Comprehensive, Customized, and Creative Treatment of Persons with Impaired Balance

Colin R. Grove, PT, DPT, MS, NCS
PhD Candidate, University of Wisconsin-Madison, Institute for Clinical and Translational Research
Physical Therapist-Expert Clinician, UW Health
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I have no disclosures or conflicts of interest.

What you see here is just stuff I use...
...or found on Google Images
Introduction:

Ecologically-based Rehabilitation

The ability to maintain the center of mass relative to the base of support

Well... yes... and...
Balance Functions (Horak)

- Align the body
- Orient the body posture
- Maintain stability before, during, and immediately after voluntary activities
- React to perturbations
- Protect the body in the event of a fall
- Stabilize vision during head, movement

Gait Functions (Patla)

- Establish initial posture and orientation
- Initiate and terminate locomotion
- Coordinate muscle activation patterns
- Ensure dynamic stability of the moving body
- Adapt locomotor patterns to environmental changes
- Guide locomotion towards a goal
- Conserve fuel
- Maintain structural stability of the body
Inverted Pendulum Models

**Postural Balance**

- Center of mass
- Degrees of Freedom
- Biomechanical
- Strength and Tone
- Limits of Stability

**Gait**

- Movement Strategies
- Automatic Adjustments
- Reactive Responses

**Cardiopulmonary**
Cardiovascular Response
Energy Cost

**Cognition**
Attention
Learning

**Dynamic Control**
Gait
Proactive

**Sensory Strategies**
Perception
Integration
Weighting

**Orientation in Space**
Visual Vertical
Postural Vertical

**Emotional**
Motivation
Psychological Status


http://rspb.royalsocietypublishing.org/content/280/1762/20130700  
http://rspb.royalsocietypublishing.org/content/280/1762/20130700
• Impairment in **any of these systems** can lead to altered balance and mobility function

• A **detailed examination** enables the clinician to determine the system(s) at fault and to develop **targeted treatment** for impaired balance

• Successful interventions also depend on the clinician’s ability to **prioritize interventions**

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Adapted from WHO

```
Health Condition (disorder/disease)

Function/Structure (Impairment)  Activities (Limitation)  Participation (Restriction)

Environmental Factors  Personal Factors
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Ecological Model

- Motor skill emerges from the interaction of many systems
- Balance is complex
- Examination drives interventions
- Customization is crucial
- Interventions arise from manipulation of the individual, task, and environment
Individual Variables

- Biomechanical
  - ROM, Flexibility, Strength
- Cognition
  - Memory, Attention, Learning
- Emotion and Motivation
  - Psychological state, Behavior, Lifestyle
- Cardiopulmonary
  - Cardiovascular and respiratory response to activity
- Dynamic Control
  - Gait, Proactive
- Postural and Gaze Strategies
  - Automatic, Reactive, VOR
- Sensory Organization
  - Perception, Integration, Weighting
- Orientation in Space
  - Subjective visual and postural vertical

Environmental Variables

- Optokinetic Stimulation
  - Background complexity, Visual Motion
- Contextual Variability
  - Changing contextual demands
- Ambient Conditions
  - Lighting and Weather Conditions
- Terrain and Architecture
  - Steps, Curbs, Surface Characteristics
- Postural Transitions
  - Stop, Start, Turns
- Traffic Density
  - People, Vehicular
Task Variables

- Frequency
  - Sessions, Augmented Feedback
- Intensity
  - Repetitions, Rest
- Spatial Characteristics
  - Distance, Amplitude
- Temporal Factors
  - Velocity, Time, Coordination
- Physical Load
  - Transport, Manipulate
- Target Characteristics
  - Size, Speed, Contrast
- Practice Schedule
  - Random, Variable, Blocked

Super-impairment

- Postural balance is far more complex than a simple relationship between the center of mass and the base of support

- Imbalance is a super-impairment that requires a comprehensive approach to treatment
How do you know to intervene?

- The relationships between health, impairments, activity limitations, and participation restrictions are complex and dynamic
- Impairments in body structure/function alone do not result in specific activity limitations
- Activity limitations that lead to participation restriction depend on the individual’s impairments and the “strategies” that person uses to compensate for those impairments

Adapted from Horak (2006)

What is needed for success?

- Knowledge of...
  - the systems controlling normal equilibrium
  - the postural control systems likely to be disordered by aging and pathology
  - expectations for recovery based on factors likely to influence outcome
  - environmental influences on balance
  - motor learning concepts regarding task development
- A **clinical framework** for assessment and treatment
- Understanding of the patient’s “lived experience”

  » Adapted from Horak, Henry, Shumway-Cook (1997)
Course Objectives

1. Implement a comprehensive balance assessment in order to accurately diagnose underlying impairments related to abnormal postural balance and locomotion

2. Select appropriate intervention strategies to address specific aspects of impaired balance based on data from a systems approach to assessment

3. Integrate patient-specific factors when designing interventions that are personalized for each patient

History: Questions to Ask

- Can you describe your symptoms?
- How long ago did the symptoms start?
- Describe the onset of your symptoms?
- Are symptoms improving, worsening?
- Do you have any hearing problems?
- Do you experience other symptoms with your dizziness?
- Do you have any visual problems?
History: Questions to Ask

- How strong are the symptoms?
- Are your symptoms continuous or episodic in nature?
- What time of day is best, worst?
- When did you last have your symptoms?
- How long do these spells last?
- How many times per day do you experience symptoms?
- Do you experience a sense of being off-balance (disequilibrium)?
- What relieves your symptoms?
- What provokes your symptoms?
History: Questions to Ask

Do you drift when you walk, to which side?

Do you stumble or side-step while walking?

Is the disequilibrium worse with fatigue, in the dark, outside, or on uneven surfaces?

Does the feeling of disequilibrium occur when you are lying down, sitting, standing or walking?

The Activities-specific Balance Confidence (ABC) Scale

Instructions to Participants:
For each of the following, please indicate your level of confidence in doing the activity without losing your balance or becoming unsteady from choosing one of the percentage points on the scale from 0% to 100%. If you do not currently do the activity in question, try and imagine how confident you would be if you had to do the activity. If you normally use a walking aid to do the activity or hold onto someone, rate your confidence as if you were using these supports. If you have any questions about answering any of these items, please ask the administrator.

The Activities-specific Balance Confidence (ABC) Scale
For each of the following activities, please indicate your level of self-confidence by choosing a corresponding number from the following rating scale:

0% 10 20 30 40 50 60 70 80 90 100%
no confidence 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
completely confident

*How confident are you that you will not lose your balance or become unsteady when you:

1. walk around the house? ______% 
2. walk up or down stairs? ______% 
3. bend over and pick up a slipper from the front of a closet floor ______% 
4. reach for a small can off a shelf at eye level? ______% 
5. stand on your tiptoes and reach for something above your head? ______% 
6. stand on a chair and reach for something? ______% 
7. sweep the floor? ______% 
8. walk outside the house to a car parked in the driveway? ______% 
9. get into or out of a car? ______% 
10. walk across a parking lot to the mall? ______% 
11. walk up or down a ramp? ______% 
12. walk in a crowded mall where people rapidly walk past you? ______% 
13. are bumped into by people as you walk through the mall? ______% 
14. step onto or off an escalator while you are holding onto a railing? ______% 
15. step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? ______% 
16. walk outside on icy sidewalks? ______%


ABC

• Populations:
  – Elderly
  – Multiple Sclerosis
  – Parkinson's
  – Stroke
  – Transtibial Amputation
  – Vestibular Disorders
DHI

- Populations:
  - Vestibular disorders
  - Benign Paroxysmal Positional Vertigo (BPPV)
  - Individuals with dizziness
  - Multiple Sclerosis (MS)
  - Brain Injury
  - Geriatrics

Dizziness Handicap Inventory

Instructions: The purpose of this scale is to identify difficulties that you may be experiencing because of your dizziness or unsteadiness. Please answer “yes”, “no” or “sometimes” to each question. Answer each question as if applies to your dizziness or unsteadiness only.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>QUESTION</th>
<th>Y</th>
<th>N</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Does looking up increase your problem?</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Because of your problem, do you feel frightened?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Because of your problem, do you restrict your travel for business or recreation?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Because of your problem, do you restrict your social life?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Because of your problem, do you have difficulty getting in or out of bed?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Does your problem significantly reduce your participation in social activities such as going out to dinner, the movies, dancing, in public places?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Because of your problem, do you have difficulty eating?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Does performing more ambitious activities such as sports or dancing or household chores such as vacuuming or putting dishes away increase your problem?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Because of your problem, are you afraid to leave your home without having someone accompany you?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Because of your problem, are you embarrassed in front of others?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Do-quick movements of your head increase your problem?</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Because of your problem, do you avoid heights?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Does running or in bed increase your problems?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Because of your problem, is it difficult for you to do common homemaking or yard work?</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Because of your problem, are you afraid people may think you are intoxicated?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Because of your problem, is it difficult for you to walk by yourself?</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Because of your problem, do you hesitate to move quickly?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Because of your problem, is it difficult for you to concentrate?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Because of your problem, is it difficult for you to walk around the house in the dark?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Because of your problem, are you afraid to stay at home alone?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Because of your problem, do you feel handicapped?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Has your problem placed stress on your relationship with members of your family or friends?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Because of your problem, are you depressed?</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Does your problem interfere with your job or household responsibilities?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Does bending over increase your problem?</td>
<td>F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL P E F

0-20: severe perception of handicap, 21-40: moderate perception of handicap, 41-60: low perception of handicap

Past History

Is the patient carrying baggage?
Past History

- Past medical history and co-morbidities?
- Have you been in an accident?
- Do you smoke, amount?
- Do you drink alcohol, amount, frequency?

Past History (continued)

- Medical work up and tests to date?
- Treatment to date and effect?
  - Medical
  - Physical Therapy
Past History (continued)

- **What medications do you take?**
  - Potential Ototoxic Medications
    - (Table 21-2 in Umphred)
  - How many medications do you take?
    - Polypharmacy increase the risk for falls
  - Caution with anti-vertiginous medications
    - meclizine
    - scopolamine

- **Cardiopulmonary**
  - Six Minute Walk Test
  - Balke Treadmill Test

- **Biomechanical**
  - Functional Reach Test
  - Limits of Stability

- **Cognition**
  - Timed Up & Go with Dual Task
  - Trail Making A and B

- **Dynamic Control**
  - Four Square Step Test
  - Timed Up & Go
  - Dynamic Gait Index
  - Functional Gait Assessment

- **Movement Strategies**
  - Berg Balance Scale
  - Five Times Sit to Stand
  - Push & Release
  - Motor Control / Adaptation Tests

- **Sensory Strategies**
  - Sensory Organization Test
  - mCTSIB
  - Incline Toes Up

- **Orientation in Space**
  - Fukuda Stepping Test
  - Subjective Vertical

- **Emotional**
  - Activities-specific Balance Confidence
  - Dizziness Handicap Inventory
Cardiopulmonary
Six Minute Walk Test Balke Treadmill Test

Biomechanical
Functional Reach Test Limits of Stability

Cognition
Timed Up & Go with Dual Task Trail Making A and B

Dynamic Control
Four Square Step Test Timed Up & Go Dynamic Gait Index Functional Gait Assessment

Movement Strategies
Berg Balance Scale Five Times Sit to Stand Push & Release Motor Control/Adaptation Tests

Sensory Strategies
Sensory Organization Test mCTSIB Incline Toes Up

Orientation in Space
Fukuda Stepping Test Subjective Vertical

Emotional
Activities-specific Balance Confidence Dizziness Handicap Inventory

NO TEST STANDS ALONE

Is the BESTest at its Best? A Suggested Brief Version Based on Inter-rater Reliability, Validity, Internal Consistency, and Theoretical Construct

Background: The disease continuum is related to the gait dysfunction and gait re-education that may occur in post-stroke patients. The initial goal is to minimize the risk of falling. This study investigated the best way to evaluate the patient's gait function and assess their ability to stand alone.

Methods: This was a randomized trial with 100 participants (50 in each group) with a mean age of 60 years. All participants had a history of stroke. The primary outcome was the Timed Up & Go (TUG) test, which was performed twice by the same investigator.

Results: The TUG test had a correlation of 0.85 with the Berg Balance Scale (BBS). The TUG test was found to be a reliable and valid tool for assessing gait function in stroke patients. The TUG test was also found to be a more sensitive tool for detecting gait changes in stroke patients than the BBS.

Conclusion: The TUG test is a reliable and valid tool for assessing gait function in stroke patients. The test should be used as a part of the gait assessment in these patients. Further studies are needed to validate the TUG test in other populations.
Sensory Organization

High-tech

Low-tech

Motor Control

High-tech

Low-tech

(A) Performing the Push and Release Test

PUSH

Backward Push

Hips and Shoulders Behind Heels

RELEASE

Backward Step
Optokinetics

High-tech

Low-tech
It is possible to do a good exam anywhere with low-tech tests and minimal equipment in 15 minutes on a budget

Bedside Balance Systems Test

- Five Times Sit to Stand  
  – (1 minute)
- Modified Clinical Test of Sensory Interaction in Balance  
  – (2 minutes)
- Single Leg Stance  
  – (1 minute)
- In-place Response  
  – (1 minute)
- Compensatory Stepping  
  – (1 minute)
- Functional Reach Test  
  – (1 minute)
- Four Square Step Test  
  – (1 minute)
- Timed Up and Go + Dual-task Timed Up and Go  
  – (3 minutes)
- 4 Item Dynamic Gait Index  
  – (4 minutes)
- 10 Meter Walk Test  
  – (1 minutes)
Don’t Forget The Basics

• Feet
• Footwear
• Somatosensory
• Vision
• Biomechanical
• Neuromuscular
• Non-equilibrium coordination

Additional Tests
Dynamic Visual Acuity

- Early Treatment Diabetic Retinopathy Study (ETDRS) Chart
- Distance specific
- Record lines changed
- Preliminary evidence for including VOR x 1

Positional Tests

9% of younger and older adults have BPPV without reports of the classic symptoms
Tools for Observing Nystagmus

Frenzel Lenses

Ganzfeld

Ophthalmoscope

Micromedical Technologies

Interacoustics

Questions to Consider When Testing

1. Who is your patient (context, population)?
2. Which aspect of health are you assessing?
3. How is the test designed to be used?
4. What are your and your patient’s goals?
1. Who is your patient?

- Health Condition
- PT Diagnosis
- Prognosis
- Contextual Factors

2. Which aspects health condition?

<table>
<thead>
<tr>
<th>Body Structure &amp; Function</th>
<th>Activity Limitation</th>
<th>Participation Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities-specific Balance Confidence Scale</td>
<td>Five-times Sit to Stand</td>
<td>Vestibular Activities and Participation Measure</td>
</tr>
<tr>
<td>Modified Clinical Test of Sensory Interaction in Balance</td>
<td>Functional Reach Test</td>
<td></td>
</tr>
<tr>
<td>In-place Response Test</td>
<td>4-item Dynamic Gait Index</td>
<td></td>
</tr>
</tbody>
</table>
3. How is the test used?

• Domain(s) measured
• Administration instructions (avoid drift)
• Scoring and Interpretation (per population)
  – Normative data
  – Falls risk cut score
• Psychometrics (per population)
  – e.g. Minimal Detectable Change
  – e.g. Minimal Clinically Important Difference
More than a Score

• Movement observation
• Psychological response
• Cardiovascular response
• Underlying impairments
• Others...
4. What are your goals?

• Understanding the **saliency** of personal and environmental contextual factors guides clinical decision making

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**Course Objectives**

1. Implement a comprehensive balance assessment in order to accurately diagnose underlying impairments related to abnormal postural balance and locomotion
2. Select appropriate intervention strategies to address specific aspects of impaired balance based on data from a systems approach to assessment
3. Integrate patient-specific factors when designing interventions that are personalized for each patient
How do you decide what intervention approach is right for your patient?

https://safercommunity.net/falls-prevention/prevention-programs/
Intervention Approaches

Packaged Interventions
• Stepping On
• Tai Chi Fundamentals
• Moving for Better Balance
• NoFalls
• Living Falls Free
• Balancing Act
• Ballroom Basics fo Balance

Customized Interventions
• Physical Therapy
• Geriatrics Falls Clinics
• Faint and Falls Clinic

Do you have fidelity?
• The CDC is implementing three research-backed programs (e.g. Otago) across the US
• In order to cite results of these programs to justify your therapy, you must accurately reproduce the program
Augmented and Alternative Approaches to Balance Rehab

Systematic Reviews

Meta-analyses

Virtual Reality
Impaired Adults

Booth et al. 2013

- 8 RCTs, N = 239
- Virtual vs. control group
- Methods varied
- No between-group differences for Berg Balance, gait speed, 30-second Chair Stand, and Timed Up & Go

Vestibular

Bergeron et al. 2015

- 7 studies, N = 176
- Methods varied
- Significantly reduced sx
- Complexity and type of device did not matter
- Total time spent in virtual reality was related to outcomes
Chronic Stroke

Chen et al. 2015
- 9 studies
- Virtual vs. control group
- Methods varied
- Moderate evidence to support virtual reality as an adjunct to standard therapy for balance training

Stroke

Laver et al. 2015
- 37 trials, N = 1019
- Low to very low quality
- Equivalent outcomes for gait speed and global motor function
- Significant differences seen for ADL
Parkinson’s

Bekkers et al. 2016
• 8 trials, N = 263
• Low to very low quality
• Virtual reality superior to standard therapy for step, stride length
• Equivalent results for standardized balance and gait measures

Healthy Seniors

Donath et al. 2016
• 18 trials, N = 619
• Virtual vs. alternative
• Both groups improved
• Better studies show smaller effect sizes
• Slightly less efficacy for virtual interventions
Cerebral Palsy

- Ravi et al. 2017
- 31 studies, N = 369
- Moderate evidence for improved balance and mobility
- Evidence not sufficient to recommend virtual reality for clinical practice

Telerehabilitation
**Stroke**

**Johansson & Wild, 2011**
- 9 studies
- Tele vs. conventional
- Low quality evidence
- Participants satisfied
- Unclear how tele compares to conventional rehab due to few controls

**Chen et al. 2015**
- 7 RCTs
- Tele vs. conventional
- No significant differences in Barthel Index, Berg Balance, Fugl-Meyer
- Outcomes with tele are similar to conventional
**Motor Impaired**

Argostini et al. 2015
- 12 studies, N = 1047
- Tele vs. conventional
- Inconclusive results for neurological patients
- Favorable outcomes for total knee and cardiac patients

**Total Knee**

Shukla et al. 2017
- 6 studies, N = 408
- Patients highly satisfied
- No difference in ROM
- Similar outcomes for physical activity and functional status for tele and conventional rehab
Exergaming / Serious Games

Older Adults

Molina et al. 2014

- 13 studies
- Methods varied
- Low quality studies
- Some outcomes favor gaming over control
- Consensus around the positive motivational effects of gaming
Elderly Fallers

Guo et al. 2016
- 25 articles
- Methods varied
- Physical function and cognition improved overall
- Superiority over conventional therapy unclear

Impaired Adults

Bonnechere et al. 2016
- 126 papers
- Games vs. conventional
- Use of video games in rehab results in similar outcomes
- Video games could be used for motivation and carry-over in the home
3-dimensional Exercise

Rochester et al. 2011

- 94 RCTs, N = 9,821
- Included a variety of interventions
- 3D exercise led to significant improvements in Timed Up & Go, Single Leg Stance, and Berg Balance
Older Adults

Fernandez-Arguelles et al. 2014
• 7 articles, N = 354
• Dance and methods varied
• Positive effects on factors associated with risk for falling
• Evidence is not conclusive

Parkinson’s

Dreu et al. 2012
• 6 studies, N = 158
• Improvements seen in Berg Balance, Timed Up & Go, and Stride Length
• Music-based therapy appears promising for persons with Parkinson’s
Parkinson’s

- Sharp & Hewitt 2014
- 5 trials
- Dace and methods varied
- Improved UPDRS Motor, Berg Balance, & gait speed (vs. no exercise)
- Improved Berg Balance & quality of life (vs. other exercise)

Parkinson’s

- Lotzke et al. 2015
- 13 articles
- Small samples
- Improved UPDRS, Mini-BEST, Berg Balance, Timed Up & Go
- No effect on 6-minute walk or Freezing of Gait
Healthy Elders

Huang & Lui 2015
- 7 RCTs, N = 1088
- Tai Chi vs. other
- Improvements in Timed Up & Go, Berg Balance Scale, and Single Leg Stance
- Tai Chi Chuan is beneficial for healthy elderly

Older Adults

Hwang & Braun, 2015
- 18 studies
- Dance for adults with and without health conditions
- Findings suggest that dance, regardless of the type, leads to significant improvements in strength, and endurance, balance
Distractions in the Literature

- 80% of all published research is false (Ioannidis, 2005)
- Innovation is happening
- Observational studies often produce larger effects
- More rigorous studies tend to show equivalency
- Significant effects depend on choice of outcome
- Variability in study methods is problematic
- Rely on meta-analyses more than systematic reviews

Back to Basics: Balance Exercise Rx

In the most basic sense, prescription of balance exercises comes down to the abnormal test becoming the exercise
Test Results to Exercise Rx

- Five-times Sit to Stand
  - Anticipatory adjustments
- Modified CTSIB
  - Sensory organization
- Single Leg Stance
  - Decreased base of support
- In-place Responses
  - Ankle and/or hip strategies
- Compensatory Stepping
  - Assisted perturbed stepping
- Functional Reach Test
  - Reaching activities
- Four Square Step Test
  - Multi-directional gait
- TUG/TUG Dual Task
  - Add secondary tasks
- 4-item DGI/DGI/FGA
  - Obstacle course
- 10-meter/6-minute Walk
  - Walking program
Stroop Twister

- YELLOW
- BLUE
- RED
- GREEN

PURPLE  YELLOW  RED
BLACK  RED  GREEN
RED  YELLOW  ORANGE
BLUE  PURPLE  BLACK
RED  GREEN  ORANGE
Obstacle Course and Visual Training

- Rising from a chair
- Stepping over
- Ducking under
- Going around
- Picking up a weight
- Going up and down steps
- Walking a foam beam
- Turning 360 degrees
- Sitting down in a chair

Jones et al. 2012
Dual Tasking

What is the optimal dosage?
American College of Sports Medicine Guidelines: Exercise Quantity & Quality

- Cardiorespiratory
- Resistance
- Flexibility
- Neuromotor
- Balance


ASCM: Cardiorespiratory

- Adults should get at least 150 minutes of moderate-intensity exercise per week.
- Exercise recommendations can be met through 30-60 minutes of moderate-intensity exercise (five days per week) or 20-60 minutes of vigorous-intensity exercise (three days per week).
- One continuous session and multiple shorter sessions (of at least 10 minutes) are both acceptable to accumulate desired amount of daily exercise.
- Gradual progression of exercise time, frequency and intensity is recommended for best adherence and least injury risk.
- People unable to meet these minimums can still benefit from some activity.

ASCM: Resistance

- Adults should train each major muscle group two or three days each week using a variety of exercises and equipment.
- Very light or light intensity is best for older persons or previously sedentary adults starting exercise.
- Two to four sets of each exercise will help adults improve strength and power.
- For each exercise, 8-12 repetitions improve strength and power, 10-15 repetitions improve strength in middle-age and older persons starting exercise, and 15-20 repetitions improve muscular endurance.
- Adults should wait at least 48 hours between resistance training sessions.


ASCM: Flexibility

- Adults should do flexibility exercises at least two or three days each week to improve range of motion.
- Each stretch should be held for 10-30 seconds to the point of tightness or slight discomfort.
- Repeat each stretch two to four times, accumulating 60 seconds per stretch.
- Static, dynamic, ballistic and PNF stretches are all effective.
- Flexibility exercise is most effective when the muscle is warm. Try light aerobic activity or a hot bath to warm the muscles before stretching.

ASCM: Neuromotor

- Neuromotor exercise (sometimes called “functional fitness training”) is recommended for two or three days per week.
- Exercises should involve motor skills (balance, agility, coordination and gait), proprioceptive exercise training and multifaceted activities (tai ji and yoga) to improve physical function and prevent falls in older adults.
- 20-30 minutes per day is appropriate for neuromotor exercise.


Effective Balance Programs

- > 50 hours
- Challenging exercises
- Decreased base
- Minimal use of hands
- Controlled movements
- No walking program
## Dosage Parameters

- **Frequency:**
  - Programs must be feasible
- **Intensity:**
  - The level of challenge must be appropriate
- **Time:**
  - Interventions must provide a sufficient stimulus
- **Type:**
  - Exercises must have meaning

“In determining optimum level of challenge of balance exercises, recommendations commonly relate to the difficulty of the balance task, rather than to the intensity of the activity relative to the ability of the individual....” (Farlie et al, 2013)
How do you set the intensity?

About to Fall

Completely Stable

Rate of Perceived Stability Scale

http://csumotionanalysislab.blogspot.com/p/rate-of-perceived-stability.html
Intensity Markers (Farlie)

**Figure 1.**
Framework created to guide the analysis of verbal and nonverbal responses to testing. Analysis was concentrated on 3 time periods related to task completion and a head-to-toe analysis of verbal responses and nonverbal responses during testing. Each category was scored dichotomously.

**Head**
- **Verbal responses**
  - **Comprehension:** response indicates participant did or did not comprehend instruction
  - **Nature of additional remarks:** response indicates participant has positive, neutral, or negative feelings or attitudes toward the task

**Nonverbal responses**
- **Global:** whole-body reactions, hesitation, sway, whole-body stiffening
- **Cardiorespiratory:** increased depth of breathing, increased respiratory rate
- **Head, neck, and face:** facial expressions, grimacing, biting lips, clenching jaw, and tilting head to side
- **Shoulders and upper limbs:** shoulder shrug, arm flare (any degree), reaching strategy, and stiffening
- **Trunk:** flexion, extension, lateral flexion, and rotation; trunk stiffening
- **Lower limbs:** knee bend, hip flexion/hip strategy, stiffening
- **Hands and feet:** grabbing, holding clothing to brace against, shuffling feet, stepping strategy, ankle dorsiflexion/ankle strategy

**Toe**
Intensity Markers (Farlie)

- A key pretask finding was an increased delay to task commencement with increased task difficulty.
- Physical markers of the intensity were grouped into 3 categories (bracing, postural reactions, and sway) and were increasingly observed as intensity of balance challenge increased.
- Participants described tasks as pushing them toward the limits of their balancing capacity as the intensity of balance challenge increased.
Clinic vs. Home

- Supervision?
- Equipment?
- Assistance?
- Monitoring?
- Adjust visit frequency?
- Added value of clinic?
- Added value of home?

Thoughts on Modifying the Treatment Plan
Response to Interventions

• Immediate
  – Safe!
  – Understanding
  – Correct performance
  – Signs and symptoms

• Delayed
  – Symptoms (especially pain and dizziness)
  – Success at home

Regression

Rules of thumb...
• Reduce
  – Frequency: cut back by 50%
  – Intensity: lower difficulty
  – Time: cut back by 50%
  – Type: change the modality
Progression

Rules of thumb...
- Static to dynamic
- Slower to faster speed
- Wide to narrow base
- Single to dual task taxonomy
- Quiet to busy environment
- Others...

Progress Plateau?

Key questions to ask...
1. Are optimal metrics of change being used?
2. Has the dosage of therapy been sufficient, and
3. If so, why might a plateau be occurring and what, if anything, can be done to change course of care and improve the outcome?
Course Objectives

1. Implement a comprehensive balance assessment in order to accurately diagnose underlying impairments related to abnormal postural balance and locomotion
2. Select appropriate intervention strategies to address specific aspects of impaired balance based on data from a systems approach to assessment
3. Integrate patient-specific factors when designing interventions that are personalized for each patient

Pathology-specific Considerations

- Vestibular
- Acquired brain injury
- Cerebellar ataxia
- Parkinson’s disease
- Multiple sclerosis
- Cardiopulmonary
- Diabetes mellitus
- Cognitive dysfunction
How do we weight the emphasis on different rehabilitation approaches?

**Ecological Model of Balance Rehabilitation**

- **Environment**
  - Optokinetic Stimulation
  - Contextual Variability
  - Ambient Conditions
  - Terrain & Architecture
  - Postural Transitions
  - Traffic Density

- **Individual**
  - Biomechanical
  - Cognition
  - Emotion & Motivation
  - Cardiopulmonary
  - Dynamic Control
  - Postural & Gaze Strategies
  - Sensory Organization
  - Orientation in Space

- **Task**
  - Frequency
  - Intensity
  - Spatial Characteristics
  - Temporal Factors
  - Physical Load
  - Target Characteristics
  - Practice Schedule
History: Case 1JB (Biomechanics)

- 42 year old man
  - Onset x 4-6 years ago
  - Resting tremor
  - Masked face
  - Hypophonia
  - Progressive imbalance
  - Multiple falls
  - Reduced exercise capacity
- Personal Factors
  - Declines PD meds
  - Avid former runner
  - Life Roles
    - Husband
    - Civil Engineer
- Environmental Factors
  - 2-story house, basement, no railings
  - No sidewalks
  - Exercises daily by walking along county highway

- Health Condition
  - Parkinson’s disease
- PT Diagnosis
  - Central
Exam: Case 1JB

Sensory Organization Test

Sensory Organization Test Raw Data

Exam: Case 1JB

Adaptation Test

Limits Of Stability

C. Grove, PT, DPT, MS, NCS
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Goal: ↓ frequency of falling while walking

Environment
No distractions

Individual
Flexibility

Task
Time
Intensity

---

**Goal:** Improve postural alignment to ↑ effectiveness of postural reactions and ↓ frequency of falls in yard and on road he uses for exercise by > 50%

- **Flexibility**
  - 1 set x 4 reps, daily
    - Gastrocnemius
    - Hamstrings
    - Rectus femoris
    - Pectorals
  - Daily spinal mobilization x 5 minutes
    - Supine over a 6 inch Styrofoam roll

- **Response**
  - Patient reports pain in the cervicothoracic junctio during spinal mobilization

- **Possible modifications**
  - **Time**
    - Decrease to 3 minutes
  - **Intensity**
    - Decrease diameter of the roll to 3 inches
History: Case 2KD (Gaze Stability)

- 42 year old woman
  - Onset x 4-6 weeks ago
  - Severe imbalance
  - Multiple falls
  - Walks with SBQC
  - Reduced household duties
  - Interactions with kids hard
  - Unable to drive or work
- Health Condition
  - Central vestibular
  - BVH
- PT Diagnosis
  - Fluctuating + Mixed

- Personal Factors
  - B SNHL (Auto-immune)
  - B esotropia, surgery x 2
  - Financial constraints
  - Life Roles
    - Wife
    - Mother of three
    - Active in church (prayer)
    - Assembly line worker
- Environmental Factors
  - 2-story farmhouse, basement, no railings
  - One dog (falls), one cat
  - Could not tolerate modified job duties, seated only
Exam: Case 2KD

- ABC: 36%
- DHI: 54/100
- DGI: 14/24
- FGA: 13/30
- CDP:
  - Composite = 47(80/70)
  - Vision+Vestibular abnl
- DVA: 7 line change

Goal: Return to driving in familiar places

Environment
Limit optokinetics

Individual
Gaze stabilization

Task
Duration
Position
Goal: Improve dynamic visual acuity to 20/63 or better to facilitate safety and tolerance of driving activities

- Gaze stabilization
  - VOR x 1: 30 sec, 3 x / day
    - Supine
    - Large target
    - Quiet room
    - Plan ceiling

- Motion intolerance
  - Pursuit: 30 sec, 3 x / day
    - Supine
    - Large target
    - Quiet room
    - Plan ceiling

- Response
  - Initially strong sx, but currently reports 25% decrease in dizziness

- Possible modifications
  - Time
    - VOR, pursuit x up to 2 min
  - Optokinetics
    - Plain ceiling as background
  - Position
    - If tolerate above, then perform these seated with full support

Re-eval: Case 2KD

- ABC: 84%
- DHI: 42/100
- DGI: 21/24
- FGA: 23/30
- CDP:
  - Vestibular Pattern
- DVA: 6 line change
Goal: Improve dynamic visual acuity to 20/63 or better to facilitate safety and intolerance of driving activities

- Gaze stabilization
  - VOR x 1: 2 min, 3 x / day
    - Seated
    - Small target
    - Quiet room
    - Plan wall
- Motion intolerance
  - Pursuit: Discontinued

- Response
  - Reports dramatic improvements, and asymptomatic with HEP

- Possible modifications
  - Frequency
    - VOR x 1, 5 x / day
  - Optokinetics
    - Plain wall as background
  - Position
    - If tolerate above, then perform these standing with UE support

Long-term Follow Up: Case 2KD

- ABC: 41%
- DHI: 52/100
- DGI: 21/24
- FGA: 23/30
- CDP:
  - Composite = 53(80/70)
  - Vision+Vestibular abnl
- DVA: 4 line change
- Rx: Resume HEP per prior recommendation
- Return to driving?
History: Case 3GH

- 29 year old woman
  - Onset x 6 months
  - Imbalance
  - Motion intolerance
  - Supermarket syndrome
  - Problems in crowds

- Health Condition
  - Multiple sclerosis

- PT Diagnosis
  - Central vestibular

- Personal Factors
  - Sub-optimal energy conservation techniques
  - Rebif q 3 days
    - Disease modifying med
  - Topamax
    - Migraine HA
  - Life Roles
    - Wife
    - Mother of a colicky infant
    - Interior designer

- Environmental Factors
  - Exposed to busy patterns in design materials
Exam: Case 3GH

- ABC: 68%
- DHI: 64/100
- DGI: 19/24
- FGA: 23/30
- DVA:
  - Horizontal = 2 lines
  - Vertical = 5 lines
- CDP:
  - Composite = 76(80/70)
  - Somatosensory abnl
- MSQ = 41.4

Goal: Improve tolerance of basic ADL

Individual Sensory Strategy

Task Pattern Timing

Environment Lighting

Not to be copied without permission.
Goal: Able to shower, wash hair, and get dressed in the dark without dizziness

- Postural control
  - Somatosensory Training
    - Standing, dim lighting
      - Weight shifting
      - Decreased BOS
  - Possible modifications
    - Lighting
      - Postural control
        - Eyes closed
    - Timing
      - Emphasize training on day 2 and 3 after taking Rebif
- Motion intolerance
  - Movement Pattern
    - Habituation with ADL
      - Rolling over in bed
      - Bending over to crib
    - Possible modifications
      - Brandt-Daroff
      - Bending forward seated
      - ↓ frequency of others

Response
- No falls, asymptomatic with habituation on good days

Possible modifications
- Lighting
  - Postural control
    - Eyes closed
- Timing
  - Emphasize training on day 2 and 3 after taking Rebif

Outcome: Case 3GH

6 visits over 3 months

- ABC: 95%
- DHI: 30/100
- DGI: 23/24
- FGA: 28/30
- DVA:
  - Horizontal = 2 lines
  - Vertical = 3 lines
- CDP:
  - Composite = 82(80/70)
- MSQ = 4.7
History: Case 5SJ

- 46 year old man
  - Onset x 1 month ago
  - Diplopia
  - Reduced endurance
  - Frequent falls with unexpected perturbations
  - Uses SBQC, variable BOS

- Health Condition
  - Vertebral artery dissection
  - Cerebellar, Brainstem CVA
  - Pituitary adenoma

- PT Diagnosis
  - Central vestibular

- Personal Factors
  - Severe HA
  - Eye patch for diplopia
  - Exercises regularly
  - Life Roles
    - Husband
    - Vice-president for major corporation
    - Automobile enthusiast

- Environmental Factors
  - Steep terrain at work between buildings
Case Exam: Case 5SJ

- Stroke Impact Scale: 50%
- Abnl oculomotor
  - Skew deviation
  - L CN VI palsy
- DVA: 8 line change
- 6MW: 1084’ 4 w/w
  - RPE = 13
  - Variable BOS
  - Momentum issues
  - Force regulation impaired

Exam: Case 5SJ

1JB Parkinson’s

5SJ Cerebellar CVA
Exam : Case 5SJ

1JB Parkinson’s 5SJ Cerebellar CVA

Environment
Surface Features

Goal: ↓ tendency to fall when bumped into

Individual
Work Ethic

Task
Scaling
Goal: Maintain balance during standing and walking when nudged unexpectedly or when encountering changes in surface

- **Response**
  - Gait shows improvement, but patient continues to be concerned about falling
  - Unable to perform narrow BOS activities or exercises on 6 inch foam without LOB

- **Possible modifications**
  - **Surface features**
    - Fine line between too narrow and too dynamic of a surface for postural control exercises
  - **Scaling**
    - Slow down, adjust BOS...
    - Match reaction to the size of perturbation through slip and step training

**Movement Strategies**
- Practice using the right strategy at the right time
- Gait training with standard cane with constraints on BOS
- Focus on modulating force production and movement control

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**Exam (Outcome): Case 5SJ**

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Exam (Outcome): Case 5SJ

18 visits; 1 year post-onset
- Improved oculomotor
  - Minimal diplopia: left gaze
- DVA: 1-2 line change
- Ambulation
  - Fully independent
    - All surfaces
    - Without assistive device
- Returned to driving distance up to 200 miles
History: Case 6MR

- 33 year old man
  - Onset x 18 months
    - Pinned by 5000 lb mixer
  - Lightheadedness, neck pain, HA, and daily falls
  - MRI = non-specific white matter changes, VNG = abnl, RC & VEMP = nl

- Health Condition
  - Traumatic Brain Injury
  - Whiplash

- PT Diagnosis
  - Central vestibular

- Personal Factors
  - Work-related injury
  - Hired attorney
  - Farmer
  - Limited financial resources
  - Tylenol for HA
  - Wife working outside home

- Environmental Factors
  - Lives in old farmhouse
  - Hazards in barns
  - Terrain on the farm
  - Chores before sunrise

Exam: Case 6MR
Exam: Case 6MR

- ABC: 46%
- DHI: 50/100
- Abnl COR function
- Spine: tender to palpation throughout cervical spine, restricted A/PROM, pain decreased with moderate forward head posture, able to mobilize upper lumbar spine with decreased HA, dizziness
Goal: Gain confidence with balance while performing farming chores and bending over to play with young child

- **Dynamic Control**
  - Sensory Substitution
    - Use of “cattle prod” cane
    - Sit down instead of bend
    - Play in supine or seated
    - Supplementary lighting
    - Postural Control
      - Decreased BOS allowing visual fixation
      - Surface orientation in standing, eyes closed

- **Response**
  - Patient continues to fall
    - Increased HA, neck pain

- **Possible modifications**
  - Falls prevention counseling
  - Sensory Substitution
    - Headache recovery position instruction
    - Compensatory saccades
    - Imaginary targets supine
    - Postural Control
      - Perform eyes closed exercises in corner with body touching both walls
Outcome: Case 6MR

- 8 visits over 3 months
- Reduced rate of falls to 1-2 x / week
- No change in COR
- No change in HA or neck pain
- Patient went on to fail spine PT and then craniosacral therapy
- Permanent disability
- Compensation pending
History: Case 7PJ

- 46 year old man
  - Onset x 14 months ago
  - Sudden vertigo initially
  - Currently “off” balance
  - Fatigued all the time
  - 50 lb weight gain

- Health Condition
  - Vestibular neuritis

- PT Diagnosis
  - Peripheral hypo-function

- Personal Factors
  - Hx/o panic attacks
  - Morbid obesity
  - Life Roles
    - Husband
    - Father, 3 in middle school
    - Information Technology

- Environmental Factors
  - Becomes dizzy at work when using his computer for long periods

Exam: Case 7PJ

- ABC: 69%
- DHI: 52/100
- DGI: 19/24
- DVA: 5 line change
Goal: Improve feeling of security with activity

- "Where am I?"
  - Week One
    - Somatosensory
      - Surface and body orientation, eyes closed
  - Week Two
    - Vision
      - Vertical alignment
  - Week Three
    - Vestibular
      - Upright control
        - Foam, eyes closed
        - Marching, eyes closed

Goal: Increase balance-related confidence as measured by a score of > 80% on the ABC Scale

- Response
  - Reported increased confidence each week
  - Demonstrated improved stability each week

- Possible modifications
  - Referral to health psychologist
  - Anti-anxiety med
Exam: Case 7PJ

7 visits over 3 months

- ABC: 86%
- DHI: 10/100
- DGI: 24/24
- DVA: 2 line change

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<tr>
<th>Task</th>
<th>Frequency</th>
<th>Intensity</th>
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<td>Spatial</td>
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<td>Characteristics</td>
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<td>Physical Load</td>
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<td>Terrain &amp; Architecture</td>
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<td>Postural Transitions</td>
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C. Grove, PT, DPT, MS, NCS
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History: Case 8DL

- 62 year old man
  - Onset x 1 month ago
  - Difficulty walking
  - Colliding with doorways
  - Tripping over furniture
- Health Condition
  - s/p R PCA CVA
  - Alcoholic encephalopathy
  - Dementia
- PT Diagnosis
  - Central Dysfunction
- Personal Factors
  - Lives with brother’s family
  - Strain in relationships
  - Culture: Indian-born
  - Financial issues
- Environmental Factors
  - Stairs inside with railing
  - Home located on busy street, but several blocks to bus stop

Exam: Case 8DL

- ABC: Not completed
- Vision: LHH
- Cognition:
  - Oriented to person
  - 1/3 short recall
  - Follows 1 step verbal commands
  - Follows demonstration more accurately
- DGI: 15/24
- TUG-DT: Unable to walk while performing mental tasks
- Locates 60% of cues in 100’ in 5 min
- 22 min to navigate x 500’ with > 75% verbal cues
- MD: “Gait is normal”
  - Tested in exam room
  - Pushing family for community access
Exam: Case 8DL

Goal: Go to the grocery store by myself

Environment
Limited Variability

Individual
Meaningful Cues
Navigation

Task
Repetition
Goal: Navigate short distances to unseen point, < 50% verbal cues to promote independence with community access

- Visual scanning
  - Reading
    - Compensatory strategies
  - Walking
    - Visual scanning tasks within home environment

- Reactive postural control
  - Decreased BOS activities
  - Supervised walking on uneven terrain

- Response
  - DGI: 14/24
  - Stops walking while thinking
  - Locates 50% of cues in 100’ hallway in 5 min
  - 15 min to navigate x 500’ with > 80% verbal cues

- Possible modifications
  - Repetition
    - Encouraged supervised practice of HEP
  - Meaningful cues
    - Encouraged use of personal objects, pictures
  - Recall
    - Encourage recall of activities through path reversal

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History: Case 9MI

- 79 year old woman
  - Onset x 7 months ago
    - After panic attack
  - Cyclical spells of vertigo
    - Valium to sx relief
  - Positional vertigo also
  - Asymmetrical B SNHL
  - Walks with SBQC
- Health Condition
  - Mixed Vestibular Disorder
- PT Diagnosis
  - Same

- Personal Factors
  - Anxiety + Depression
  - Diplopia (prism)
  - DDD, DJD
  - Morbid obesity
  - Life Roles
    - Mother
    - Homemaker
    - Active in church
- Environmental Factors
  - Multiple architectural barriers at home

Exam: Case 9MI

- ABC: 34%
- DHI: 58/100
- Abnormal oculomotor
- BBS: 34/56
- CDP: Abnl SOT
- BPPV: L horizontal
- Orthostatic hypotension
- Irregularly irregular HR
Goal: Improve activity tolerance

Environment
Shopping Mall

Goal: Appropriately manage cardiovascular response to activity

- Manage cardiovascular response
  - Orthostatic Hypotension
    - Get up slow
    - Ankle / Hand pumps
    - Increase fluid intake
    - Compression garments
  - Accommodation
    - Fanny pack with phone
  - Behavior modification
    - Use of 4 wheeled walker
    - Guide activity with RPE scale

- Response
  - Sx of BPPV eliminated
  - Sx of OH reduced by 50%
  - Continues to c/o fatigue with < community distances

- Possible modifications
  - Increase Time
    - Walking program with RPE
      - Increase by 10% / month up to 30 minutes, 4-5 times per week as tolerated

- Initiated referral back to PCP
  - Cardiac Work up
    - Stenting procedure
    - Cardiac rehabilitation

Goal: Improve activity tolerance

Individual
Rate of Perceived Exertion

Task
Time
Device
Exam: Case 10LM

- ABC: 24%
- DHI: 96/100
- CDP:
  - Multi-sensory pattern
- BPPV: B posterior
- Rx = CRT B posterior canal during first visit
Follow Up Exam: Case 10LM

- Denies positional sx
  - BPPV: negative
- Complains of disorientation, veering while walking, and feeling insecure with child care activities

- Rx:
  - Sensory Strategies
  - Dynamic Control

D/C Exam: Case 10LM
Take Home Messages

• Balance is complex!
• Imbalance is a super-impairment
• Ecological model for examination & treatment
• You can observe a lot just by watching
Take Home Messages

• Get to know your patient
• Learn the tests inside and out
• Tests give you more than a score
• Don’t be distracted by shiny things or squirrels
• Treat everyone like they’re your loved one

Questions?

cgrove@uwhealth.org
608-265-0109