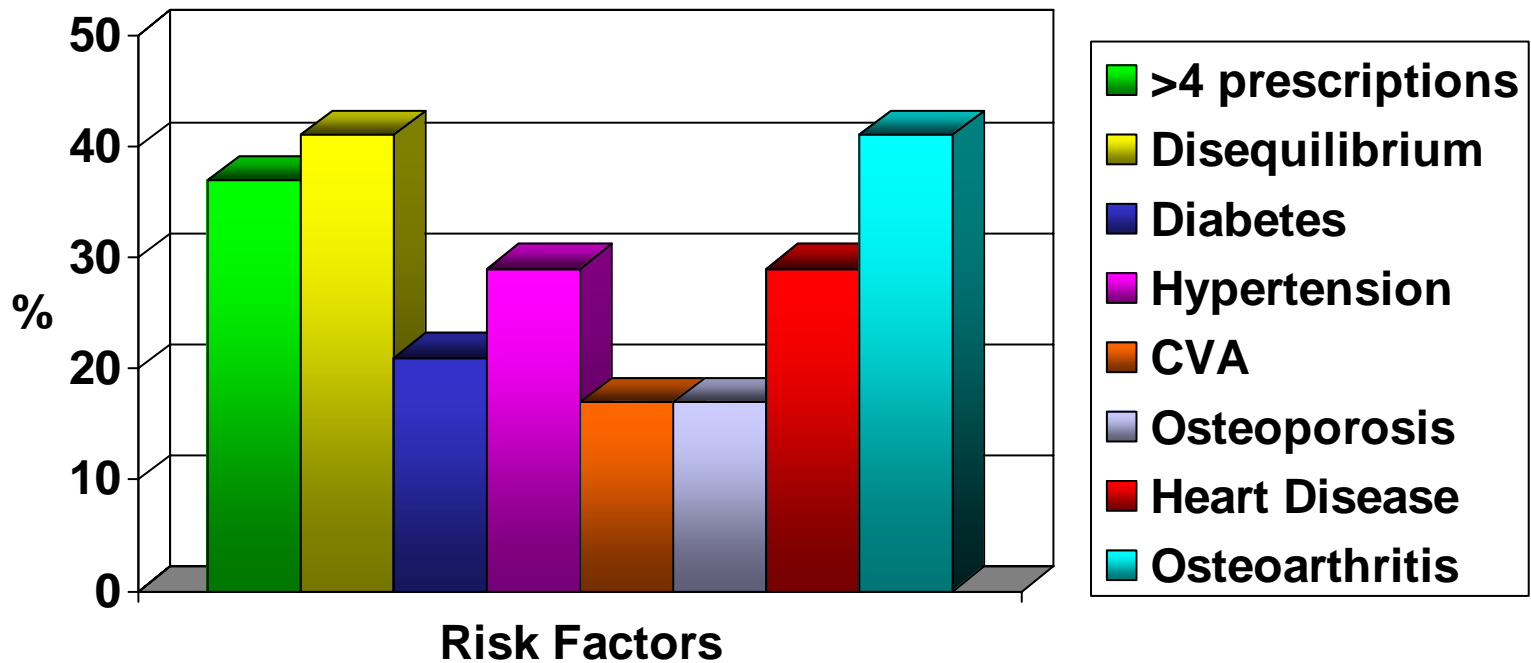
# Patient Demographics

(N = 76)

- **Mean age** = 75 yrs (sd 10 yrs, range 40 yrs – 93 yrs)
- **Gender** = 53 female, 70% of sample
- **History of previous falls (in or outside the home)** = 61%

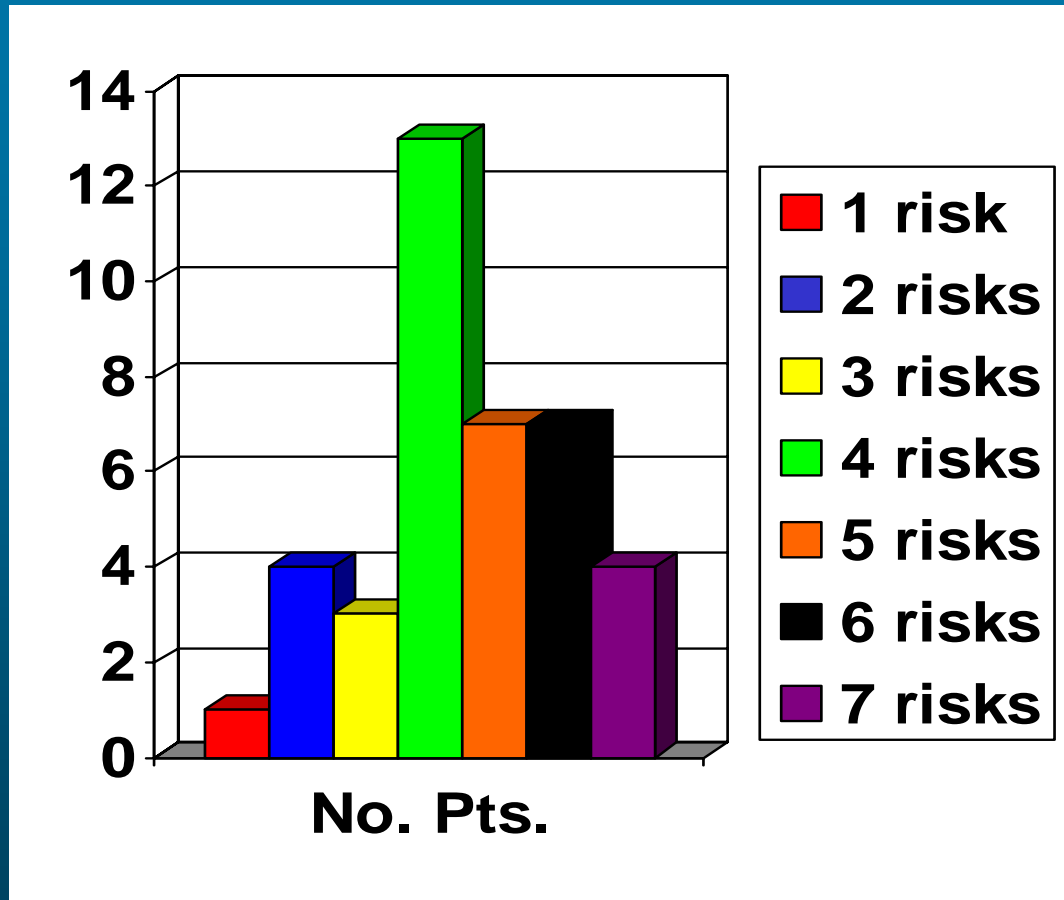


# Directed History



# Numbers of Risks Per Patient

From Results of Risk of Falls Assessment





# Cognitive/Psychological Factors

- **MMSE:** Mean = 27 pts. (range = 14-30 pts. normal = 23-30 pts.)
  - Abnormal performance in 11% of cohort (smaller % than expected)
- **Depression:** Mean = 10 pts. (range = 0-24 pts)
  - Abnormal performance in 33% of cohort (approx. proportional to that seen in elderly seeking medical care)



# Orthostatic Hypotension

- Defined as decrease in systolic blood pressure on standing...
  - by  $\geq 20$  mm Hg, or,
  - to  $< 90$  mm Hg
- Postural hypotension was observed in 18 patients or 24% of the sample.
  - Similar to % observed in elderly on antihypertensive medications



# Timed “Up and Go” Test

<i>Test</i>	<i>Cut off score (sec)</i>	<i>Sensitivity (% Fallers)</i>	<i>Specificity (% Non fallers)</i>	<i>Overall Prediction (%)</i>	<i>Predicted Probability</i>
<b>TUG</b>	<b><math>\geq 13.5</math></b>	<b>80</b>	<b>100</b>	<b>90</b>	<b>.77</b>
<i>TUG manual</i>	$\geq 14.5$	86.7	93.3	90	.5
<i>TUG cognitive</i>	$\geq 15$	80	93.3	86.7	.5



# Gait

- Mean elapsed time = 13.5 sec.
  - Range = 6 – 42 sec.
- 26 patients (34%) demonstrated abnormal performance



# Visual Acuity

- Effect on postural stability when acuity is 20/50 or poorer (Brandt, 1985)



# Visual Acuity

## Best Corrected Binocular Vision

- $\geq 20/50 = 33\%$
- $\geq 20/70 = 20\%$
- $\geq 20/100 = 10\%$



# Vestibulo-ocular Reflex

- **Unilateral weakness (asymmetry):** mean asymmetry for group = 17% (sd 17%; range 0-88%)
  - UW = 23 patients (31%).
- **Rotary Chair abnormalities:**
  - 44 patients (64%)
- **Total combined = 76% of sample showed evidence of vestibular system impairments**



# Falls in Patients With Vestibular Deficits

Herdman et al. (2000)

- Examined frequency of falls for patients with unilateral and bilateral peripheral vestibular deficits
- N = 70 (unilateral) & 45 (bilateral)
- Mean age 63 yrs ( $\pm$  14 yrs)
- Compared to numbers of falls for community-dwelling adults





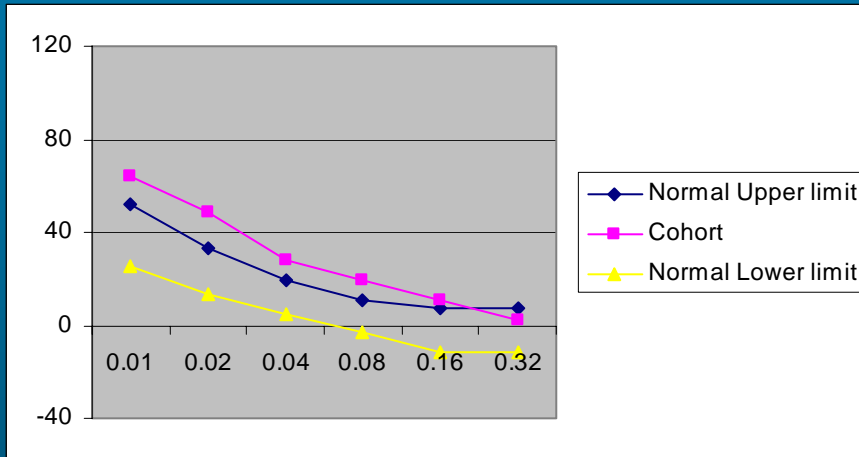
# Falls in Patients With Vestibular Deficits

Herdman et al. (2000)

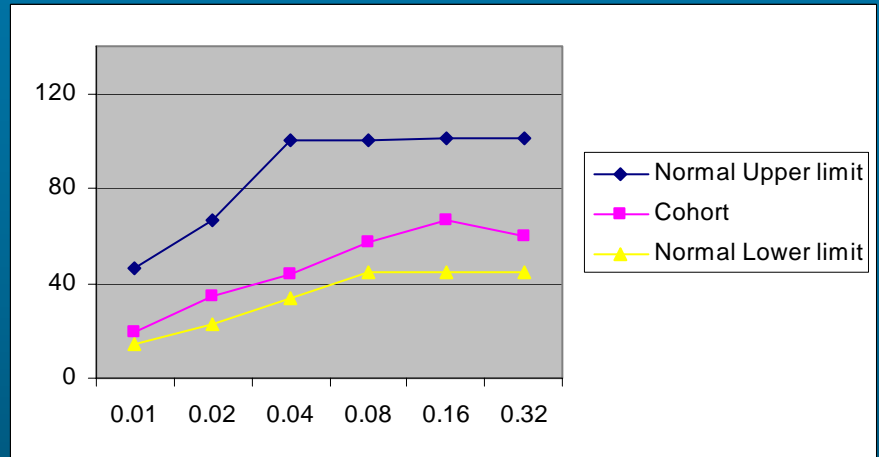
- Results:
  - **Unilateral deficits** = incidence of falls not different from that of community dwelling adults
  - **Bilateral deficits** = significantly > incidence of falls re: unilateral deficit patients and community dwelling adults



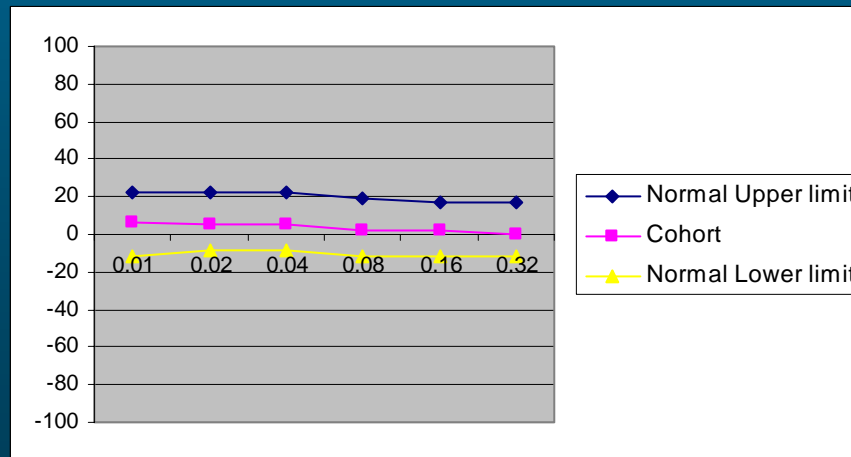
# Patients with Normal Caloric Examination and Abnormal Rotary Chair Test



Phase



Gain



Symmetry

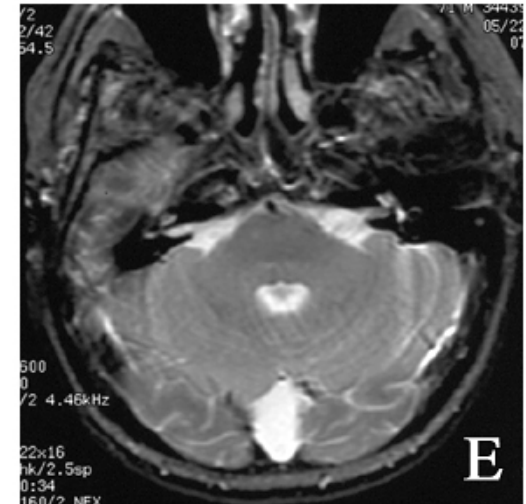
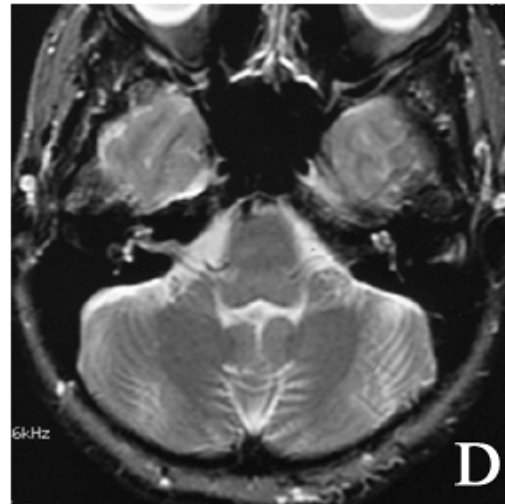
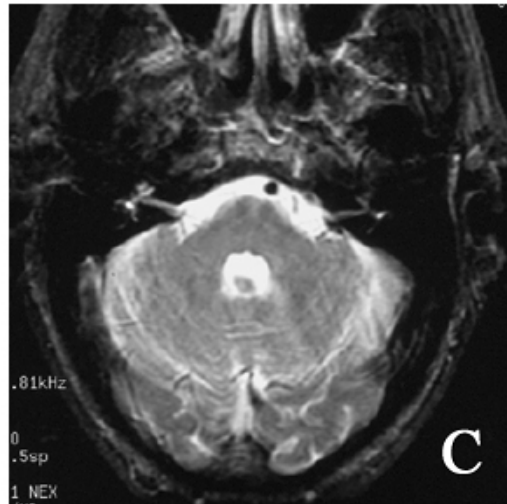
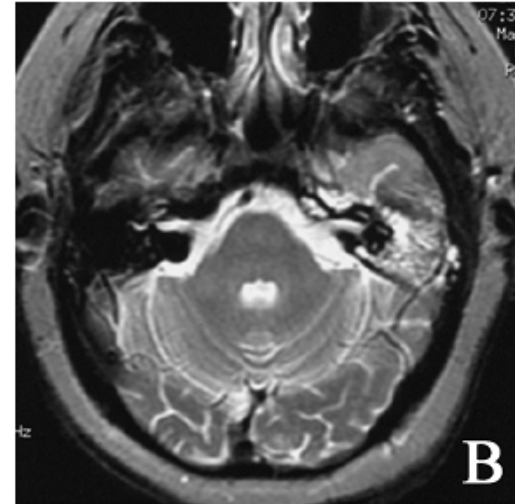
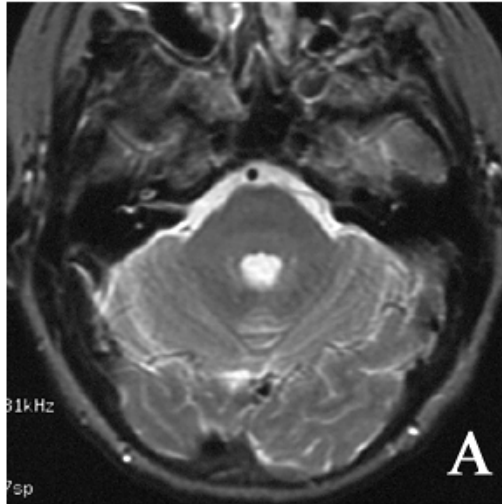


# Two Subgroups of Patients Presented to Risk of Falls Clinic

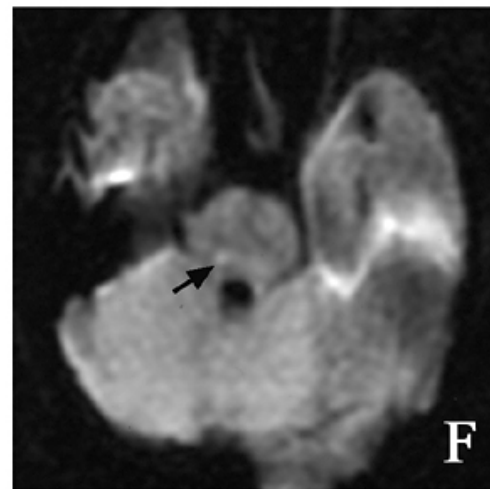
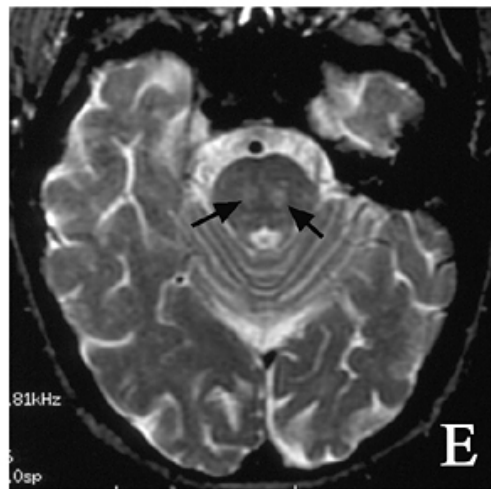
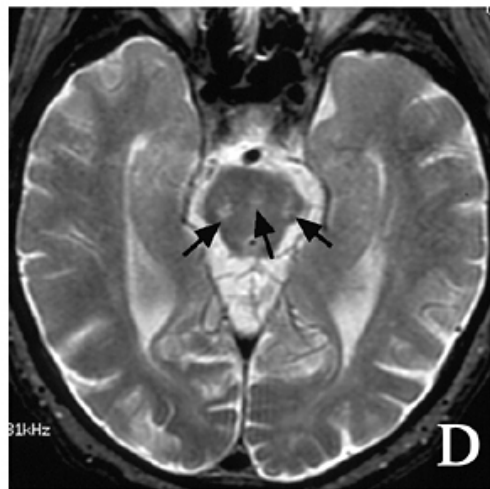
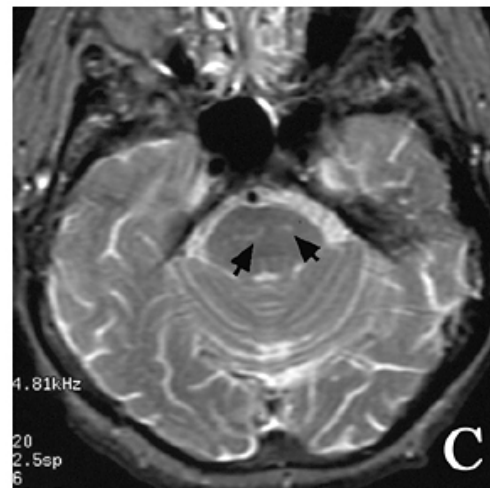
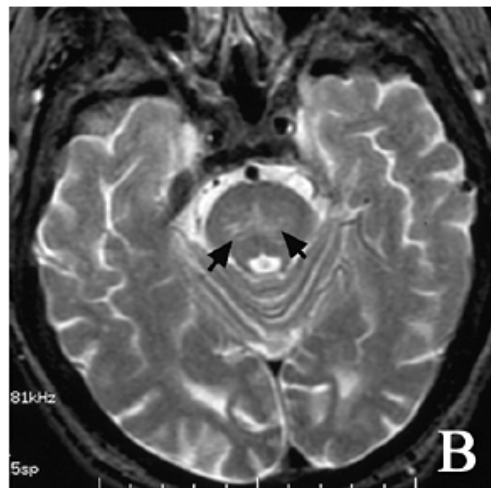
- Group 1 (control)
  - Normal caloric examination
  - Normal VOR gain, phase and symmetry measures on rotational testing
- Group 2 (experi.-abn. VS)
  - Normal caloric examination
  - Normal VOR gain, symmetry but multi-frequency phase abnormalities on rotational test (min. 3 adjacent freq. beginning with 0.01 Hz)



# Patients – Group 1



# Patients – Group 2

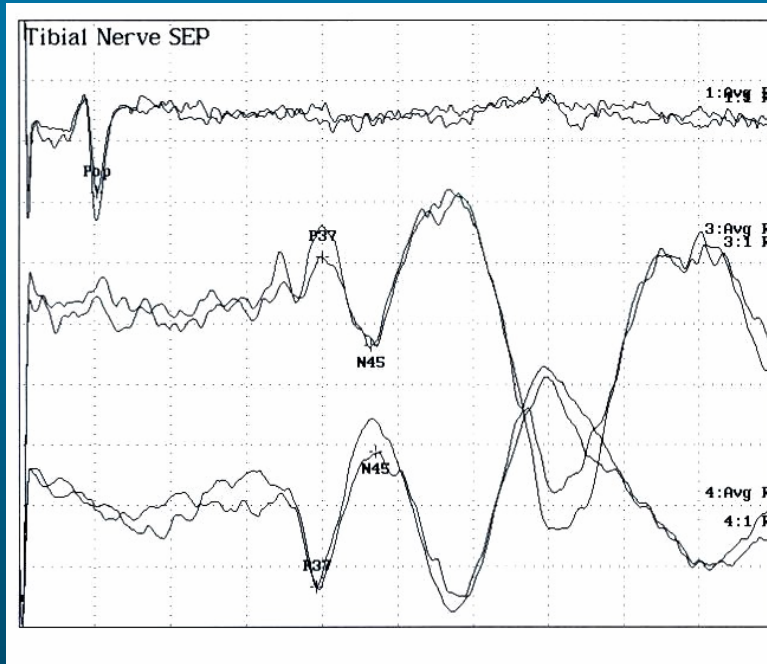


# Somesthesia L/SEP

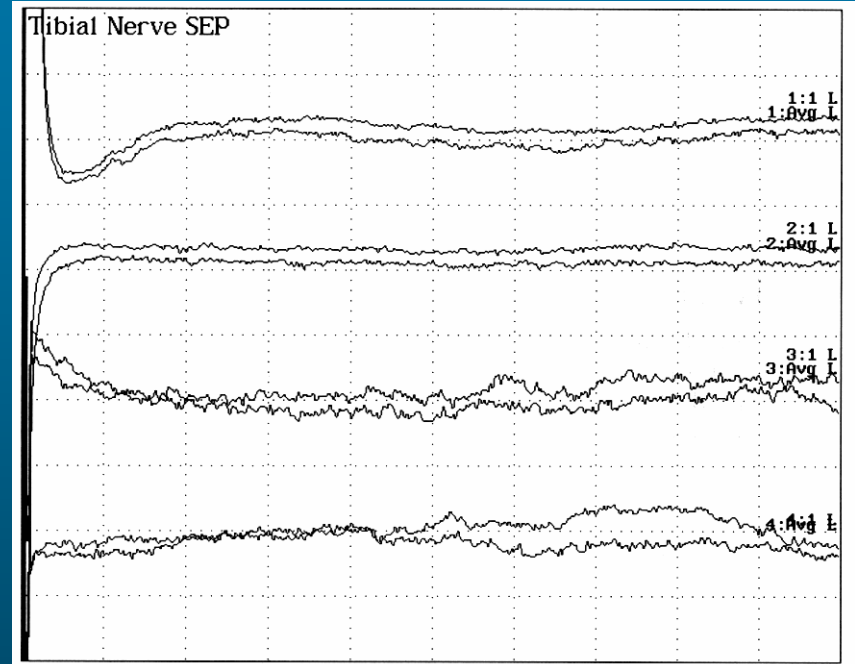
- **Tibial n. SEP**
  - abnormalities were observed in 73 patients (89%)
    - abnormalities supported evidence of peripheral neuropathy



# Tibial n. SEP



Normal sample



Patient



# Postural Stability

## Sensory Organization Test

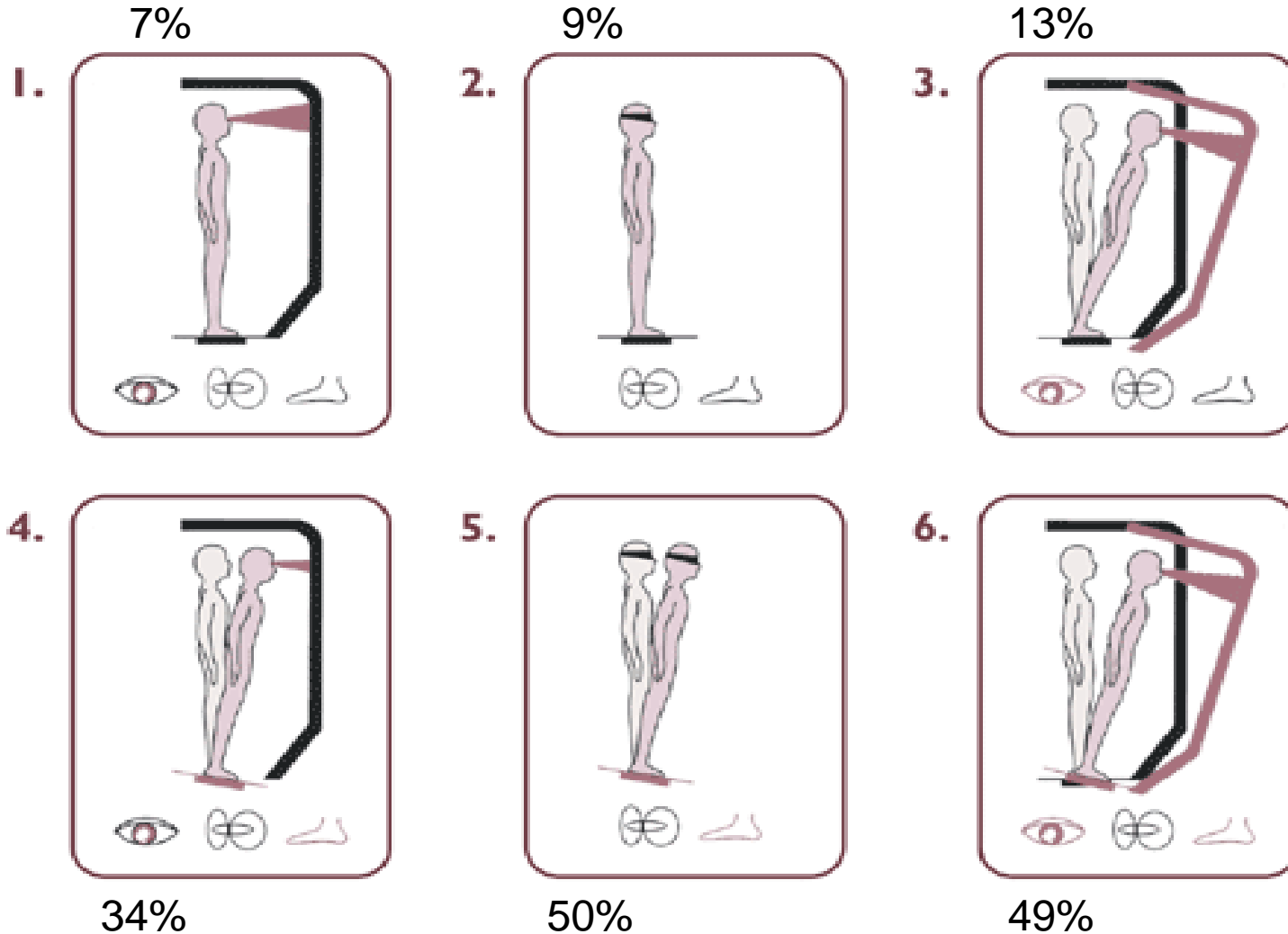
- Normal: 15 patients (20%)
- Abnormal performance: 54 patients (71%)
- Too unsteady to test (abnormal): 7 patients (9%)





# SOT Conditions

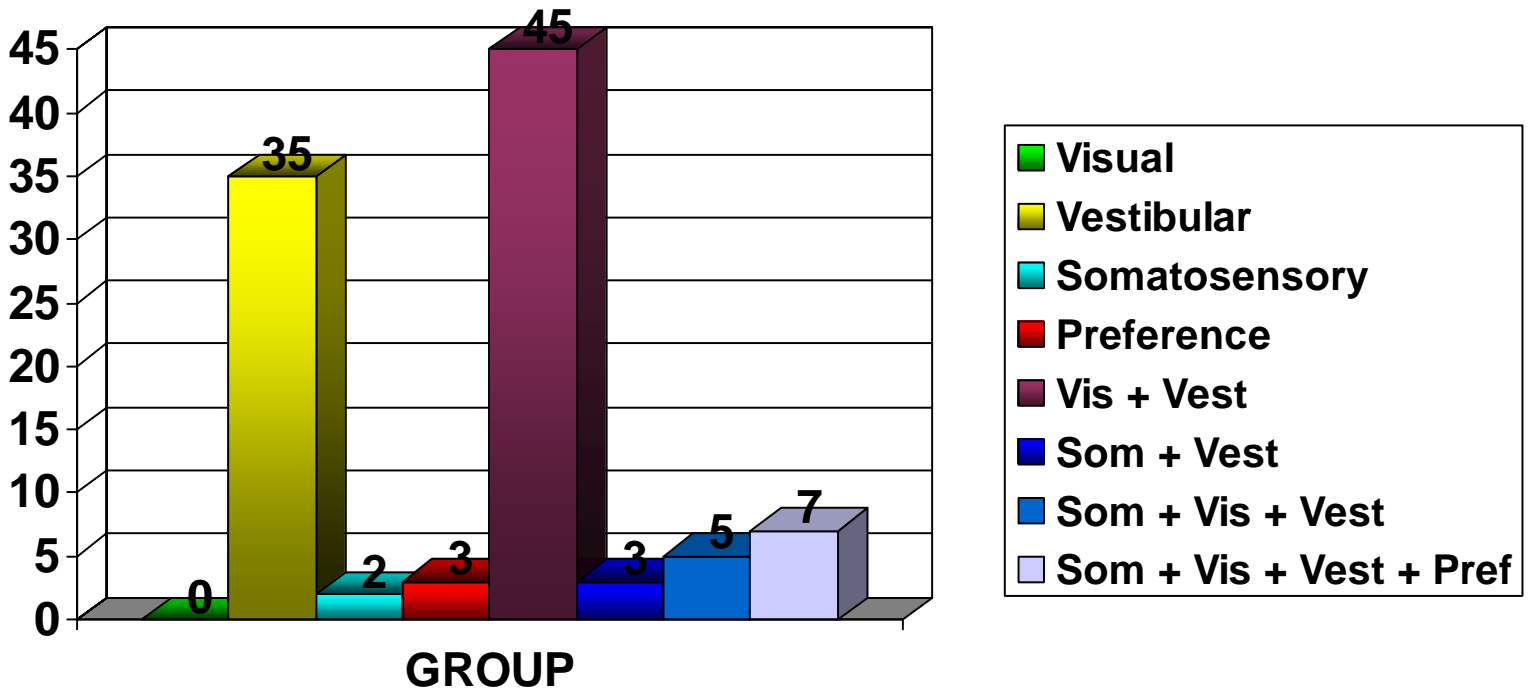
## Percent Abnormal on Individual Conditions



Sensory Organization Test

# SOT Patterns

## Percent Abnormal Combinations



# Multi-modal Abnormalities

Snellen (acuity)/SEP (proprioception)/VOR

- Abnormalities in a single modality: **13%**
- Abnormalities in multiple modalities:
  - Visual acuity + proprioception = **15%**
  - Visual acuity + Vestibular = **3%**
  - Vestibular + proprioception = **50%**
  - Visual acuity + proprioception + vestibular = **19%**



# “Multisensory System Impairment”

- Drachman and Hart, 1972 – coined the term
- Tinetti, 2000 - feels that dizziness in elderly is a geriatric syndrome (i.e. it is multifactorial) like delerium and falling



# Summary of N = 76

- We were surprised by the number of patients with unsuspected vestibular and somesthetic system impairments (70% +)
  - Of the somatosenses impairments of proprioception and vibration are most predictive of those who fall (Lord et al. 1991,1994)
  - Commented on the relationship between peripheral neuropathy, loss of somesthesia and postural instability and falls (Richardson et al. 1992; Horak, 2001)



# Summary of N = 76

- In absence of intact somesthetic information elderly rely on the slower visual sense to remain upright (Pyyko et al. 1990)
  - Camicioli et al. (1997) reported their elderly were more unstable on Condition 4 of SOT where vision is non-distorted and somesthetic information is distorted,
  - Same as we observed



# Future Considerations

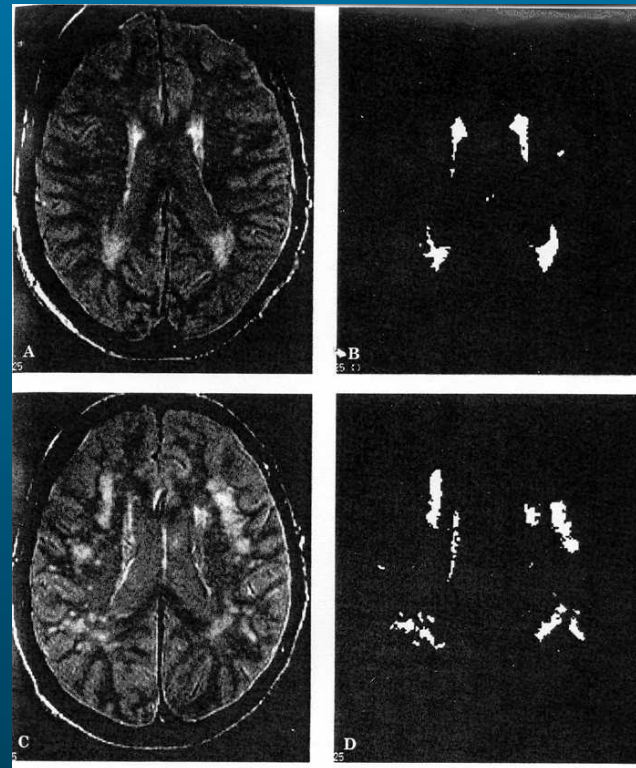
- **Periventricular white matter disease**



# Periventricular White Matter Disease

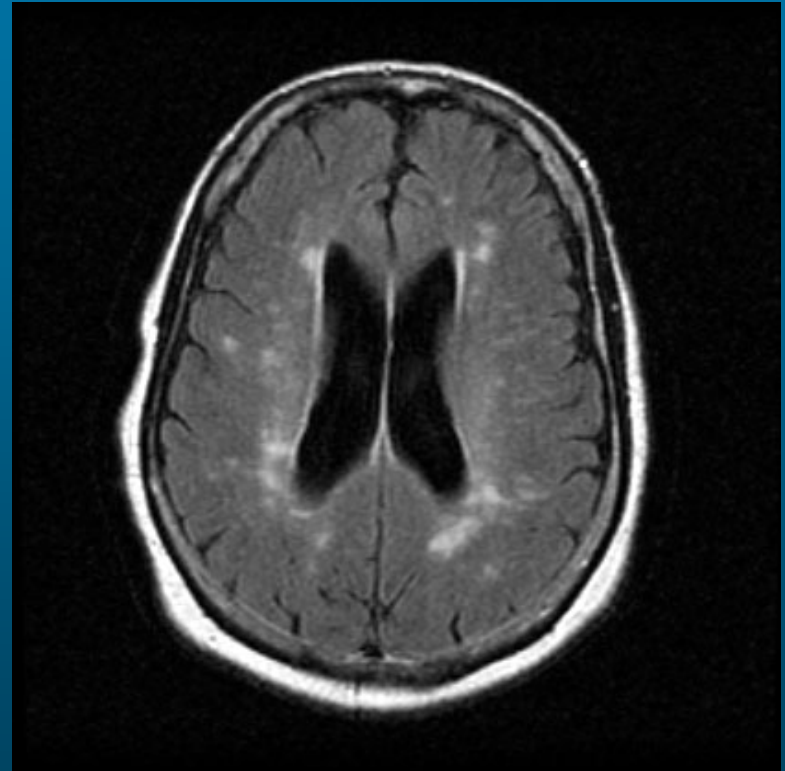
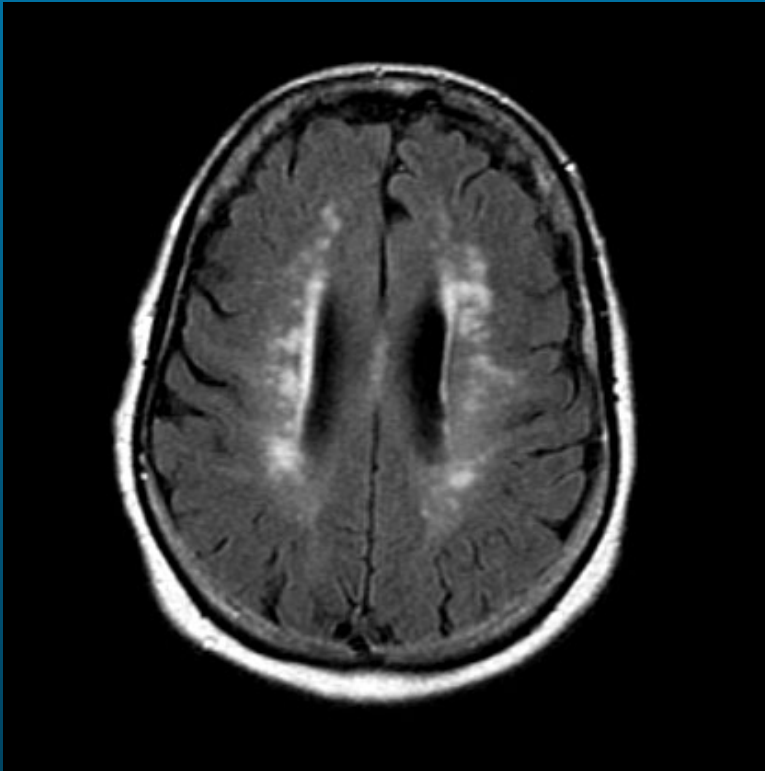
Benson et al. 2002

- Is significant when present symmetrically in frontal and parietal areas
- High sensitivity for identification of patients with reduced mobility





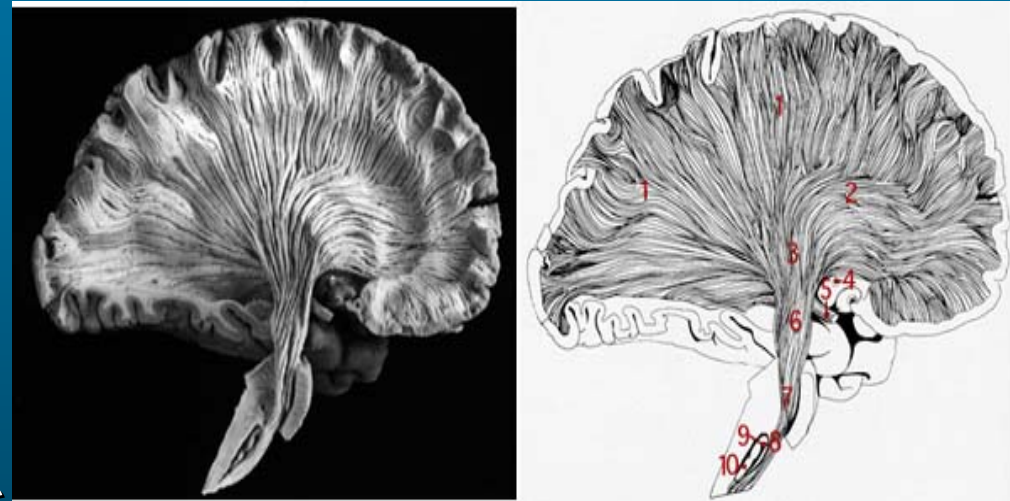
# Periventricular White Matter Disease



# Periventricular White Matter Disease

Fife & Baloh, 1993

- Fibers mediating long-loop reflexes pass through the periventricular white matter
- These fibers traverse great distances connecting remote sensory and motor cortical and subcortical sites
- Lesions in these areas would affect sensorimotor processing.



Corona Radiata



# Periventricular White Matter Disease

<b>Distorted or undistorted</b>	<b>Distorted or undistorted</b>	<b>Distorted or undistorted</b>
<b>Vision</b>	<b>Central processor for sensory inputs and formulator of motor commands for eye movements and via spinal cord for postural changes</b>	<b>Nerves and muscles in the eye movement system</b>
<b>Proprioception</b>		<b>Nerves and muscles for postural control</b>
<b>Vestibular</b>		



# Case Study



**Vanderbilt Bill Wilkerson Center**

# Current History

- 85 yo male seen by ENT for an evaluation of dizziness.
- Pt. w-hearing loss, bilateral tinnitus.
- No vertigo, states that he staggers when he walks
- Dysequilibrium X3 years (worsening over the last year)



# Past Medical History

- Hypertension
- Degenerative arthritis
- IDDM w- hx peripheral neuropathy
- Anxiety disorder
- OD enucleated, OS w-diabetic retinopathy
- Coronary artery disease



# Tests Conducted

- **MRI:** mild chronic subcortical white matter ischemic changes.
- **MRA:** demonstrated mild narrowing of the right and mild-moderate narrowing of the left proximal internal carotid arteries, consistent with atherosclerotic stenosis



# Medications

- **Levoxyl**- thyroid
- **Prinivil** - hypertension
- **Insulin**- diabetes
- **Assorted vitamins**





# Risk of Falls Assessment

- **Postural hypotension: Risk exists** (laying BP 165/65 p 59; standing BP 125/61 p60; standing X5 min. 167/73 p66)
- **Vision: Risk exists** (Uncorrected OS vision = 20/70; corrected = 20/50)



# Risk of Falls Assessment

- **Cognitive Function:** Unlikely risk (MMSE = 29/30)
- **Depression:** Risk exists (GDS = 13/30)
- **Gait:** Unlikely risk (Time “Get Up and Go” = 13 sec)

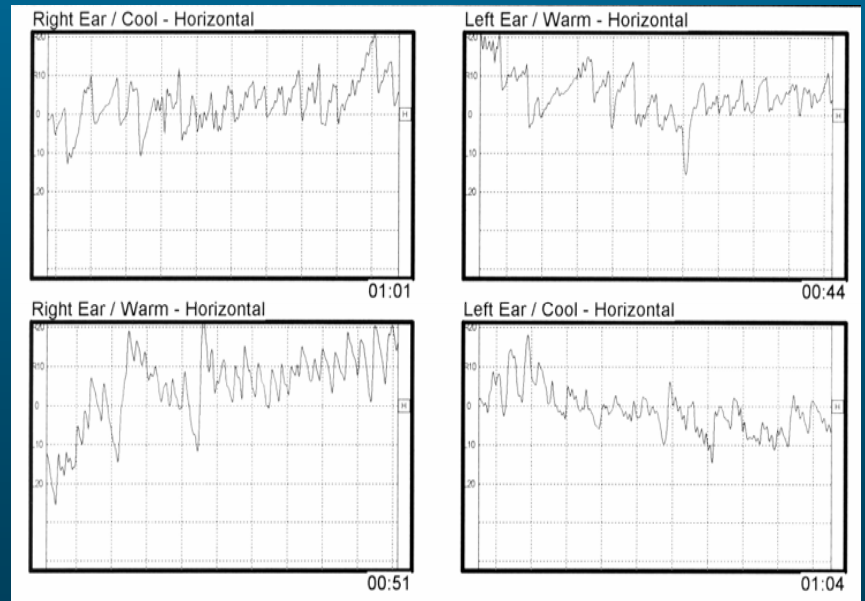
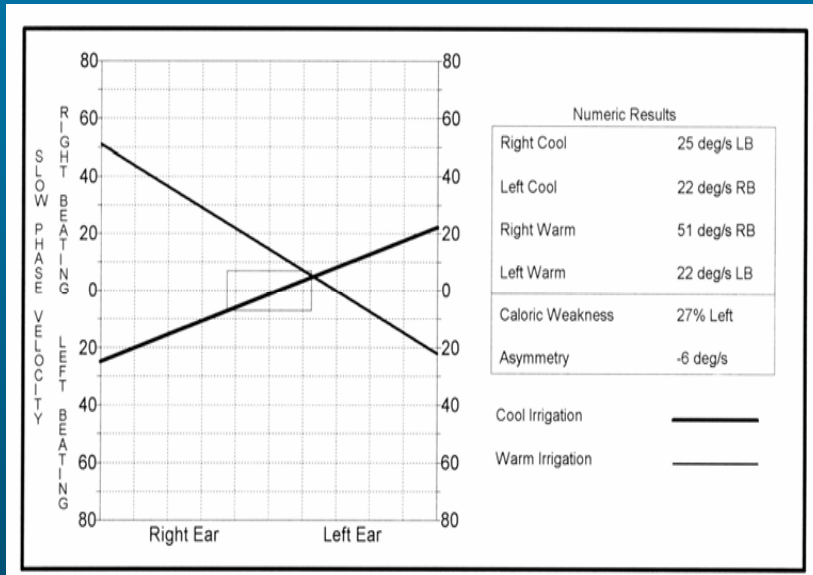


# Vestibular Function Testing

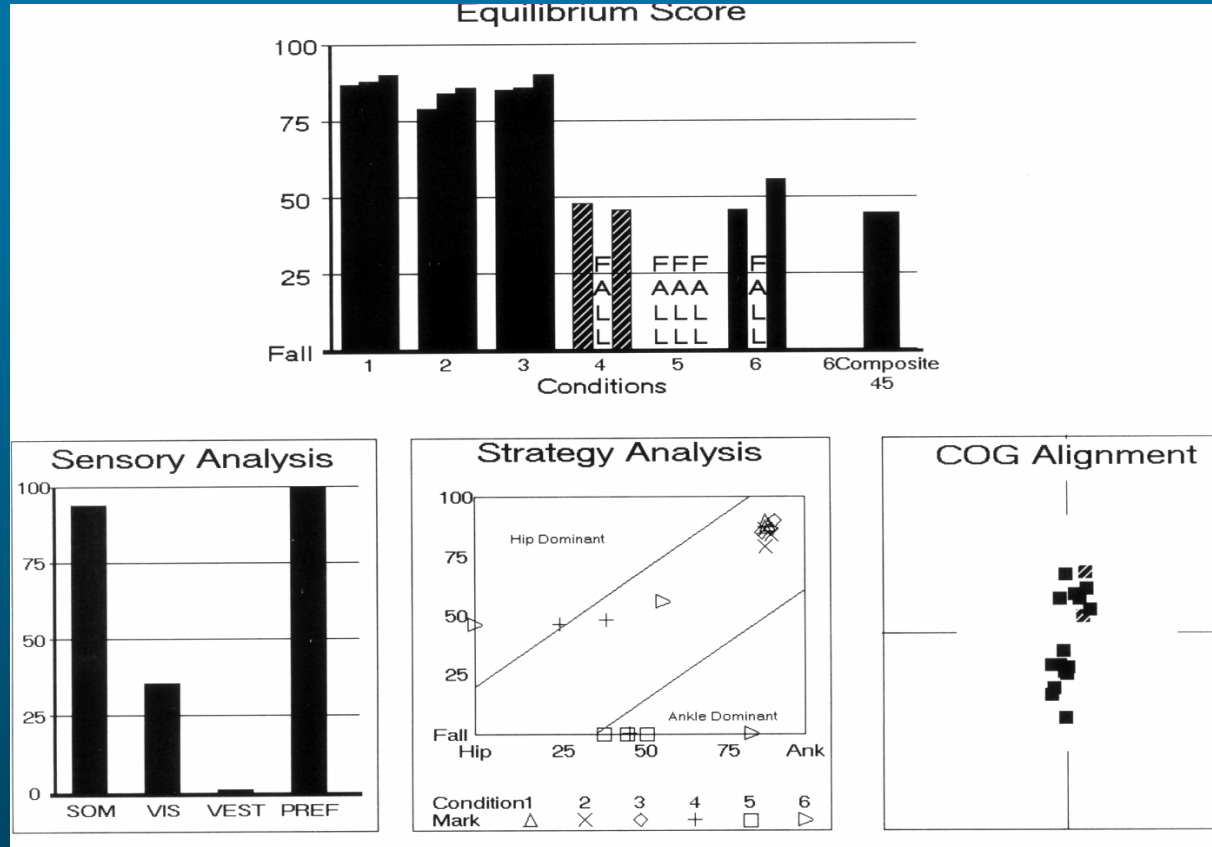
- **VFT: Risk exists**
  - Caloric exam = 27% UW
  - Rotary chair examination = CNT (low CRP)
  - CDP = Vestibular + Visual patterns



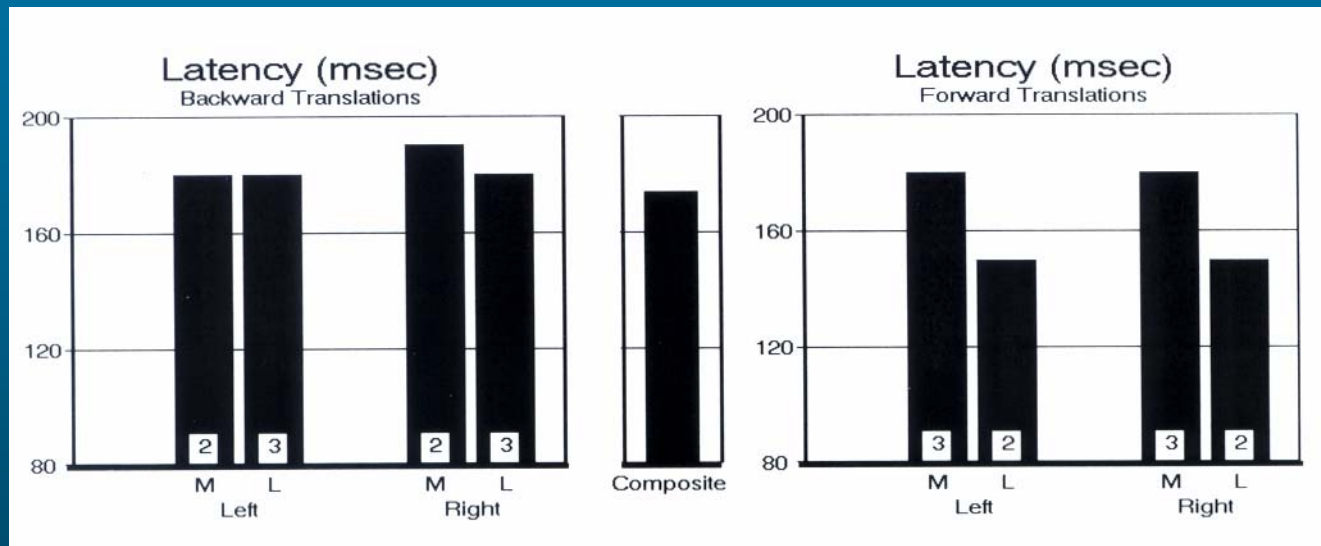
# ENG



# CDP



# Automatic Postural Responses

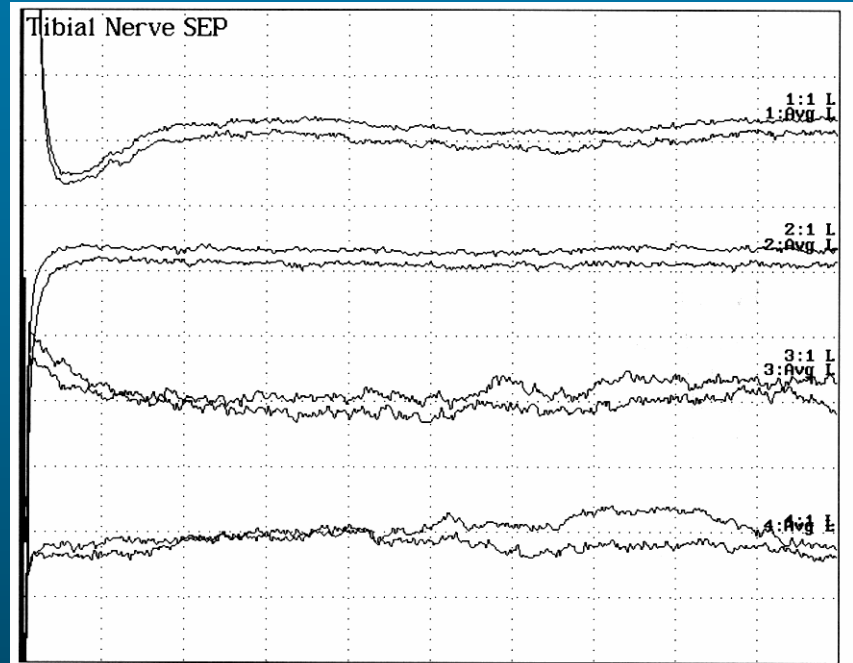
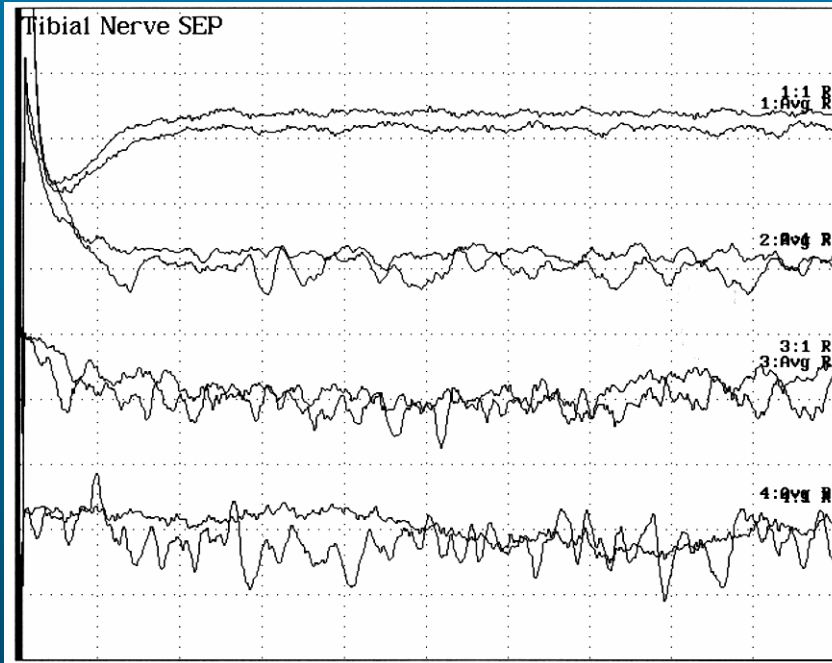


# Proprioception (somesesthesia)

- **Proprioception: Risk exists**
  - LLE & RLE vibration threshold > 40 dB HL)
  - p. tibial n. SEP abs. bilaterally
  - bilateral median n. SEP peripheral component abs. with delayed subcortical and cortical components

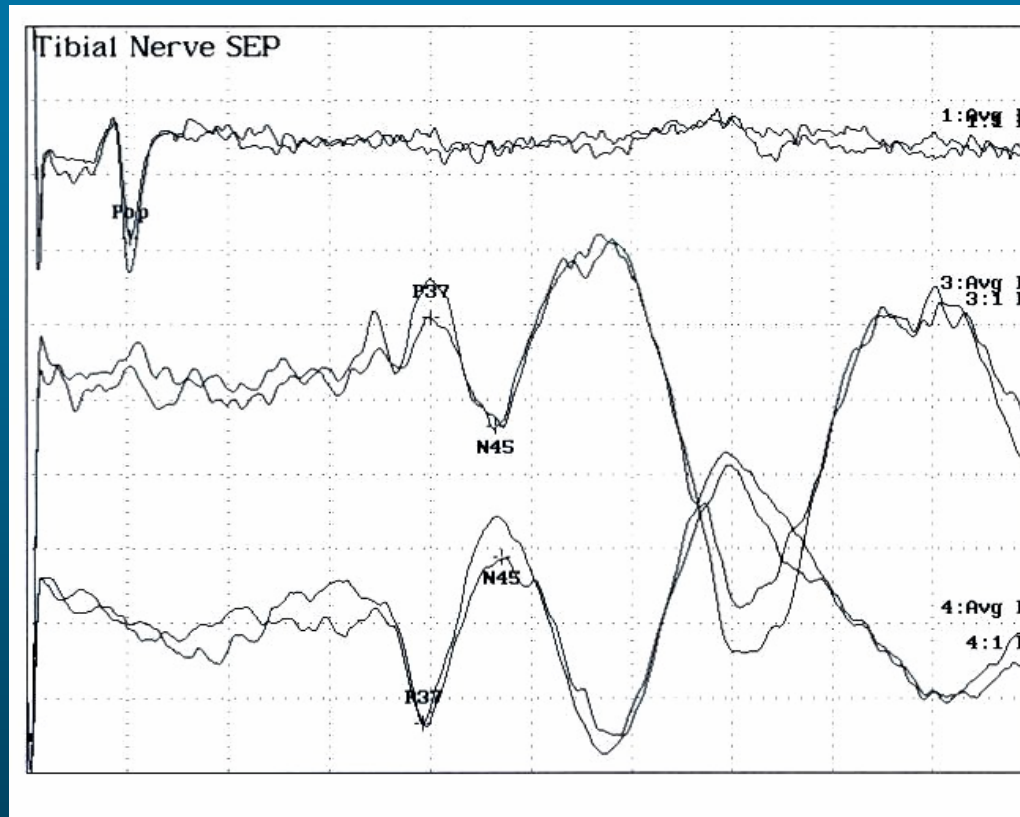


# Tibial n. SEP

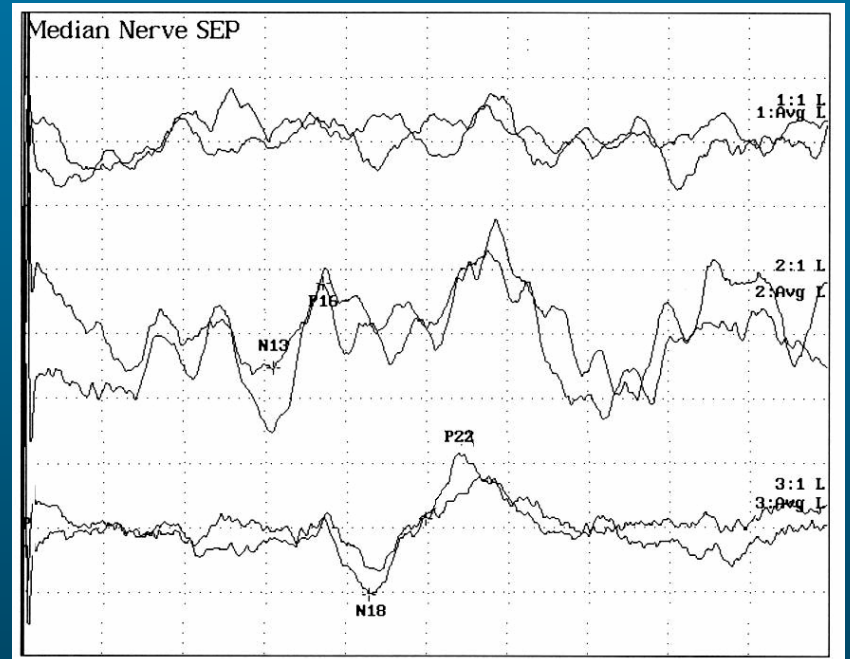
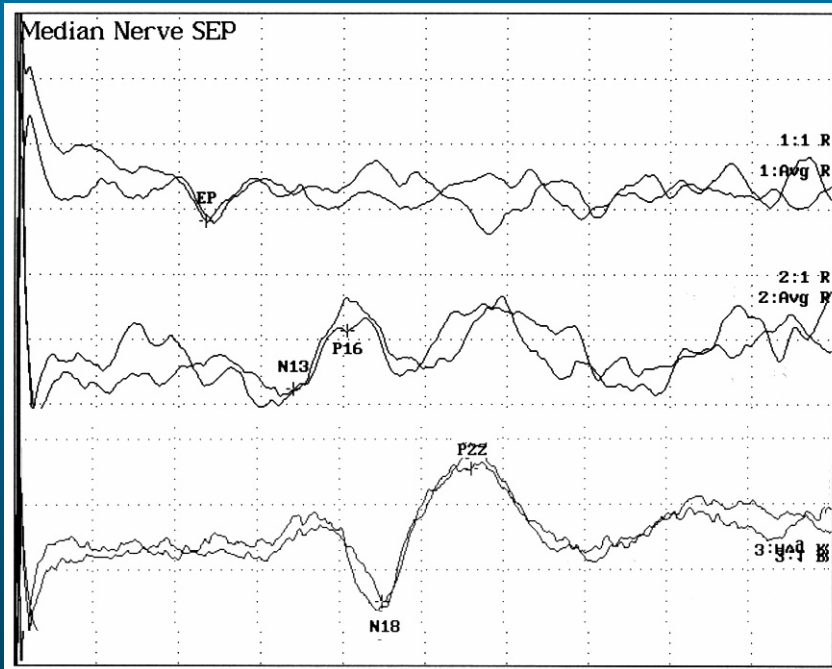




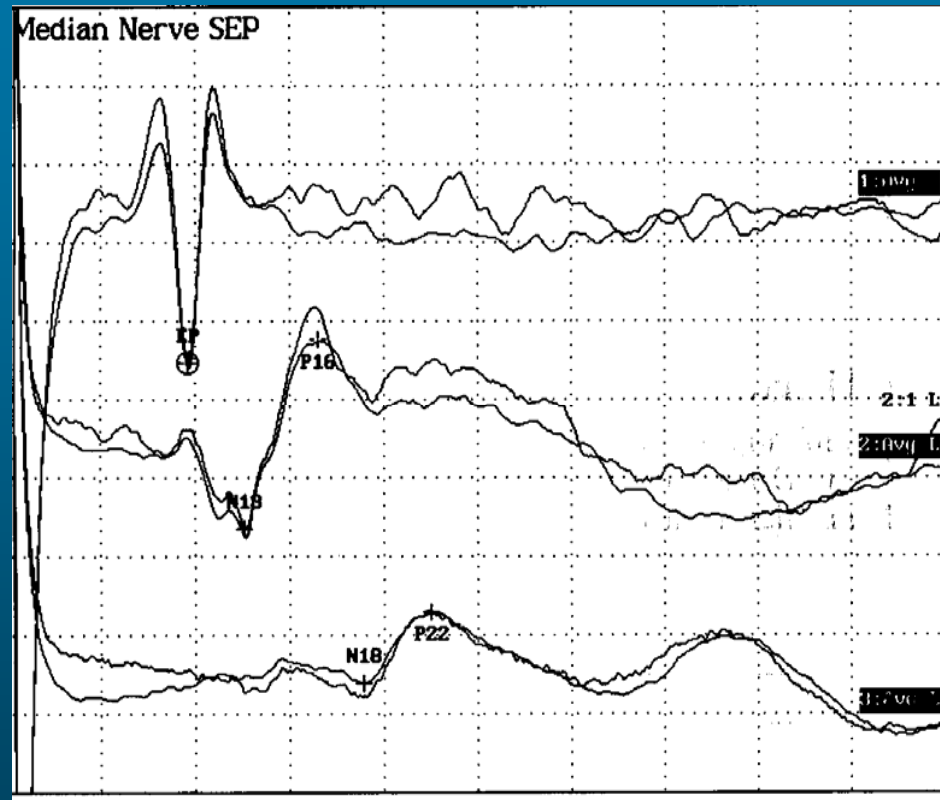
# Normal Tibial n. SEP



# Median n. SEP



# Normal Median n. SEP



# Origins of Instability

- Postural hypotension (situational)
- Visual impairment (low CRP, monocular vision)
- Unilateral peripheral vestibular system disorder
- Depression
- Somesthetic system impairment (explains abn automatic postural responses)



# Recommended Interventions

<b>Risk factor</b>	<b>Recommendation</b>
<b>Postural hypotension</b>	<b>Assessment of htn med by PCP</b>
<b>Visual impairment</b>	<b>Ophthalmology assessment to r/o diabetic retinopathy</b>
<b>Vestibular impairment</b>	<b>Physical therapy for vestibular rehab</b>
<b>Depression</b>	<b>Recc referral by PCP to psychology/psychiatry</b>
<b>Somesthesia impairment</b>	<b>Physical therapy for assistive device/s</b>



# Intervention



Vanderbilt Bill Wilkerson Center



When others can't be with you, Lifeline is...

24-hours-a-day,  
365-days-a-year.

**Henry Ford Health System**  
**LIFELINE**  
**(313) 874-6565**

## Who is Lifeline?

For over 20 years, Lifeline has been North America's leading personal response service. We've helped over 4 million people just like you make their personal declaration of independence.

Our goal is to give you the confidence to continue to live independently in your own home—doing things for yourself. We do this by ensuring that you know whenever you need help, it's just a button push away.

To call for help, you simply press the Personal Help Button you wear as a pendant or on a wristband. The Personal Help Button activates a small in-home communicator that automatically dials the Lifeline Response Center.



The attractive Classic Pendant™ and Slimline™ Wristband Personal Help Buttons are small, lightweight and waterproof.



Lifeline CarePartner™ Communicators are small and simple to use.



Our CarePartner Telephone™ Communicator has large buttons, a high-volume speaker, and VoiceAssist™—a friendly, reassuring voice that guides you in the use of the phone.

# The Lifeline Fall Prevention Checklist

- ✓ Have a lamp or light switch that you can easily reach without getting out of bed.
- ✓ Use night-lights in the bedroom, bathroom and hallways.
- ✓ Keep a flashlight handy.
- ✓ Have light switches at both ends of stairs and halls. Install handrails on both sides of stairs.
- ✓ Turn on the lights when you go into the house at night.
- ✓ Add grab bars in shower, tub and toilet areas.
- ✓ Use bath mats with suction cups.
- ✓ Use nonslip adhesive strips or a mat in shower or tub.
- ✓ Consider sitting on a bench or stool in the shower.
- ✓ Consider using an elevated toilet seat.
- ✓ Wear nonslip, low-heeled shoes or slippers that fit snugly. Don't walk around in stocking feet.
- ✓ Remove all extraneous clutter in house.
- ✓ Keep telephone and electrical cords out of pathways.
- ✓ Tack rugs and glue vinyl flooring so they lie flat. Remove or replace rugs or runners that tend to slip, or attach nonslip backing.
- ✓ Make certain that carpets are firmly attached to the stairs.
- ✓ Use helping devices, such as canes, when necessary.
- ✓ Purchase a step stool with high and sturdy handrails. Repair or discard wobbly step stools. Do not stand on a chair to reach things. Store frequently used objects where you can reach them easily.
- ✓ Paint the edges of outdoor steps and any steps that are especially narrow or are higher or lower than the rest.
- ✓ Paint outside stairs with a mixture of sand and paint for better traction. Keep outdoor walkways clear and well lighted.
- ✓ Keep snow and ice cleared from entrances and sidewalks.
- ✓ Review medications with your doctor or pharmacist. Some drugs, including over-the-counter drugs, can make you drowsy, dizzy and unsteady.



# Effects of Interventions

Lord et al. 2001

Study	Follow-up period (mo)	Event rate - Control Group	Event rate - Treatment Group	Relative Reduction in Risk (CER-ERT/CER)
Close et al. (1999)	12	52%	32%	38%
Tinetti et al. (1994)	12	47%	35%	26%
Wagner et al. (1994)	12	37%	28%	24%
Fabacher et al. (1994)	12	23%	14%	39%
Hornbrook et al (1994)	23	44%	39%	11%



# Outcomes of Falls Interventions Tinetti et al. (1994)

## The New England Journal of Medicine

©Copyright, 1994, by the Massachusetts Medical Society

Volume 331

SEPTEMBER 29, 1994

Number 13

### A MULTIFACTORIAL INTERVENTION TO REDUCE THE RISK OF FALLING AMONG ELDERLY PEOPLE LIVING IN THE COMMUNITY

MARY E. TINETTI, M.D., DOROTHY I. BAKER, PH.D., R.N., C.S., GAIL McAVAY, M.S.,  
ELIZABETH B. CLAUS, PH.D., PATRICIA GARRETT, M.H.S., R.N.-C., MARGARET GOTTSCHALK, P.T.,  
MARIE L. KOCH, M.S., P.T., KATHRYN TRAINOR, M.S., AND RALPH I. HORWITZ, M.D.



Vanderbilt Bill Wilkerson Center

# Outcomes of Interventions Tinetti et al. (1994)

- Followed 301 pts (148 controls, 153 in thx group) for 1 year
- Targeted risk factors =
  - Postural hypotension
  - Use of sedative meds
  - $\geq 4$  prescription meds
  - Impairment of balance



# Outcomes of Interventions

## Tinetti et al. (1994)

- Targeted risk factors (cont'd) =
  - Unsafe transfers (bathroom, bed)
  - Gait impairment
  - Impaired leg strength
  - Impaired arm strength/motion



# Number of Subjects in Thx Group (N = 153)

<i>Risk Factor</i>	<i>W-risk factor</i>	<i># receiving intervention</i>
<i>Postural hypotension</i>	70	69
<i>Use of sedative meds</i>	29	22
<i>Use of &gt; 4 prescription meds</i>	65	52
<i>Unsafe transfers</i>	98	80
<i>Impaired gait</i>	92	86
<i>Impaired balance</i>	95	88
<i>Impaired leg strength</i>	56	37
<i>Impaired arm strength ROM</i>	45	20



# Incidence of Falls at 1 yr F/U

<i>Outcome</i>	<i>Treated Group</i>	<i>Controls</i>
<i># pts w-falls</i>	<b>52</b>	<b>68</b>
<i># of falls</i>	<b>94</b>	<b>164</b>
<i># pts w-falls requiring med care</i>	21	26
<i># falls requiring med care</i>	<b>25</b>	<b>36</b>
<i># falls resulting in serious inj.</i>	13	18
<i># hospitalizations (days)</i>	<b>45 (300)</b>	<b>60 (671)</b>



# Cost-effectiveness of Interventions

Tinetti et al. 1994

- After 1 yr treatment group had mean decline of 1.1 risk factors
- Cost of interventions were \$891/pt.
- Cost per fall prevented = \$1,947
- Cost per fall requiring medical care = \$12,392
  - In 1994 \$'s = close to ave. cost per hospitalization of elderly who have fall-related injuries



# Cost-effectiveness of Interventions

- **Cost savings also include:**
  - Reduction in incidence of falls (and fall-related hospitalizations)
  - Improvement in functional independence
  - Increase in patient's confidence in performing daily activities







**Vanderbilt Bill Wilkerson Center for Otolaryngology  
and Communication Sciences**

# **Development of a Risk of Falls Assessment Clinic**

**Gary P. Jacobson, Ph.D.  
Devin L. McCaslin, Ph.D.  
Vanderbilt Bill Wilkerson Center**

**End**



**Vanderbilt Bill Wilkerson Center**

# Assessment of Somesthesia in the Elderly

- Age results in decreased ability to detect passive movement of the foot (direction and position).
- Associated with disorders causing distal peripheral neuropathies
  - e.g. diabetes



# Effects of Impaired Somesthesia

Lord et al. (1991)

- Somesthesia is the most important sensory system in maintenance of **static** postural stability
- Increased body sway on either firm or compliant surface with eyes open is associated with:
  - Decreased tactile sensitivity
  - **Decreased joint position sense**
  - **Decreased vibration sense**



<b>Risk of Falls Assessment</b>	
CPT code	Description
96150	Health and behavior assessment-initial assessment**
80060	Nursing visit 45-60 minutes (We bill this for BP, Vision, MMSE, Gait test, history)
95925	Short latency somatosensory evoked potential study upper extremity
95926	Short latency somatosensory evoked potential study lower extremity
95882	Cognitive evoked potential
92541	Spontaneous nystagmus test
92542	Positional nystagmus test
92543	Caloric vestibular test
92544	Optokinetic nystagmus test
92545	Oscillating tracking test
92546	Sinusoidal vertical axis rotation test
92547	Use of vertical electrodes
92548	Computerized dynamic posturography

