Assessing Motion, Strength, and Balance

Goals and Objectives

Course Description
“Assessing Motion, Strength, & Balance” examines traditional and contemporary tools and methodologies used to measure patient range of motion, muscle strength, and balance. This course includes a review of current literature relating to test reliability and validity, as well as discussions relating to practical clinical applications.

Course Rationale
The purpose of this course is to provide Athletic Trainers with a comparative analysis of traditional and contemporary techniques for assessment of range of motion, muscle strength, and balance based on current research to aid the clinician in employing these techniques effectively when assessing patient progress.

Course Goals and Objectives
Upon completion of this course, Athletic Trainers will be able to:
1. List primary differences between Nagi Disablement Model and International Classification of Functioning as conceptual frameworks in rehabilitation.
2. Identify clinician attitudes toward and barriers to implementation of evidence based practice.
3. Relate the connection between tests and measures and analysis of researched intervention effectiveness.
4. Identify variables contributing to reliability of traditional manual muscle testing.
5. Recognize opportunities for use and limitations of hand held dynamometry to assess muscle strength.
6. Select methods to promote consistency of range of motion measurement using various methods including standard goniometry, visual assessment, inclinometer, and diagrammatic recording.
7. Define how smartphone applications utilize phone components to measure joint excursion.
8. Determine the reliability of electronic goniometric measurement with smartphone applications.
10. Identify balance assessment tests that contribute to the detection of fall risk.

Course Provider – Innovative Educational Services
Course Instructor - Jodi Gootkin, PT, MEd
Target Audience – Athletic Trainers
Athletic Training Practice Domain – Clinical Evaluation & Diagnosis (0203)
Level of Difficulty – According to the education levels described by the PDC, the following continuing education course is considered to be Advanced Level.
Course Prerequisites – None
Method of Instruction/Availability – Live Interactive Webinar available on scheduled dates/times.
Criteria for Issuance of CE Credits – Verified attendance and at least 70% on the course post-test.
Continuing Education Credits – Three (3) hours of continuing education credit.
Fees - $39.95
Refund Policy - Unrestricted 100% refund upon request. The request for a refund by the learner shall be honored in full without penalty or other consideration of any kind. The request for a refund may be made by the learner at any time without limitations before, during, or after course participation.

Innovative Educational Services is recognized by the Board of Certification, Inc. to offer continuing education for Certified Athletic Trainers

Innovative Educational Services
Assessing Motion, Strength, & Balance
Live Interactive Webinar Presented By:
Jodi Gootkin, PT, MEd, CEAS
jodi@gmail.comcast.net
Copyright J. Gootkin 2016

Course Overview
- “Assessing Motion, Strength, & Balance” examines traditional and contemporary tools and methodologies used to measure patient range of motion, muscle strength, and balance. This course includes a review of current literature relating to test reliability and validity, as well as discussions relating to practical clinical applications.

Course Rationale
- The purpose of this course is to provide a comparative analysis of traditional and contemporary techniques for assessment of range of motion, muscle strength, and balance based on current research to aid the clinician in employing these techniques effectively when assessing patient progress.

Goals and Objectives
1. List primary differences between Nagi Disablement Model and International Classification of Functioning as conceptual frameworks in rehabilitation.
2. Identify clinician attitudes toward and barriers to implementation of evidence based practice.
3. Relate the connection between tests and measures and analysis of researched intervention effectiveness.
4. Identify variables contributing to reliability of traditional manual muscle testing.
5. Recognize opportunities for use and limitations of hand held dynamometry to assess muscle strength.
6. Select methods to promote consistency of range of motion measurement using various methods including standard goniometry, visual assessment, inclinometer, and diagrammatic recording.
7. Define how smartphone applications utilize phone components to measure joint excursion.
8. Determine the reliability of electronic goniometric measurement with smartphone applications.
10. Identify balance assessment tests that contribute to the detection of fall risk.

Disclaimer
- Application of concepts presented in this webinar is at the discretion of the individual participant in accordance with federal, state, and professional regulations.

Course Outline/Schedule
3 hour live interactive webinar

<table>
<thead>
<tr>
<th>Topic</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Frameworks in Rehabilitation</td>
<td>0:00-0:10</td>
</tr>
<tr>
<td>Evidence Based Practice Attitudes and Beliefs</td>
<td>0:11-0:20</td>
</tr>
<tr>
<td>Relevance of Tests and Measures</td>
<td>0:21-0:30</td>
</tr>
<tr>
<td>Manual Muscle Testing Technique Analysis</td>
<td>0:31-0:35</td>
</tr>
<tr>
<td>Contributors to Reliability of Strength Assessment</td>
<td>0:36-0:50</td>
</tr>
<tr>
<td>Interactive Discussion of Clinical Applications</td>
<td>0:51-0:60</td>
</tr>
<tr>
<td>Hand Held Dynamometry Equipment and Techniques</td>
<td>1:01-1:10</td>
</tr>
<tr>
<td>Reliability of Dynamometry Muscle Grades</td>
<td>1:11-1:20</td>
</tr>
<tr>
<td>Limiting Variables in with Standard Goniometry</td>
<td>1:21-1:30</td>
</tr>
<tr>
<td>Analysis of Alternative Range of Motion Measurement Techniques</td>
<td>1:31-1:40</td>
</tr>
<tr>
<td>Summary of Smartphone Range of Motion Measurement</td>
<td>1:41-1:50</td>
</tr>
<tr>
<td>Interactive Discussion of Clinical Applications</td>
<td>1:51-2:00</td>
</tr>
<tr>
<td>Comparative Analysis of Smartphone Goniometry Apps</td>
<td>2:01-2:15</td>
</tr>
<tr>
<td>Categorizing Balance Assessment Techniques</td>
<td>2:16-2:30</td>
</tr>
<tr>
<td>Comparing Reliability of Balance Assessment Tools</td>
<td>2:31-2:43</td>
</tr>
<tr>
<td>Balance Assessment as a Predictor of Fall Risk</td>
<td>2:41-2:50</td>
</tr>
<tr>
<td>Interactive Discussion of Clinical Applications</td>
<td>2:51-3:00</td>
</tr>
</tbody>
</table>
How To Obtain CEUs For This Course

- After the live interactive webinar and prior to 11:59 pm TONIGHT go to www.cheapceus.com
- Complete the post test with score of at least 70%
- May be retaken multiple times
- Submit online payment for course
- Print certificate
- Course review and summary for post test at the end of the webinar.

Disability Models

- Two primary conceptual models are utilized to guide clinical practice decisions and research.

WHO-ICF

Nagi Model

- A medical model with linear thought process.

Classification Of Individual Health

<table>
<thead>
<tr>
<th>ICD-10</th>
<th>ICF</th>
</tr>
</thead>
<tbody>
<tr>
<td>* International Classification of Diseases</td>
<td></td>
</tr>
<tr>
<td>* Organizes information on diagnosis and health condition</td>
<td></td>
</tr>
<tr>
<td>* International Classification Of Functioning, Disability, And Health</td>
<td></td>
</tr>
<tr>
<td>* Clarifies function</td>
<td></td>
</tr>
</tbody>
</table>

WHO – ICF Model

- World Health Organization - International Classifications of Functioning, Disability, and Health

Benefits ICF Framework

- Focus on the individual
- Considers contextual factors
- Emphasis on positive aspects
- Various opportunities to intervene
- Multidimensional process

BioPsychoSocial Model
Assessing Motion, Strength, & Balance

Copyright Jodi Gootkin 2016

---

### Fundamental Components of Allied Health Professions

- **Research**
  - Examination and testing of practice methods and principles
- **Practice**
  - Application of knowledge in clinical interactions
- **Education**
  - Formulation of a knowledge and skill base

---

### Evidence Based Practice (EBP)

- Diffusion theory is the concept of facilitating consistent application of research finding into clinical practice.

---

### Attitudes and Implementation

- Across disciplines, clinicians concur that evidence based practice research:
  - Informs practice patterns for improved outcomes.
  - Is infrequently incorporated into clinical practice.
  - Is challenging for many clinicians to access and interpret.
  - Clinician confidence with integration is low.

---

### Increasing Self Efficacy

- Access to resources
- Acquisition of studies
- Appraisal of research
- Application to practice

---

### Barriers to EBP

- Optimizing application of research in practice is inhibited due to:
  - Time constraints
  - Colleagues not employing EBP
  - Access to information challenges
  - Interpretation of research challenges
  - Patient preference
  - Individual professional experience

---

### Analyzing the Evidence

- Inconsistency in evaluating outcomes diminishes the effectiveness of evidence based practice.
- Uniformity in use of valid and reliable measurement tools is necessary to compare outcomes.
  - Validity – measures what is intended
  - Reliability – test re-test consistency

---
Data Collection
- Gathering objective reliable information quantifies signs, symptoms, function to:
  - Identify limitations
  - Demonstrate progress or lack of progress
  - Communication with other healthcare providers and payors
  - Evaluate intervention effectiveness in practice and research

Common Impairments to Evaluate
- Specialized to Patient
- More Specific to Practice Setting/Population
- Common Among Disciplines

Common Impairments to Evaluate
- Cardiovascular Status
- Fine Motor
- Gait
- Neurologic Function
- Joint Integrity
- Sensation
- Mental Status
- Pain

Strength Assessment
- Objective measurement of performance of an individual or group of muscles in relation to gravity and resistance.

Manual Muscle Testing (MMT) History
- 1912: Lovett & Wright
- 1942: Medical Research Council
- 1946: Daniels & Worthingham
- 1949: Kendall
- Today

Terminology
- Prime Mover
- Agonist
- Antagonist
- Synergist

Assessing Motion, Strength, & Balance
Copyright Jodi Gootkin 2016
**MMT Grades**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Gravity</th>
<th>ROM</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Normal</td>
<td>AG</td>
<td>Full ROM</td>
</tr>
<tr>
<td>4+</td>
<td>Good</td>
<td>AG</td>
<td>Full ROM</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
<td>AG</td>
<td>Full ROM</td>
</tr>
<tr>
<td>4-</td>
<td>Good Minus</td>
<td>AG</td>
<td>Full ROM</td>
</tr>
<tr>
<td>3+</td>
<td>Fair</td>
<td>AG</td>
<td>Full ROM</td>
</tr>
<tr>
<td>3</td>
<td>Fair</td>
<td>AG Gradual release OR &gt;50% AG ROM</td>
<td>No Resistance</td>
</tr>
<tr>
<td>2+</td>
<td>Poor</td>
<td>GE</td>
<td>Partial ROM</td>
</tr>
<tr>
<td>2</td>
<td>Poor</td>
<td>GE</td>
<td>Partial ROM</td>
</tr>
<tr>
<td>1+</td>
<td>Trace Plus</td>
<td>GE</td>
<td>&lt;50% ROM</td>
</tr>
<tr>
<td>1</td>
<td>Trace</td>
<td>Palpable or Observed Contraction</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Zero</td>
<td>No Contraction</td>
<td></td>
</tr>
</tbody>
</table>

**MMT Reliability**

- Typically accepted level of agreement for inter or intratester reliability is +/- on muscle grade.

**Rotator Cuff Isolation**

- Electromyographic analysis of rotator cuff muscle activation with standard manual muscle test positions confirms activation of prime movers.
- ABDuction – Supraspinatus
- External Rotation – Infraspinatus, Teres Minor
- Internal Rotation - Subscapularis

**Break vs. Make Testing**

- **Break**: Patient holds isometric muscle contraction against progressively increasing force provided by examiner.
- **Make**: Application of force to the moving body segment during patient performance of motion. Examiner remains stationary while patient exerts maximal isometric force against them.

**Make vs. Break Reliability**

- Research does not indicate one method is superior to the other.

<table>
<thead>
<tr>
<th>Motion Tested</th>
<th>Comparative Measure</th>
<th>Reliability Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Elbow Flexion</em></td>
<td>Digital Hand Held Dynamometer</td>
<td>Greater force generated with Break test.</td>
</tr>
<tr>
<td><strong>Thumb ABDuction</strong></td>
<td>Algometer</td>
<td>Make better interrater reliability</td>
</tr>
</tbody>
</table>

**MMT Accuracy Variables**

- Standardization of procedure increases intra and intertester reliability.

- Joint Position
- Verbal Cues
- Location of Force Application
- Stabilization
- Interpretation of Values
- Clinician Strength
- Clarification of Make vs. Break
Assessing Motion, Strength, & Balance
Copyright Jodi Gootkin 2016
Dynamometry

- Use of specific measurement device to quantify the “break force” when assessing muscle strength.
- Hydraulic Dynamometer
- Hand Held Dynamometer
- Isokinetic Dynamometer

Hydraulic Dynamometer

- Shoulder ADDuction
- Elbow 90˚ Flexion
- Wrist 0-30˚ Extension
- Wrist 0-15˚ Ulnar Deviation
- Utilize average of 3 trials

Isokinetic Dynamometer

- Machine resistance matches patient effort

Hand Held Dynamometry (HHD)

- Small hand held digital device approximated to moving body segment to read force production.
- Precise measurement of baseline and minor alterations in muscle strength.
- Measures Maximum Voluntary Isometric Contraction

Dynamometers Examined in Research

- Hydraulic
  - Jamar Technologies
  - Baseline Hand
- Isokinetic
  - Biodex
  - KinCom
  - Cybex
- Hand Held
  - MicroFet2
  - Lafayette Instrument
  - Nicholas Manual Muscle Tester
  - Jtech Commander PowerTrack II

Hand Held Dynamometer

- Measures in pounds, newtons, and kilograms
- Analysis software for data interpretation
- Test positions primarily gravity eliminated
Assessing Motion, Strength, & Balance

Copyright Jodi Gootkin 2016
**HHD Intertester Reliability**

<table>
<thead>
<tr>
<th>Participants</th>
<th>Motions</th>
<th>Reliability Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Physical Therapist Athletic Trainers</em></td>
<td>Hip, Knee, Ankle All Planes</td>
<td>Good intratester reliability regardless of experience</td>
</tr>
<tr>
<td><strong>Skilled Professor Physical Therapist</strong></td>
<td>Elbow Flexion/Extension Wrists Extension</td>
<td>Intertester correlation below acceptable limits</td>
</tr>
<tr>
<td>*** Orthopedist Chiropractor***</td>
<td>Hip All Planes</td>
<td>Poor reproducibility with large limit of agreement ranges</td>
</tr>
</tbody>
</table>


**Skilled Professor Physical Therapist**

<table>
<thead>
<tr>
<th>Motions</th>
<th>Reliability Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow Flexion/Extension</td>
<td>Intertester correlation below acceptable limits</td>
</tr>
<tr>
<td>Wrist Extension</td>
<td></td>
</tr>
</tbody>
</table>

*** Orthopedist Chiropractor***

<table>
<thead>
<tr>
<th>Motions</th>
<th>Reliability Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip All Planes</td>
<td>Inaccurate due to examiner weakness compared to subject.</td>
</tr>
</tbody>
</table>


---

**Underestimation of Strength**

<table>
<thead>
<tr>
<th>Study Information</th>
<th>Motions</th>
<th>Reliability Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy older adults comparison of HHD to Biodex</td>
<td>Knee Extension</td>
<td>Good correlation but underestimated in stronger patients</td>
</tr>
<tr>
<td><em>Physical Therapists performing HHD on healthy young adults</em></td>
<td>Hip Flexion, Extension, ABDuction, Knee Flexion/Extension</td>
<td>Excellent intertester reliability except fair for knee extension</td>
</tr>
<tr>
<td><strong>Nurses performing HHD on patients following SCI</strong></td>
<td>Elbow Flexion/Extension, Hip Flexion, Knee Extension</td>
<td>Inaccurate due to examiner weakness compared to subject.</td>
</tr>
</tbody>
</table>


---

**Range of Motion Assessment**

- **Objective measurement of joint motion, soft tissue extensibility, and flexibility.**
  - Smartphone Apps
  - Goniometer
  - Inclinometer
  - Photogrammetry
  - Visual Estimation
  - Diagrammatic Representation
  - Several Common Concerns for All Methods of Assessment
  - Manual Muscle Testing Break Test

---

**Goniometry Intertester Reliability**

- **Upper Extremity**
  - Simple Hinge Joints
  - Multi-axis joints

---

**Goniometry**

- Consistently high intratester reliability
- Consistently high intratester reliability
- Stationary Arm
- Fixed Arm
- Proximal Arm
- Body
- Dial
- Protractor
- Axis
- Fulcrum
- Moving Arm
- Distal Arm
- Hinges

---

**Underestimation of Strength**

- May not be reliable for certain joints
- Isometric hold 3-5 seconds
- 2-3 trials with 20-30 second rest
- Typically higher values

---

**HHD Intertester Reliability**

- Typically higher values
- May not be reliable for certain joints
- Isometric hold 3-5 seconds
- 2-3 trials with 20-30 second rest
- Clarify make vs. break testing

---

**Range of Motion Assessment**

- **Objective measurement of joint motion, soft tissue extensibility, and flexibility.**
- Smartphone Apps
- Goniometer
- Inclinometer
- Photogrammetry
- Visual Estimation
- Diagrammatic Representation
- Several Common Concerns for All Methods of Assessment
- Manual Muscle Testing Break Test

---

**Goniometry Intertester Reliability**

- **Upper Extremity**
  - Simple Hinge Joints
  - Multi-axis joints

---

**Goniometry**

- Consistently high intratester reliability
- Consistently high intratester reliability
- Stationary Arm
- Fixed Arm
- Proximal Arm
- Body
- Dial
- Protractor
- Axis
- Fulcrum
- Moving Arm
- Distal Arm
- Hinges

---

**HHD Intertester Reliability**

- Typically higher values
- May not be reliable for certain joints
- Isometric hold 3-5 seconds
- 2-3 trials with 20-30 second rest
- Clarify make vs. break testing

---

**Underestimation of Strength**

- May not be reliable for certain joints
- Isometric hold 3-5 seconds
- 2-3 trials with 20-30 second rest
- Typically higher values

---

**Goniometry Intertester Reliability**

- **Upper Extremity**
  - Simple Hinge Joints
  - Multi-axis joints

---

**Goniometry**

- Consistently high intratester reliability
- Consistently high intratester reliability
- Stationary Arm
- Fixed Arm
- Proximal Arm
- Body
- Dial
- Protractor
- Axis
- Fulcrum
- Moving Arm
- Distal Arm
- Hinges

---

**HHD Intertester Reliability**

- Typically higher values
- May not be reliable for certain joints
- Isometric hold 3-5 seconds
- 2-3 trials with 20-30 second rest
- Clarify make vs. break testing

---

**Underestimation of Strength**

- May not be reliable for certain joints
- Isometric hold 3-5 seconds
- 2-3 trials with 20-30 second rest
- Typically higher values

---

**Goniometry Intertester Reliability**

- **Upper Extremity**
  - Simple Hinge Joints
  - Multi-axis joints

---

**Goniometry**

- Consistently high intratester reliability
- Consistently high intratester reliability
- Stationary Arm
- Fixed Arm
- Proximal Arm
- Body
- Dial
- Protractor
- Axis
- Fulcrum
- Moving Arm
- Distal Arm
- Hinges

---

**HHD Intertester Reliability**

- Typically higher values
- May not be reliable for certain joints
- Isometric hold 3-5 seconds
- 2-3 trials with 20-30 second rest
- Clarify make vs. break testing

---

**Underestimation of Strength**

- May not be reliable for certain joints
- Isometric hold 3-5 seconds
- 2-3 trials with 20-30 second rest
- Typically higher values
Assessing Motion, Strength, & Balance

**Plus or Minus Five Degrees**

- **Standard Error of Measurement (SEM)**: Distribution of repeated ROM values using the same instrument.
- **Minimal Detectable Change (MDC)**: Smallest change in value that can be measured beyond error.
- **Minimal Clinically Important Difference (MCID)**: Smallest change in ROM value that is beneficial to the patient.

**Small Joint Intertester Reliability**

**Joint Motions Measured**

<table>
<thead>
<tr>
<th><strong>Reliability Conclusion</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Q angle</em></td>
</tr>
<tr>
<td>Positive reliability</td>
</tr>
</tbody>
</table>

**Large Joint Intertester Reliability**

**Joint Motions Measured**

<table>
<thead>
<tr>
<th><strong>Reliability Conclusion</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Shoulder Horizontal ABD, ADDuction, Extension, Internal Rotation</em></td>
</tr>
<tr>
<td>Poor intertester reliability</td>
</tr>
<tr>
<td><strong>Hip All Planes</strong></td>
</tr>
<tr>
<td>Poor to moderate intertester reliability</td>
</tr>
</tbody>
</table>

**Contributors to Inconsistency**

- Standardization of clinical procedures should minimize variability in technique.
- Potential contributors to inconsistency include:
  - Patient position
  - Body segment stabilization
  - Examiner force application
  - Improper alignment of goniometer

**Goniometer Size**

- Size of the goniometer does not appear to impact consistency of measurement.

---

Copyright Jodi Gootkin 2016
Assessing Motion, Strength, & Balance
Copyright Jodi Gootkin 2016

Patient Position
- Joint excursion values can be inflated or diminished due to alterations in muscle length.
- Documentation should include body position during joint measurement.
  - Knee Extension – Hamstring length
  - Ankle Inversion/Eversion - Subtalar neutral
  - Shoulder ABDuction – Scapular substitution

Joint excursion values can be inflated or diminished due to alterations in muscle length. Documentation should include body position during joint measurement.

Stabilization
- Failure to measure only isolated joint motions contributes to overestimation of ROM.
  - Hip ABDuction/Flexion – Pelvic motion

Examiner Force Application
- Consistency in measuring only desired motion requires clinician attentiveness to end feel.

Goniometer Alignment
- Palpation ensures proper identification of bony landmarks for the axis, moving, and stationary arms.
- Adding a level to the goniometer can assist in determining true vertical and horizontal increasing accuracy.

Goniometer Increments
- Use of 1-degree increment goniometers is most appropriate to minimize inaccuracy.

Inclinometer
- Tool measuring the ROM angle with respect to gravity.
  - Bubble and digital types available
  - Clinician must establish zero at start position to read end position as full ROM.
  - Different landmarks utilized which can result in altered end feel compared to traditional goniometry.
  - Body type may contribute to malalignment and altered measurement.

Hard
  - Firm
  - Muscular
  - Capsular
  - Ligamentous

Boggy

Empty

Soft

Small landmark Error

Substantial Measurement Error

Potential 10 degree measurement variability

5 degree increment dial

5/5 degree intertester reliability

5 degree increment dial

5 degree measurement variability
Shoulder Inclinometry

- Poor intertester reliability with significant range of disagreement (SEM).
- Compared to traditional goniometry:
  - Intertester Reliability
  - MDC
- 2 – 20 degree SEM
- Document method of ROM measurement
- If measured by different clinicians, must have at least 20 degree of change in ROM.
- Reevaluation should be by same clinician.

Spine ROM with Inclinometer

<table>
<thead>
<tr>
<th>Joint Motions Measured</th>
<th>Validity Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Cervical Flexion, Extension, Lateral</td>
<td>Excellent correlations to radiographs</td>
</tr>
<tr>
<td>Bending, and Rotation.</td>
<td></td>
</tr>
<tr>
<td>**Lumbar Flexion, Extension</td>
<td>High correlation between palpation for landmarks,</td>
</tr>
<tr>
<td></td>
<td>fluoroscopy identification of landmarks, and</td>
</tr>
<tr>
<td></td>
<td>radiography measurement.</td>
</tr>
</tbody>
</table>


Inclinometer Placement on Spine

- Dual inclinometers applied simultaneously for accurate measurement.

<table>
<thead>
<tr>
<th>Landmark Identification Method</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palpation</td>
<td>S1</td>
<td>T12</td>
</tr>
<tr>
<td>Schober Test</td>
<td>S2</td>
<td>10 cm above S2</td>
</tr>
<tr>
<td>Modified Schober</td>
<td>S2</td>
<td>15 cm above S2</td>
</tr>
</tbody>
</table>

Visual Estimation Reliability

<table>
<thead>
<tr>
<th>Participants</th>
<th>Motions Measured</th>
<th>Reliability Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthopedists</td>
<td>Shoulder flexion, ABDuction,</td>
<td>Fair to Good intratester</td>
</tr>
<tr>
<td>Physical Therapists</td>
<td>External Rotation</td>
<td>and intertester reliability</td>
</tr>
<tr>
<td>Orthopedic surgeons</td>
<td>Hip All planes</td>
<td>Good intertester reliability</td>
</tr>
<tr>
<td>Physical Therapists</td>
<td>except ABDuction</td>
<td>except ABDuction</td>
</tr>
<tr>
<td>Physical Therapists</td>
<td>Knee flexion and Extension</td>
<td>Fair intertester reliability</td>
</tr>
</tbody>
</table>


Inexperienced Evaluator

Visual vs. Goniometry

- SEM analysis indicates that accuracy is directly dependent upon experience of tester.
- Visual: 10
- Goni: 5-7

Visual Estimation

- Often considered unreliable when precise measurement values are necessary.
- May be acceptable method for specific motions.
  - Hip Flexion

Participants

<table>
<thead>
<tr>
<th>Motions Measured</th>
<th>Reliability Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder flexion, ABDuction, External Rotation</td>
<td>Fair to Good intratester and intertester reliability</td>
</tr>
<tr>
<td>Hip All planes</td>
<td>Good intertester reliability except ABDuction</td>
</tr>
<tr>
<td>Knee flexion and Extension</td>
<td>Fair intertester reliability</td>
</tr>
</tbody>
</table>

Photogrammetry
- Digital photographs calculated with software or printed paper photos measured with a goniometer.
- Beneficial applications include:
  - Telemedicine
  - Proof of progress to patients
  - Standardization among multi-clinician settings
  - Maximizing hands on time during visit

Image Analysis
Software Utilized in Research
- SAPO Software
- CorelDraw
- ALCIImagem

Printed Photogrammetry
- Research supporting the technique is valid and produces more consistent results than goniometry.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Motions Measured</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Orthopedists</td>
<td>Shoulder flexion, ABDuct, External Rotation</td>
<td>Polaroid</td>
</tr>
<tr>
<td>Physical Therapists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Athletic Trainers</td>
<td>Modified Thomas Test</td>
<td>Printed Photos</td>
</tr>
</tbody>
</table>

OpenSim
- Create models of musculoskeletal motion

Digital Photogrammetry
- Reliable but requires additional technology skills and time to manage software.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Motions Measured</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Surgeon Medical Student</td>
<td>Elbow, Forearm, Wrist all planes</td>
<td>Phone Camera</td>
</tr>
<tr>
<td>**Clinician</td>
<td>Shoulder Rotation</td>
<td>Digital Camera</td>
</tr>
<tr>
<td>***PT, PT Students, Hand Therapist</td>
<td>Thumb ABDuct, PIP flexion, MCP flexion</td>
<td>Digital Camera</td>
</tr>
</tbody>
</table>

Smartphone Components
- Accelerometer
- Gyroscope
- Magnetometer
- Ambient Light Sensor
- Proximity Sensor
- Camera

Assessing Motion, Strength, & Balance
Copyright Jodi Gootkin 2016
Smartphone Applications Examined in Research

- iShould
- Knee Goniometer
- Simple Goniometer

Accelerometer

- mROM
- DrGoniometer
- iHandy Level
- Clinometer
- GetmyROM
- Physio2Go
- Scoliguage
- Hip ROM Tester

Inclinometer Based

- Coach’s Eye

Two Dimensional Motion Analysis

Accelerometer Based Apps

- Screen image mimics universal goniometer.
- Phone’s accelerometer measures the joint angle through position changes.
- Software uses trigonometric equation to calculate joint motion.

Camera Based App

- Uses integrated camera for photo.
- Phone’s build in inclinometer guides alignment.
- On the image, the clinician drags/drops to mark the three anatomical reference points.
- The angle reflecting ROM is then calculated by the app.

Camera Based Apps Extremity ROM

- Consistent with other methods of measurement.

<table>
<thead>
<tr>
<th>Motion Measured</th>
<th>Comparative Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Shoulder ABDuction</td>
<td>Inertial sensors</td>
</tr>
<tr>
<td>**Knee Flexion</td>
<td>Goniometry</td>
</tr>
</tbody>
</table>

Camera Based Apps Potential Error

- Two potential sources of error:
  - Alignment when taking image
  - Alignment while positioning virtual goniometer

Inclinometer Based Apps

- Phone’s built in accelerometer is used to sense motion.
- The digital display mimics bubble goniometer or produces values for angle measured.
Assessing Motion, Strength, & Balance
Copyright Jodi Gootkin 2016

---

Inclinometer Based Apps Externity ROM
- Consistent with other methods of measurement for most motions.
- Similar to Goniometry, less reliable
- Hip ABDuction
- Hip External Rotation

<table>
<thead>
<tr>
<th>Motion Measured</th>
<th>Comparative Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Hip All Planes</td>
<td>Bubble Inclinometer</td>
</tr>
<tr>
<td>**Shoulder All Planes</td>
<td>Universal Goniometer</td>
</tr>
</tbody>
</table>


---

Inclinometer Based Apps Spine ROM
- Consistent with other methods of measurement for most motions for sagittal and frontal plane motions.

<table>
<thead>
<tr>
<th>Motion Measured</th>
<th>Comparative Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Trunk Flexion, Extension, Lateral Flexion</td>
<td>Bubble Inclinometer</td>
</tr>
</tbody>
</table>

---

Cervical ROM Inclinometer App
- Does not appear to be valid for cervical rotation.

<table>
<thead>
<tr>
<th>Motion Measured</th>
<th>Comparative Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>**Cervical Rotation, Flexion, Extension, Lateral Flexion</td>
<td>Glasses with Inclinometers Three Dimensional Motion Analysis</td>
</tr>
</tbody>
</table>


---

Inclinometer Based Apps Potential Error
- Zero start position must be established.
- Method of phone placement can vary.
- Port vs. Power
- Calculation may be necessary:
  - $\text{Start value} + \text{End value} = \text{Total ROM}$
- Infection control and hygiene concerns
- Scoliosis alignment

---

Scoliosis Apps
- Thoracic rotation evaluated to determine severity of postural deformity.
- Measurements with smartphone apps can be made with confidence.
- Stabilization with a holder may be necessary for sufficient phone length to measure rib hump.

---

Two Dimensional Motion Apps
- Video recording of active motion with software analysis.
- Comparable analysis to more expensive three dimensional analysis systems.
- Adding reflective markers for anatomical landmarks enhances accuracy.
Assessing Motion, Strength, & Balance
Copyright Jodi Gootkin 2016
### Functional Reach Test
- Evaluates limits of stability in standing by forward, lateral, and backwards reaching.

### Balance Evaluation Systems Test (BESTest)
- Assesses six different balance control systems to determine underlying postural or physiological system contributing to the balance deficits.
  - Biomechanical Constraints
  - Stability Limits/Verticallity
  - Anticipatory Postural Adjustments
  - Postural Responses
  - Sensory Orientation
  - Stability in Gait

### MiniBESTest
- 14 task clinical balance scale that rates items on a 3-point scale (Normal, Moderate, Severe)
- Maximum score 28
- Higher score indicates better performance
- Takes 10-15 minutes to complete

### Physiological Profile Approach (PPA)
- Organized based on physiologic impairment that contribute to fall risk:
  - Postural sway
  - Hand reaction time
  - Knee extension strength
  - Leg proprioception
  - Visual edge contrast sensitivity
- Identifies fall risk, but does not direct treatment

### Fullerton Advanced Balance (FAB)
- Each of the 10 items requires static and dynamic postural control.
- Scored on a 5 point scale (0-4)
- Maximum score 40
- Higher score indicates better balance
- Takes 10 – 12 minutes to complete
- Excellent reliability
- Quicker to complete than MiniBESTest and BBS

### Static Posturography
- Static analyzes postural sway
- Angular velocity sensors on trunk or head can obtain measurements
- Higher velocity of center of pressure (COP) displacement associated with aging, neuropathy, Parkinson’s disease, vestibular loss, and stroke.
Dynamic Posturography

- Dynamic assesses response to external perturbations, surface changes, and/or visual condition changes.
- Moveable surface creates disequilibrium to measure response.

Alternative Methods of Posturography

- Gaming systems are an inexpensive and alternative to posturography systems.

<table>
<thead>
<tr>
<th>System</th>
<th>Population</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Wii Balance Board</td>
<td>Individual Post Stroke</td>
<td>Concurrent validity with posture equipment. Excellent reliability and sensitivity.</td>
</tr>
<tr>
<td>*Microsoft Kinect</td>
<td>Healthy Participants</td>
<td>Comparable intertester reliability. Can accurately assess kinematic control of posture.</td>
</tr>
</tbody>
</table>

Falls

- Screen
  - Identifies someone at risk for falls.
  - Has the individual had 2 or more falls in the prior 12 months?
  - Does the individual present with an acute fall?
  - Does the individual have a self-reported or is there an observed difficulty with walking or balance?

Assessment

- Multifaceted measurement to determine interventions needed

Predicting Falls

- Postural assessments alone are not sufficient as they do not consider the multiple systems and contributors to falls.
- MiniBESTest prospective prediction with accuracy for 6 months from completion.

<table>
<thead>
<tr>
<th>Tasks Compared</th>
<th>Population</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAB</td>
<td>Patients with Parkinson’s Disease</td>
<td>Similar ability to identify fallers with one or more falls from non fallers</td>
</tr>
<tr>
<td>MiniBESTest</td>
<td>BBS</td>
<td></td>
</tr>
</tbody>
</table>

SCAT3 Assessment

- Sport Concussion Assessment Tool (SCAT3) is utilized for concussion assessment. Components include:
  - Symptom Evaluation
  - Glasgow Coma Scale (GCS)
  - Maddocks Score
  - Standardized Assessment of Concussion (SAC) Cognitive Assessment
  - Coordination Assessment
  - Balance Examination

Sideline Concussion Assessment Elements

- Vital Signs
- Mental Status Exam
- Neurologic Exam/Cranial Nerve Exam
- Musculoskeletal Exam/Reflexes
- Balance/Coordination Exam
- Vestibulococular Exam

---

Assessing Motion, Strength, & Balance
Copyright Jodi Gootkin 2016
SCAT3 Balance Examination

- Modified Balance Error Scoring System (BESS)
- Double leg stance
- Single leg stance
- Tandem stance
- Limited intertester reliability, high false positive rate, and limited discrimination

Star Excursion Balance Test (SEBT)

- Eight direction star tape pattern created on floor.
- Reaching assessed by sequentially reaching in each direction.
- Predictor of potential injury if anterior left right difference greater than 4 cm.

Conclusion

- Traditional range of motion, strength, and balance assessment tools continue to be valid.
- As staffing patterns continue to shift, awareness of strategies to ensure intertester reliability of data collection will preserve accurate assessment of patient progress.
- Opportunities to utilize new technology will continue to grow as the practice environment expands beyond the traditional workplace.

Interactive Discussion and Clinical Applications

1. Which disability model includes personal and environmental factors?
   A. Nagi disablement model
   B. International Classification of Function
   C. Multidisciplinary Impact assessment
   D. Disability Influence Factoring

2. Which statement about rehab professional’s beliefs toward evidence based practice is FALSE?
   A. Research guided patient care decisions can improve clinical outcomes
   B. Most clinician’s lack confidence in their ability to access and interpret research
   C. Evidence based practice is the standard but infrequently used
   D. All intervention decisions must be supported by evidence
3. Why is establishing valid and reliable measures an important element of evidence-based practice?
   A. Consistent measurement tools should be utilized to compare outcomes
   B. To improve reimbursement from insurance companies
   C. Subjective data collection has strong inter-tester reliability
   D. Data collection is not sufficiently emphasized in rehabilitation

4. Which of the following increases manual muscle testing inter-tester reliability?
   A. Standardized joint position
   B. Location of resistance force
   C. Joint stabilization
   D. All of the above

5. Which statement is true regarding hand held dynamometry?
   A. Only “make testing” can be performed
   B. Clinician strength may alter accuracy
   C. It is most accurate for grades below 2/5
   D. The patient must always be positioned supine

6. Which of the following is NOT a recognized method of assessing range of motion?
   A. Visual estimation
   B. Volumetric excursion
   C. Electronic measurement
   D. Diagrammatic representation

7. What smartphone component is used by goniometry apps to detect position changes?
   A. Accelerometer
   B. Level
   C. Microphone
   D. Dynamometer

8. Which statement accurately reflects current evidence on goniometry?
   A. Variability exists in standard goniometry techniques across disciplines
   B. Passive range of motion assessment always produces lower measurement values
   C. Smartphone applications appear to be as reliable as traditional measurement
   D. Smartphone methods do not require the clinician to be attentive to alignment
9. Which balance assessment tool identifies the underlying postural or physiological systems contributing to balance deficits?

A. Berg
B. TUG
C. BESTest
D. Tinetti

10. Which of these balance measures are best at predicting future falls?

A. Sit to stand and tandem stance
B. One leg stance and sit to stand
C. Compensatory stepping backwards and functional reach
D. Tandem stance and compensatory stepping backwards

References


Conliffe, Ken, and Mario Castellini. “Which of these balance measures are best at predicting future falls?” *Journal of Physical Therapy Education* 2012, Article ID 923493, 6 pp.


