CONTINUED

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The Science of Fall Prevention

MIKE STUDER, PT, MHS, NCS, CEEAA, CWT, CSST

Objectives: Participants will be able to:

4

1) Identify at least three fall-risk screening tools known to improve examination selection and probability of fall risk.

2) Identify at least two appropriate tests in an effort to identify patient skill in function, sensori-motor capacities, and impairments.

3) Identify outline of an individualized treatment plan with at least three interventions to reduce fall risk.

4) List at least three ways to monitor response to treatment interventions with objective measures to reduce fall risk for older adults.

Course organization

⑤

- Imbalance and fall prevention – defining populations, risk, causes, screening

- Balance – measurement

- Balance – dosage

- Balance – unique diagnostic considerations

Physiology AND Pathophysiology of normal aging

⑥

BALANCE-SPECIFIC *NORMAL* AGE-RELATED CHANGES

- ▣ Reduced conduction velocity
- ▣ Reduced reaction speed and attention networks
- ▣ Reduced Type I and Type II mm fibers/strength
- ▣ Reduced visual acuity
- ▣ Presbycusis

Falls and Fall related injuries in the U.S.

⑦

- 38% unintentional deaths

- 1 person to the ED/13 seconds; 1 fatality/20 min.

- Financial toll by 2020 > $67 billion

- One fall every 14 seconds

The facts on falls*...

⑧

- One-third of Americans aged 65+ falls each year.
- Falls are the leading cause of fatal injury and the most common cause of nonfatal trauma-related hospital admissions among older adults.
- Falls result in >2.5 million injuries in the ED
- 2013, the total cost of fall injuries was $34 billion.
- Average cost/fall > $13,000

*NCOA.org/falls-prevention-facts

Balance and fall prevention

⑨

Established that…

- Cost of healthcare after a fall is high
- Cost of caregiving to attend those at high risk is high
- Rate of deaths due to falls is high

- We understand that "balance"…is (mostly) about…

Fall prevention

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continued™

...fall prevention

11

Imbalance –populations, risk, causes

12

Fall frequency due to imbalance HIGHEST in persons with:

- Weakness
- Neurological (sensory or motor) impairment
- Dizziness
- Pain
- Loss of body part or motion of a joint
- Cognitive impairment

Clinical Guidance Statement: AGPT

(13)

- Ask and screen ALL older adults about fear or and fall hx

- Risk assessment if indicated by screening

- Intervention built around risk factors, individualized

- Intervention is comprehensive: Walking, balance, strength

- Prevention is comprehensive: home, meds, other medical

- Role of PT is primary, secondary, tertiary

SCREENING for BALANCE: Fall risk

(14)

Evidence-based screening: STEADI

- Timed Up and Go (TUG)
- 5 times sit to stand (5TSTS)
- 4 stage balance test

SCREENING for BALANCE: Fall risk

(15)

Evidence-based screening: STEADI

- Timed Up and Go (TUG)

SCREENING for BALANCE: Fall risk

(16)

Evidence-based screening: STEADI

- 5 times sit to stand (5TSTS)

SCREENING for BALANCE: Fall risk

17

Evidence-based screening: STEADI

- 4 stage balance test

MEASUREMENT in BALANCE

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Evidence-based treatment is based on:

- Establishing a diagnosis through examination
- Using tests and measures of function, impairment, and participation
- Re-examining patients to ensure that they are improving
- Challenging balance in a task-specific manner that is consistent with tested impairments

Balance Control Systems

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- Biomechanical Constraints
- Stability Limits/Verticality
- Anticipatory Postural Adjustments
- Postural Responses
- Sensory Orientation
- Stability in Gait

Mancini M, Horak F. Eur J Phys Rehabil Med. 2010 Jun; 46(2): 239–248.

Measurement of fall risk stand and reach

20

- **Tools that are measuring primary performance in flexibility and "Stability Limits/Verticality"**

- Functional reach (FRT)

- Multidirectional Reach Test

- Forward, sideways, standing or sitting

Functional Reach Testing...

Measures of fall risk: sit to stand, endurance

- **Tools that are measuring resources (strength, endurance) related to and using balance**

- 5 times sit to stand
- 30 second sit to stand
- 2 minute step test

Sit to stand testing

(23)

5 times sit to stand

(24)

- **When should I use this test?**
- **Strength test in a frail patient**
- **Limited time**
- **Screening for more detailed strength**

- **Unique characteristics**
- **May be adapted and applied with assistive device**

What can I do with these results?
- Apply more detailed strength testing; assign home program; age-norms; accountability for patient to progress

30 second sit to stand

(25)

- **When should I use this test?**
- **Looking for a functional strength application**
- **Sensitive to change**

- **Unique characteristics**
- Combines strength and endurance

What can I do with these results?
- Compare to normative and assign home or clinical strength program
- Motivate a patient to achieve norms; compete against themselves (accountability)

2 minute step test

(26)

- **When should I use this test?**
- **Endurance, incapable of walking**
- **Limited space, time, equipment**
- **Precautions for gait/antalgic in gait**

- **Unique characteristics**
- May use counter-top or assistive device

What can I do with these results?
- Prescribe endurance program
- Educate about cardiovascular response to exercise
- Motivation and accountability!

Measures of fall risk: Gait and higher skill

27

- **Tools that are measuring performance primarily in gait**

- 2 and 6 min walk
- 10 meter walk test
- Dynamic Gait Index and Modified DGI
- Functional Gait Assessment (FGA)
- Timed Up and Go (TUG)
- High level Mobility Assessment Test (HiMAT)

2 min walk (2MWT)

28

When should I use this test?
- Measuring functional endurance and cannot tolerate 6 minute walk
- Limited time, used as a part of battery testing
- Sensitive to change with confidence, gait speed

Unique characteristics

What can I do with these results?
- Determine perceived exertion and cardiovascular response
- Benchmark and educate about norms
- Ascribe an endurance program

6 min walk (6MWT)

(29)

When should I use this test?
- Investigating endurance response over time or times of the day
- Investigating balance performance when fatigued (after 6MWT)

Unique characteristics

What can I do with these results?
- Motivate and hold accountability!!
- Compare to age/gender expectations

10 meter walk

(30)

When should I use this test?
- Short on time, space, equipment
- Looking for a pure measure of gait speed and capacity without turns
- Patient uses an assistive device

Unique characteristics:

- Gait speed without turns
- Eliminates turns, acceleration and deceleration

What can I do with these results?
- Create a dosage for high speed gait training: land or treadmill

Dynamic Gait Index and Modified DGI

(31)

When should I use this test?
- Looking for a measure that it sensitive and responsive to change in balance
- Vestibular applications

Unique characteristics:
- Uses obstacles; stairs; head-rotations
- Can be performed with an assistive device

What can I do with these results?
- Prescribe programming based on tolerance of head motion; obstacles; turns; speed changes

---

Functional Gait Assessment (FGA)

(32)

When should I use this test?
- Neuropathy, vestibular, general imbalance; fear in gait

Unique characteristics
- Eyes closed
- Walk normal-fast-slow in the same sub-test
- Head motion, obstacles

What can I do with these results?
- Prescribe programming based on tolerance of head motion; obstacles; turns; speed changes

Timed Up and Go (TUG)

(33)

When should I use this test?
• Screening for function, fall risk

Unique characteristics
• Well-studied, normative
• May use an assistive device

What can I do with these results?
• Determine need for a more advanced balance test
Compare with cognitive load (C-TUG)

High level Mobility Assessment Test (HiMAT)

(34)

When should I use this test?
• High level patient after brain injury, stroke, young onset PD, senior athlete

Unique characteristics
• Jogging, hopping, skipping, jumping

What can I do with these results?
• Identify specific age-appropriate or sport-specific skills to be remediated

Screening tools and measures of fall risk

(35)

- **Tools that are measuring performance primarily in standing balance**
- CTSIB and mCTSIB*
- Dynamic Posturography*
- Balance Error Scoring System (BESS)
- Berg Balance Test
- 4 Stage balance
- Functional reach (FRT)

- * Covered in more detail within the section on technology in balance measures below

CTSIB and mCTSIB

(36)

When should I use this test?
- Diagnostics: determining sensory interplay
- Limited space
- Vestibular and neuropathy
- Responsive to change in balance processing; sensory reweighting

Unique characteristics
- Investigate response to aberrant visual effects
- Determine visual dependence

What can I do with these results?
- Begin to prescribe sensory-specific/condition-specific balance programming

Shumway-Cook A, Horak FB Phys Ther. 1986 Oct; 66(10):1548-50

Dynamic Posturography

(37)

When should I use this test?
• Sophisticated diagnostics; precise response to change in ability and confidence

Unique characteristics
• Forceplate
• Sway-referenced testing (aberrant visual applications)

What can I do with these results?
Begin to prescribe balance programming to reduce visual dependence, improve tolerance to unstable surfaces; physically measure fear of falling

---

Berg Balance Test

(38)

When should I use this test?
• Investigating a broad spectrum of balance conditions

Unique characteristics
• Incorporates transfers; reach; body rotation; sit to stand; standing; and limited BOS in 1 test
• Prognostic relationships to outcomes in stroke

What can I do with these results?
• Begin to prescribe balance programming by attribute of imbalance
• Limited time for examiner, function for patient

4 Stage Balance

(39)

When should I use this test?
- Screening for fall risk (stages 1-3, untimed)
- Limited time, space, equipment

Unique characteristics
- Incorporates single limb stance
- Logical progression from which to build intervention

What can I do with these results?
- Determine the need for more detailed tests: Berg, BEST
- Motivate patients with clear and irrefutable change in capacities

Functional Reach Test (FRT)

(40)

When should I use this test?
- Investigating limits of stability
- Health fair, screening, ROM attributes

Unique characteristics
- One of few tests to combine range of motion in static balance
- Predictability, age norms available

What can I do with these results?
- Determine the need for more sophisticated testing
- Physical screen for fear of falling

Screening tools and measures of fall risk

(41)

Mixed performance: gait and standing balance/agility

- Four Square Step Test (4SST)
- Tandem walk test (timed 10')
- BEST and Mini BEST*
- HiMAT – High level mobility assessment test

*Contains performance measures in gait and standing

Four Square Step Test (4SST)

(42)

When should I use this test?
- Investigating agility, ability to follow directions
- Screening to ascribe fall risk
- Portable for health fairs

Unique characteristics
- Combines obstacles, sequencing in a limited space

What can I do with these results?
- Screening for coordination, sequencing, and fear

Tandem walk test (timed 10')

43

When should I use this test?
- Investigating agility, ankle strategies

Unique characteristics
- Dynamic assessment with limited BOS

What can I do with these results?
- Determine and motivate with an irrefutable response to change
- Assign related home exercise programming

BEST: Balance Evaluation Systems Test

44

When should I use this test?
- Comprehensive balance assessment with clear treatment indications by system
- Time and energy allow

Unique characteristics
- Abbreviated versions available
- Comprehensive nature

What can I do with these results?
- Direct prescription of balance treatment from test results

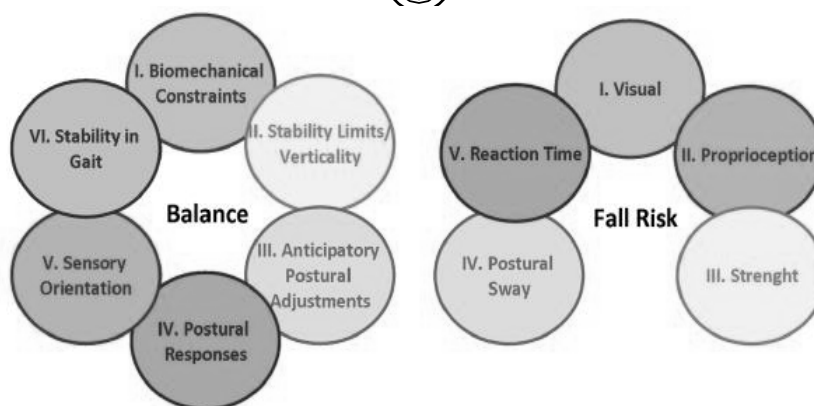## BEST: Balance Evaluation Systems Test

45

- Biomechanical constraints
- Stability limits/verticality
- Anticipatory postural adjustments
- Postural responses
- Sensory orientation
- Stability in gait

BEST: Balance Evaluation Systems Test

46

Mancini M, Horak F. Eur J Phys Rehabil Med. 2010 Jun; 46(2): 239–248.

Psychological aspects of imbalance

47

```
        History of
          falls
Weakness            Fear
 due to
inactivity
        Inactivity
         due to
          fear
```

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Falls Efficacy Scale

48

When should I use this test?
- Determine patient insight for safety
- Determine the relative contribution of fear or anxiety
- Prove quality of life changes in response to treatment

Unique characteristics
- Entirely household mobility based

What can I do with these results?
- Explore treatment venues based on responses
- Educate in the cases of undue fear *or* lack of insight/safety in the impulsive patient

NWRA

continueD

Activity-Specific Balance Confidence

(49)

When should I use this test?

- Investigating the role of fear in patient activity

Unique characteristics

- Household and community mobility

What can I do with these results?

- Baseline the role of fear for later comparison
- Understand your patient and consider fear in balance dosage, treatment planning

Activity-Specific Balance Confidence

(50)

Powell LE, Myers AM. Journal of Gerontology: MEDICAL SCIENCES 1995. Vol. 50A. No. i. M28-M34

Measuring cognitive influences on imbalance

51

Executive Function

- MoCA
- SLUMS
- Mini-mental Status Examination

Attention and Dual Task capacities

- Walking While Talking (WWT) or Stops Walking While Talking
- Walking and Remembering Test (WART)
- Cognitive Timed Up and Go (C-TUG)

Cognitive Timed Up and Go (C-TUG)

52

When should I use this test?

- Functional gait in combination with cognition
- Creates a comparative "Dual Task Cost" to TUG

What can I do with these results?

- Understand conditions that can increase fall risk
- Build a more individualized balance program
- Screen for early cognitive signs

Instrumented assessments

53

- GaitRite

- Mobility Lab

- GaitSens

- New applications "apps" with mobile technology
  GaitSpeed, etc.

Using balance measures to build person-specific treatment

54

- Understand what each balance measure gives you...

- Treat to the body structure, system or impairment

- Treat toward the activity loss

- Treat with an understanding of participation/roles

- Understand personalities, psychological and cognitive influences
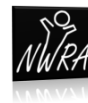
Frail, Functional…and Fun

(55)

Parameter	Frail	Functional	Fun
Gait speed	< 1.0 m/sec **2.2mph**	1.0-1.5 m/sec **2.2-3.3mph**	>1.5 m/sec **3.3mph**
6 min walk	< 1200'	1200-1750'	1750'
30 second sit to stand	< 8 repetitions	8-12 repetitions	>12 repetitions
Berg Balance	<45/56	45-49/56	>49/56

(Modified by Mike Studer. Original by Marilyn Moffat 2009, CEEAA course 2, San Marcos CA)

Dosage: Balance

(56)

- Daily

- Task specific

- Dynamic

- Creates a stimulus (causes imbalance 30%)

- How do we grade intensity, though?

Completely Stable	1
Standing/sitting undisturbed on solid ground	
Steady	2
Balance does not feel challenged, but may have some body movements	
	3
Unsteady	4
Feels like work to keep balanced, but still do not need to step	
	5
Mildly Unbalanced	6
Feels like I might/could have to take a step OR reach for support to maintain balance	
Moderately Unbalanced	7
Unbalanced	8
Feels that even the smallest or sudden movements will cause a fall	
Very Unbalanced	9
About to Fall	10
Extremely challenged; and have to step or grab support to keep balance	

Espy, D

Used with personal permission

57

Diagnostic considerations in balance

58

- Stroke

- Parkinson's Disease

- Neuropathy

- Geriatrics

- Dizziness

NWRA

Intensity: Balance - VIDEOS

(59)

Balance: Neuropathy - Visual dependence

Balance: Parkinson's Disease - Perception of Vertical

Balance: Vestibular - Acceleration detection

Balance: Gait training in Neuropathy

Balance: Geriathletics - Tennis

Balance: Return to work after brain injury

Intensity: Balance - VIDEOS

(60)

Balance: Stroke – Forced Use and SENSORY Advantage

Balance: Parkinson's Disease Dual Task

Balance: Parkinson's Dual Task Go-No Go

Balance: PD: 4Square DT = FSSTDT

Balance: Stroke DT gait procedural

Diagnostic considerations in balance: Stroke

61

- Asymmetry is persistent in static and dynamic function
- Persistently displaced center of mass due to asymmetry
- Learned nonuse in balance strategies
- Learned nonuse leads to more impairment
- Sensory and motor control impairment WITH visual, cognitive, and resting muscle tone changes
- Balance activities must be lifelong and challenging

❖ Rehabilitation potential: neuroplasticity + learning reverse non-use: strength, balance, sensory

Diagnostic considerations in balance: PD

62

- Trends/tendencies of LOB:
     festination/freezing vs. retropulsive
- Capacity for producing power
- Posture and available strategies
- Multidirectional capacities

Rehabilitation potential through response to power and amplitude training + adaptation with cues, devices high level balance (phenotype-specific)

Diagnostic considerations in balance: Neuropathy

63

- Etiology and prognosis
- Joint and tissue involvement
- Proximal reserves: strength, sensation
- Fear – history of falls
- Awareness – underlying condition, compensation

Rehabilitation potential through proximal
kinesthesia and strength bracing, devices,
+ compensation

Diagnostic considerations in balance: Geriatrics

64

- History of falls
- Multimodal sensory: vision, vestibular, somatosense
- Comorbidities: DM, vascular, arthritis
- Age-induced: sarcopenia, reaction speed, etc.

Rehabilitation potential:

| strength | balance training |
| endurance | core stability |

Diagnostic considerations in balance: Dizziness

(65)

- Imbalance and confidence cause corollary loss
- Provoked with head or body motion
- Severe visual dependence and OVER-dependence
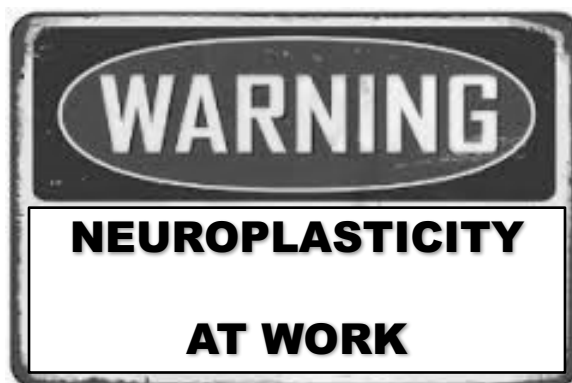- Acute vs. Chronic management

Rehabilitation potential:
Response and tolerance (sx) to habituation
Neuroplasticity, reweighting

How is balance improved?

(66)

continued

Somatosensory Reweighting

67

Neuroplasticity of the sensory network
Intensity, specificity, difficulty, complexity

Constraint-induced sensory processing

Forcing the re-integration and use of sensation

The Science of Balance Retraining: Past, Present and Future

68

- Challenging neural networks/connections with attended learning based activities can improve timing and sequencing across sensory modalities

- Modify the "topographical" and "functional" brain representations of sensation, movement and task performance

(Jenkins et al, 1984; Merzenich et al, 1985-2011;Byl et al, 1996; Blake et al 2002, Serino 2017)

Future of Balance: Technology

(69)

Virtual Reality	Inertial Body sensors
• Adaptable/personalized • Interesting • Measurable	• Objective • Timely • Irrefutable • Transportable Horak F, King L, Mancini M. Role of body-worn movement monitor technology for balance and gait rehabilitation. Phys Ther. 2015 Mar;95(3):461-70.

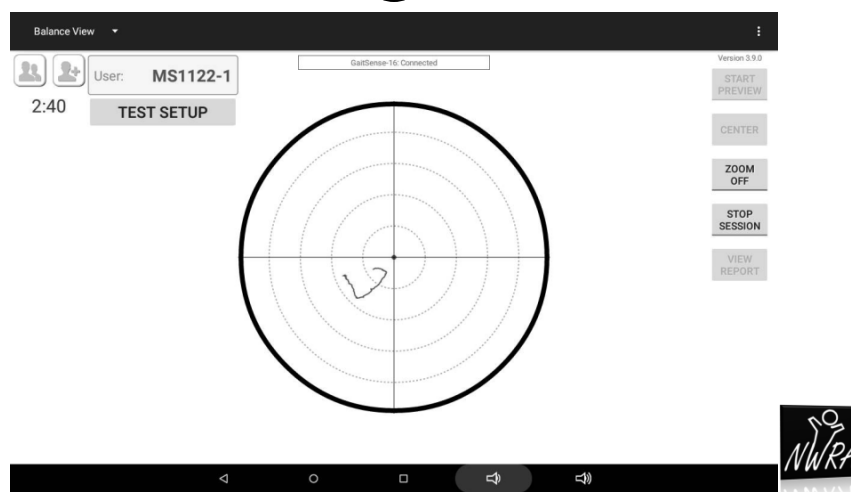## Future of Balance: Technology – Forceplate Enabled Treadmill

(70)

• Immediate feedback

• Quantified gait

• Measurable

NWRA

Future of Balance: Technology – Forceplate Enabled Treadmill

71

Balance View ▾

User: **MS1122-1**

Version 3.9.0

2:40   **TEST SETUP**

GaitSense-16: Connected

START PREVIEW

CENTER

ZOOM OFF

STOP SESSION

VIEW REPORT

Future of Balance Training: REACHING MORE and CONTINUING-ON

72

- Otago

- Stepping-On

- Tai Chi: A Matter of Balance

Your questions…

73

Mike Studer, PT, MHS, NCS, CEEAA, CWT, CSST

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mike@northwestrehab.com

YouTube: Rehabilitation NWRA

www.northwestrehab.com

FB: NWRehab