Measuring Gait and Balance in the Clinical Setting: Translating Research into Practice

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1. Overview

2. Why measure gait and balance?

3. How do we measure gait and balance?
   - Clinical measures
   - Laboratory measures
   - Limitations/restrictions

4. How should we measure gait and balance?
   - Fundamentals of control – focus for measurement
   - New tools for the clinic

5. Summary
Overview

How do you measure gait / balance in the clinic?

What determines the selection of a specific measure?

**We don’t need to add any new measures!**

Rather - we need to find commonality among the many measures to develop a ‘universal standardized’ assessment.

Can advances in understanding and technology help us to get there?
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Why measure gait and balance?

Variation in techniques to assess gait and balance arise in part from different purposes of the measure.

Use of measure (examples):
- Predictor of future risk (eg falling) (binary)
- Discharge/admission criteria (binary)
- Treatment decision/guidelines
- Assessment of treatment
- Assistive device prescription
- Understanding physiology/biomechanics
- Program/resource planning (population data)
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What are you measuring?

Definitions
   (mobility, gait, independent walking, balance)
Gait versus balance
Static versus dynamic balance control

What are the necessary characteristics?

Validity
Reliability
Sensitivity (measuring change)
Commonly used Measures of Gait and Balance

Semi-quantitative (some subjective evaluation)

**Global measures**
- FIM (mobility component)
- Fugl-Meyer, EDSS, UPDRS (patient specific)

**Component/element measures**
- *Performance Oriented Balance Assessment*
- *Berg Balance Test*
- Tinetti Gait Assessment
- Community Balance and Mobility Scale
- Observational Gait Analysis
- Postural sway
- Functional Gait Assessment
- Dynamic Gait Index
Commonly used Measures of Gait and Balance

Quantitative (measurement of distance/time)

- Functional reach
- One foot-stance / tandem stance
- Timed up and go
- Gait speed
- 5 metre walk (gait speed)
- 6 minute walk test
The Research Laboratory

**Detailed quantitative measures of gait and balance**

- Kinematics – joint movement
- Kinetics - forces
- Electromyographic – muscle activity
- Spatiotemporal – footfall information

**New measures proposed for clinical assessment**

- Step/stride variability
- COP/COM sway
- Rapid stepping (compensatory and choice RT)
Force plates
Reflective markers
Cameras
Electromyography (EMG) electrodes
Moveable platform
video cameras

force plates

multi-axis perturbation platform
Practical Restrictions to Type of Assessment

- Time
- Safety
- Cost / complexity

Some of the Limitations of Existing Measures

Clinical measures
- Ceiling and/or floor effects
- Some lack of sensitivity
- Lack of insight into underlying dyscontrol

Laboratory measures
- Too complex – lack of composite measure
- Time consuming
- Expensive
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What should be measured?

What are the elements of balance and gait that should be the focus of assessment?

Task performance versus ‘Fundamentals’

Example - Measuring fitness:

- a ‘fundamental’ component of fitness is aerobic capacity

- assessing maxVO2 during a cycle ergometer test serves as measure of the ‘fundamental’ that translates well to most tasks
Is there an underlying commonality?

To increase the complexity there are many different measures used that provide complementary outcomes.

For example prediction of future fall risk:
- Tinetti
- Berg
- Timed up and go
- Functional reach
- Sway
- Step variability
Example

- Tinetti Performance-Oriented
  - (short) score < 19 out of 28 - high risk
  - (long) score < 36 out of 40 - 7 of every 10 future fallers identified

- Berg Balance Scale
  - < 37 out of 56 - 100% fall risk in community

- Timed Up and Go
  - > 20 seconds - high risk of falling

Chu LW et al. Risk factors for falls in hospitalized older medical patients *J Gerontology* 1999; 54: 38-43
Why do different measures often provide parallel results?

For example – why does spontaneous sway during quiet standing provide comparable predictive benefit as a task-based clinical index such as Berg balance scale?

One answer is that the behaviours share common control ‘fundamentals’!
The Control of Gait and Balance

Understanding control can help to reveal fundamentals

Balance control
  Reactive control (static, dynamic)
  Predictive control

Gait control
  Progression control
  Dynamic stability control
  Adaptability
vestibular Input

vision

muscle and joint proprioception

pressure receptors

sensory feedback

motor commands
Example: Learned the importance of compensatory limb control leading to a new emphasis
Example: Probing reactive control can be performed by applying perturbations.
Challenge balance / gait to reveal control limitations

Clinicians have long recognized need to challenge system

Standing still or walking a preferred speed over level ground is not enough to reveal capacity

Examples of challenges:
  Balance – transitions, sensory, base of support,
  Gait - speed, base of support, obstacles
BERG SCALE ITEMS (timed, distance, judgment)

Standing unsupported
Sitting unsupported
Standing with eyes closed
Standing with feet together
Standing with one foot in front
Standing on one foot
Reaching forward with outstretched arm
Standing to sitting
Sitting to standing
Transfers
Retrieving object from floor
Turning to look behind
Turning 360 degrees
Placing alternate foot on stool
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Reactive control (static)
TINETTI BALANCE SCALE (judgment)

Sitting balance
Initial standing balance (first 5 sec)
Standing balance
Standing eyes closed
Arises (sit to stand) – and attempts
Sitting down
Perturbation
Turning 360 degrees

Reactive control (static)
Reactive control (dynamic)
Example: Sway as a continuous measure of reactive control (static)
Example: Simplified perturbation techniques to probe reactive control (dynamic) – with a focus on rapid stepping

"Fixed-support" (FS) strategies

"Change-in-support" (CS) strategies
TINETTI GAIT SCALE (judgment)

Initiation
Step length
Symmetry
Continuity
Path
Trunk sway
Walking time

Link to fundamentals?
Progression
Dynamic stability
Adaptability

Gait assessment considerations:
Interpreting preferred velocity
Challenges - speed, obstacles, direction
Correlation between spatiotemporal measures and velocity
Example: New technology (pressure carpet, accelerometry) provides opportunity to assess fundamentals of gait in clinical setting

(e.g. dynamic stability - step/stride variability)
Relationship between symmetry and walking velocity

![Graph showing the relationship between symmetry and walking velocity. The x-axis represents velocity (stats/sec), and the y-axis represents symmetry ratio. The graph compares patients (represented by pink triangles) and controls (represented by blue circles).]
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Consideration of measures of gait and balance based on fundamentals of control rather than on task performance.

Necessary to challenge balance and gait control to reveal capacity (links to mobility and falls).

New technology improving possibility of ‘lab’ measurement within practical constraints of the clinic.

Benefits of detailed quantitative measures:
• Improved sensitivity linked to dyscontrol
• Data to serve multiple purposes
Linking the Clinic and the Lab
(at the Toronto Rehabilitation Institute)

**Why?**
Develop ‘universal standardized’ balance/gait assessment.

Quantification of fundamentals of balance and gait afford information relevant to treatment and clinical decision making.

**How?**
Access to new technologies and approaches – sharing of expertise and needs.

Comparing existing indexes with new approaches.