Goniometry 101

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The technique of quantifying human joint position or range of motion
**What do goniometers assess?**

A. Pathology

B. Impairment – this is correct
Goniometry assesses range of motion which is considered an impairment on Nagi’s Disablement model

C. Functional Limitation

D. Disability

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**Measurement Tools**

Universal Goniometer
plastic or metal protractor like device with moveable and stationary arms of varying lengths
Measurement Tools

- Gravity Dependent Goniometers - *Inclinometers*
  - Pendulum
  - Fluid (bubble)
  - report position of distal or proximal segment relative to the line of gravity requiring the adjacent segments to be positioned vertically or horizontally

• Electrogoniometers
  - potentiometer detects changes in position of two segments

• Radiographs
• Photographs

*These devices are generally only used in research applications*
Goniometric Procedure

- Explain/demonstrate procedure
- Position and drape appropriately
- Observe or measure uninvolved and AROM first
- Make visual estimation of motion
- Ensure proximal stabilization
- PROM with identification of end feel
- Landmark identification through palpation
- Align measurement device in neutral or zero position
- Measure end range position
- Document findings and compare to “normals” or uninvolved

Positioning

- Not standardized
- Start in reference “zero” position
  - document if zero position can’t be achieved
- Permit complete range of motion
  - avoid positions that put biarticular muscles in position of passive insufficiency
  - knee extensor flexibility vs. knee flexion range of motion
- Ensure proximal segment stability
Device Alignment

1. Expose landmarks
2. Position Axis or “fulcrum”
   - Convex pivot point
   - Axis may move with motion
   - prioritize arm alignment over axis alignment!
3. Align Proximal Arm
   - stationary arm parallel to the long axis of the segment
4. Align Distal Arm
   - moving arm parallel to the long axis of the segment

Stabilization

- Are you assessing functional ability or isolated joint motion?
- Unreliable measures if inconsistent monitoring of substitution
- Must anticipate compensatory motions
  - subtalar joint pronation to increase ankle dorsiflexion ROM
  - lumbar hyperextension to increase shoulder flexion
  - jaw opening to increase cervical flexion
  - trunk lateral flexion to increase hip rotation
What would you rather know?

A. How much motion you have?

B. What is limiting the motion you have? — correct!

From an intervention standpoint it may be more important to know what is limiting the motion as opposed to having much you have because that information will help you pick the appropriate intervention.

End Feel

Nature of the motion barrier that characterizes the type of tissue limiting range:

- **Soft** (spongy):
  - Start
  - 1st Stop
  - Final Stop

- **Firm** (distinct arrest):
  - Start
  - 1st Stop
  - Final Stop

- **Hard** (abrupt halt):
  - Start
  - 1st Stop
  - Final Stop
Pathological End Feels

- Empty
  - Painful
- Boggy
  - Mushy
- Muscle spasm
  - Painful rebound
- Springy
  - Internal derangement

Is goniometry error free?
Potential Sources of Error

- Failure to read at eye level causing parallax distortion
- Incorrect landmark identification
- Failure to read proper scale
- Lack of patient cooperation

Consistent repeatable, and reproducible measurements have:

A. Sensitivity
B. Specificity
C. Reliability – correct!
D. Validity
Reliability

- Measurement is consistent, repeatable and reproducible
- Goniometric reliability is maximized by standardized:
  1) measuring device
  2) positioning and landmarks
  3) procedure
  4) examiner

- Higher reliability in measuring a position than a motion
- UE measurements > than LE measurements > than spine measurements
- Intratester (< 5°) better than intertester (> 5°)
- Questionable reliability benefit to using mean of measurements
Measures that represent the true value are:

A. Sensitive
B. Specific
C. Reliable
D. Valid – correct!

Validity

- Measurement represents the true value of the variable
- Extent to which the measurement fulfills its purpose
  - goniometric value actually represents the angular relationship of the two articulating segments
- Validity assumes reliability
- Criterion validity (using radiographs as the gold standard) has generally been established in the literature
  
  Gogia, PT, 1987
  Gadjdoski, PT, 1987
Documentation

• WNL unacceptable unless referenced
  – AAOS, Kendall, Hoppenfeld, AMA Impairment
• Compare involved to uninvolved sides
• Compare to subjects of similar age and gender

Examples of Limited Range Documentation

• 0-152° (R) pain free passive elbow flexion with soft tissue end feel
• 7-0-85° (L) passive knee motion with capsular end feel and symptom reproduction at end range flexion
• Always use a third value to indicate neutral position if motion exist on each side of the neutral position

Can you only assess motion by angular measure? NO
Linear Alternatives

• Shoulder
  – Functional Reach Tests

• Hand
  – Thumb Opposition
  – Fingertip to Palm

• Knee
  – Prone heel height

• Cervical Spine
  – Flexion-Extension
    • Sternal notch
  – Cervical LF/Rotation
    • Acromion

• Lumbar Spine
  – Spinous process distraction
  – Fingertip to floor

What does the literature say about goniometry?
• Excellent intratester reliability

• Suspect intertester reliability
  – except ext. rotation

• Functional reach tests good alternative

Goniometric Reliability of Shoulder Measurements in a Clinical Setting
*Phys Ther* 67:668-673, 1987

### Intratester and Intertester Reliability of Shoulder Goniometric Measures

<table>
<thead>
<tr>
<th>MOTION</th>
<th>Intratester ICC</th>
<th>Intertester ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>.98</td>
<td>.89 questionable</td>
</tr>
<tr>
<td>Extension</td>
<td>.94</td>
<td>.27</td>
</tr>
<tr>
<td>Abduction</td>
<td>.98</td>
<td>.87 unfunctional</td>
</tr>
<tr>
<td>Horz Abduction</td>
<td>.90</td>
<td>.30</td>
</tr>
<tr>
<td>Horz Adduction</td>
<td>.95</td>
<td>.41</td>
</tr>
<tr>
<td>External Rotation</td>
<td>.99</td>
<td>.88</td>
</tr>
<tr>
<td>Internal Rotation</td>
<td>.94</td>
<td>.55</td>
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### Comparison of Functional Reach and Goniometric Assessment of Shoulder Motion

#### Intratester Reliability ICC

<table>
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<tr>
<th></th>
<th>Pathological Group</th>
<th>Non-Pathological Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross Body</td>
<td>.95-97</td>
<td>.95</td>
</tr>
<tr>
<td>Flexion</td>
<td>.90-93</td>
<td>.75-92</td>
</tr>
<tr>
<td>Internal Rotation</td>
<td>.94-97</td>
<td>.92-95</td>
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#### Intertester Reliability ICC

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<tr>
<td>Flexion</td>
<td>.70</td>
<td>.47</td>
</tr>
<tr>
<td>Internal Rotation</td>
<td>.71</td>
<td>.44</td>
</tr>
</tbody>
</table>


- + 2-7° intratester variation for flexion-extension
- + 8-10° intratester variation for pronation-supination
- Pro-supination reliability best with distal arm parallel to forearm
- Acceptable reliability for both universal goniometers and fluid-based inclinometers
Wrist-Hand

- ± 5-8° intratester variation for wrist flexion-extension
- ± 6-10° intertester variation for wrist flexion-extension
- Dorsal goniometer placement generally accepted as preferred method for finger IP flexion-extension assessment

Spine

- Reliability and criterion validity has been established for inclinometry and is the recognized standard of motion assessment
**Spine**

- **Alternative methodologies**
  - Universal goniometer
  - Flexible ruler
  - Tape measure attraction-distraction
  - Finger tip to floor measurements

**Hip**

- Both inclinometers and goniometers have acceptable intratester reliability but are not interchangeable
- Intertester reliability has not been established
- Lowest coefficient of variance for flexion ROM, extension ROM the highest
• Excellent intra and intertester goniometric reliability for knee flexion range of motion

• Tibial rotation ROM reliability has not been established

Intratester/Intertester Reliability of Measuring Knee Extension Position with a Goniometric Method

Excellent intra and intertester reliability

| Therapist 1 involved extremity | .94 |
| Therapist 1 uninvolved extremity | .96 |
| Therapist 2 involved extremity | .97 |
| Therapist 2 uninvolved extremity | .94 |
| Therapist 1 vs. 2 involved extremity | .88 |
| Therapist 1 vs. 2 uninvolved extremity | .83 |

Mulligan 1995
Intratester/Intertester Reliability of Measuring Knee Extension Position with the Prone Heel Height Method

| Therapist 1 | .98 |
| Therapist 2 | .98 |
| Therapist 1 vs. 2 | .94 |

Continuing ED

Interchangeability of Prone Heel Height and Goniometric Methods of Determining Knee Extension Position

<table>
<thead>
<tr>
<th>Measurement Method</th>
<th>M</th>
<th>SD</th>
<th>t</th>
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</thead>
<tbody>
<tr>
<td>Goniometry</td>
<td>7.0</td>
<td>2.94</td>
<td>1.99</td>
</tr>
<tr>
<td>Prone Heel Height</td>
<td>6.35</td>
<td>2.66</td>
<td></td>
</tr>
</tbody>
</table>

Note: *M* represents the average mean difference in degrees between the end range extension position for each method of measurement

Continuing ED

*Mulligan 1995*
Ankle-Foot

- Excellent Intratester reliability for plantar-dorsiflexion
- Fair to good intertester reliability for plantar-dorsiflexion
- Fair intratester reliability for STJ inversion-eversion
- Poor intertester reliability for STJ Inversion-eversion

References

- Physical Therapy
- Archives of Physical Medicine and Rehabilitation
- Journal of Orthopedic and Sports Physical Therapy
- Spine
- Journal of Hand Therapy
Recommended Readings

- American Academy of Orthopedic Surgeons (Green WB, Heckman JD eds.): The Clinical Measurement of Joint Motion. 6300 North River Road, Rosemont, IL 60018, 1994

Practice and Discuss Standards with your Colleagues