Using Research to Predict Recovery in Whiplash Associated Disorders

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Disclosures

• Private Practice, Modern Chiropractic Center (mc²),
  – Boise, ID since 2001, Nampa, ID since 2019
• Certified Instructor, Chiropractic BioPhysics (CBP®)
• CBP® researcher, co-authored Chapters in CBP® Lumbar Rehab book
• Vice President, CBP® NonProfit, Inc
• Immediate Past-President, Idaho Association Chiropractic Physicians
• President, Mountain West Independent Practice Association
• Board of Directors, International Chiropractors Association
  – Co-Chair, Technique and Posture Committee
  – Chair, Chiropractic Guidelines Committee
  – Instructor, Advances in the Management of Traumatic Injuries (AMTI)
• Principle Investigator, PCCRP X-ray Guidelines
• Principle Investigator and Co-Editor, ICA BPPG
• Co-Author of ICA of CA Management of WAD Guidelines
• Consultant for ScoliCare (Sydney AU)
• Certified Independent Medical Examiner (CIME): ABIME
• Co-Founder, Advanced Clinical Consultants (Expert Witness, Plaintiff IME)
• Module 2: March 23-24 (Denver, CO)
• Module 3: June 1-2 (Denver, CO)
• Module 4: September 7-8 (Denver, CO)
• Module 5: November 2-3 (Denver, CO)
• Module 6: Home Study/Certification Exam
Spectrum of Whiplash-Induced Injuries in Typical Chiropractic Office

**MILD**
- Subluxation
- Strains
- Minor sprains
- Bumps
- Bruises

**SEVERE**
- Subluxation
- Major sprains
- Mild radicular Sx
- Resolved ligamentous instability
- Cervical hypolordosis

- Subluxation
- Disc derangement
- Severe radicular Sx
- Permanent ligamentous instability
- Cervical kyphosis
- Permanent Impairment
- Severe TBI
Definitions of Subluxation:

International Chiropractors Association:
• “The subluxation complex includes any alteration of the biomechanics and physiological dynamics of contiguous spinal structures which can cause neuronal disturbances.”

Association of Chiropractic Colleges:
• “A subluxation is a complex of functional and/or structural and/or pathological articular changes that compromise neural integrity and may influence organ system function and general health.”

Stephenson’s 1927 chiropractic text:
• “A subluxation is the condition of a vertebrae that has lost its proper juxtaposition with the one above or the one below, or both; to an extent less than a luxation; which impinges nerves and interferes with the transmission of mental impulses.”
"Chiropractic" defined.

(1) Chiropractic is the practice of health care that deals with the diagnosis or analysis and care or treatment of the vertebral subluxation complex and its effects, articular dysfunction, and musculoskeletal disorders, all for the restoration and maintenance of health and recognizing the recuperative powers of the body.
WSCA Annual Meeting 2019

Saturday, March 16, 2019 • 9:00AM-2:00PM
Radisson Hotel Seattle Airport
Factors Worsening Injury, Complicate Care and Predict Recovery

• Risk Factors:
  • Pre-existing factors that predispose a patient to injury in a crash

• Complicating Factors (Factors Inhibiting Recovery):
  • Pre-existing AND post-injury factors that inhibit recovery

• Prognostic Factors:
  • Factors that can predict recovery vs chronicity
Complicating factors slowing recovery

- People in a car accident
  - Risk factors for acute whiplash injury
    - People with acute whiplash injury
      - Complicating factors slowing recovery
        - People with chronic pain and disability
          - Prognostic factors for the outcome and chronicity of acute whiplash injury
<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>Advance Age</td>
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<tr>
<td>2</td>
<td>Disc protrusion/herniation</td>
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<td>3</td>
<td>Prior vertebral fracture</td>
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<td>4</td>
<td>Metabolic disorders</td>
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<tr>
<td>5</td>
<td>Spondylosis and/or facet arthrosis</td>
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<td>6</td>
<td>Osteoporosis or bone disease</td>
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<td>7</td>
<td>Congenital anomalies of the spine</td>
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<td>8</td>
<td>Arthritis of the spine Spinal or foraminal stenosis</td>
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<td>9</td>
<td>Development anomalies of the spine</td>
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<td>10</td>
<td>AS or other spondylarthropathy</td>
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<td>11</td>
<td>Paraplegia/tetraplegia</td>
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<td>12</td>
<td>Degenerative disc disease</td>
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<td>13</td>
<td>Prior cervical or lumbar spine surgery</td>
</tr>
<tr>
<td>14</td>
<td>Prior spinal injury; scoliosis</td>
</tr>
</tbody>
</table>
### Complicating Factors for WAD Tx: ICA BPPG Chapter 11, Table 7

<table>
<thead>
<tr>
<th>1.</th>
<th>&lt;5 yrs at same employer</th>
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<tbody>
<tr>
<td>2.</td>
<td>Abnormal joint motion</td>
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<td>3.</td>
<td>Abnormal Posture</td>
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<td>4.</td>
<td>Absolute cervical spinal canal stenosis (10-12 mm)</td>
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<td>5.</td>
<td>Advanced age</td>
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<td>6.</td>
<td>Asymmetry of muscle tone</td>
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<td>7.</td>
<td>Cervical Kyphosis</td>
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<td>8.</td>
<td>Compression fracture</td>
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<td>9.</td>
<td>Condition chronicity</td>
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<td>10.</td>
<td>Congenital fused cervical segments</td>
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<td>11.</td>
<td>Dens fracture</td>
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<td>12.</td>
<td>Emotional stress</td>
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<td>Employment satisfaction</td>
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<td>14.</td>
<td>Ergonomic factors</td>
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<td>15.</td>
<td>Expectations of recovery</td>
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<td>16.</td>
<td>Facet fracture</td>
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<td>17.</td>
<td>Falling as a mechanism of prior injury</td>
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<td>18.</td>
<td>Family/relationship stress</td>
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<td>19.</td>
<td>Fixated segment on flexion/extension films</td>
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<td>20.</td>
<td>Increased spine flexibility</td>
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<td>21.</td>
<td>Laterolisthesis</td>
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<tr>
<td>22.</td>
<td>Leg length inequality</td>
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<td>23.</td>
<td>Leg pain greater than back pain</td>
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<td>24.</td>
<td>Level of fitness</td>
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<td>25.</td>
<td>Likely mechanical tissue damage</td>
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<td>26.</td>
<td>Loss of cervical lordosis</td>
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<td>27.</td>
<td>Loss of consciousness after trauma</td>
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<td>28.</td>
<td>Lower wage employment</td>
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<td>29.</td>
<td>Lumbar Kyphosis</td>
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<td>30.</td>
<td>Managing Named Diseases (e.g., MS, Chrones Disease, Asthma, etc)</td>
</tr>
<tr>
<td>31.</td>
<td>NRS ≥ 7.0</td>
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<td>32.</td>
<td>Obesity</td>
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<td>33.</td>
<td>One-sided sports/exercise activity</td>
</tr>
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<td>34.</td>
<td>Osteoarthritis</td>
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<td>35.</td>
<td>Pain with radicular signs/symptoms</td>
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<tr>
<td>36.</td>
<td>Physical limitations (can’t exercise, can’t walk, wheelchair, etc)</td>
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<tr>
<td>37.</td>
<td>Poor body mechanics</td>
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<td>38.</td>
<td>Poor spinal motor control</td>
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<td>39.</td>
<td>Pre-existing degenerative joint disease</td>
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<td>40.</td>
<td>Prior recent injury (&lt;6 mos.)</td>
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<td>41.</td>
<td>Prior surgery in area of complaint</td>
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<td>42.</td>
<td>Prolonged static postures</td>
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<td>43.</td>
<td>Reduced muscle endurance</td>
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<td>44.</td>
<td>Relative cervical spinal canal stenosis (13-15 mm)</td>
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<td>45.</td>
<td>Retrolisthesis</td>
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<td>46.</td>
<td>Rheumatoid arthritis</td>
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<td>47.</td>
<td>Scoliosis (define: 10° or more?)</td>
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<tr>
<td>48.</td>
<td>Smoking</td>
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<tr>
<td>49.</td>
<td>Spinal Anomaly</td>
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<tr>
<td>50.</td>
<td>Spondylolisthesis/spondylolyasis</td>
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<tr>
<td>51.</td>
<td>Surgically fused cervical segments</td>
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<tr>
<td>52.</td>
<td>Sustained (frequent/continuous) trunk load &gt; 20 lbs.</td>
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<tr>
<td>53.</td>
<td>Traumatic causation</td>
</tr>
<tr>
<td>54.</td>
<td>Wearing high heel shoes</td>
</tr>
<tr>
<td>55.</td>
<td>Work-related duties</td>
</tr>
</tbody>
</table>
8 Prognostic Factors for WAD Recovery

1. Initial Pain Intensity (NRS, VAS, etc)
2. Initial Neck Disability Index (NDI)
3. Initial WAD Grade of Injury
4. Initial Cervical Range of Motion
5. Hyeralgesia (cold, algometry, etc)
6. Initial Expectations of Recovery
7. Post-Crash Emotional Factors (e.g. catastrophizing)
8. Muscle Fatty Infiltration (on MRI)
Why is this Important??

1. 50% of people injured in a crash never fully recover
   • 25% of these people have permanent impairment/disability
2. Give the patient a real “prognosis”
3. Determine how aggressive (diverse) to be with Tx plan and co-management plan
   • Do everything you can early in management
4. Medicolegal implications of likely becoming permanently impaired
1. Initial Pain Intensity
Hierarchy of Evidence

- Systematic Reviews
- Critically-Appraised Topics & Articles
- Randomized Controlled Trials (RCTs)
- Cohort Studies
- Case-Controlled Studies
- Background Information / Expert Opinion
Predictors of Poor Prognosis after Acute WAD

#1 predictor that a patient will not fully recover to pre-injury status:
Self-Reported Pain Intensity


Predictors of Poor Prognosis after Acute WAD

#1 predictor that a patient will not fully recover to pre-injury status: Self-Reported Pain Intensity


- Synthesized the data (meta analysis) from eight cohorts and established a cutoff point of \( \frac{5.5}{10} \) on a VAS, with pain greater than this demonstrating a nearly sixfold (OR: 5.77; 95% CI: 2.89–11.52) increase in the risk of persistent pain or disability at long-term follow-up.
The significant variables included:

- high baseline pain intensity (greater than 5.5/10)
- report of headache at inception
- less than postsecondary education
- no seatbelt in use during the accident
- report of low back pain at inception,
- high Neck Disability Index score (greater than 14.5/50)
- preinjury neck pain
- report of neck pain at inception (regardless of intensity)
- high catastrophizing
- female sex
- WAD grade 2 or 3, and
- WAD grade 3 alone.

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome</th>
<th>Follow-up, mo</th>
<th>Odds Ratio</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>z Value</th>
<th>P Value</th>
<th>Odds Ratio and 95% CI*</th>
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</thead>
<tbody>
<tr>
<td>Berglund et al²</td>
<td>Pain</td>
<td>12</td>
<td>8.85</td>
<td>6.32</td>
<td>12.38</td>
<td>12.72</td>
<td>.00</td>
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<tr>
<td>Hartling et al¹⁰</td>
<td>Pain</td>
<td>6</td>
<td>9.14</td>
<td>2.92</td>
<td>28.61</td>
<td>3.80</td>
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<tr>
<td>Hendriks et al¹²</td>
<td>Pain</td>
<td>12</td>
<td>4.06</td>
<td>1.69</td>
<td>9.74</td>
<td>3.13</td>
<td>.00</td>
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<tr>
<td>Kasch et al¹⁷</td>
<td>Disability</td>
<td>12</td>
<td>6.86</td>
<td>1.71</td>
<td>27.46</td>
<td>2.72</td>
<td>.01</td>
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<tr>
<td>Kivioja et al²¹</td>
<td>Pain</td>
<td>12</td>
<td>8.84</td>
<td>2.54</td>
<td>30.72</td>
<td>3.43</td>
<td>.00</td>
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<tr>
<td>Kivioja et al²²</td>
<td>Pain</td>
<td>12</td>
<td>4.22</td>
<td>1.23</td>
<td>14.47</td>
<td>2.29</td>
<td>.02</td>
<td></td>
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<tr>
<td>Nederhand et al²⁸</td>
<td>Disability</td>
<td>6</td>
<td>9.99</td>
<td>3.38</td>
<td>29.49</td>
<td>4.17</td>
<td>.00</td>
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<tr>
<td>Radanov et al²⁹</td>
<td>Pain</td>
<td>24</td>
<td>3.41</td>
<td>1.29</td>
<td>9.01</td>
<td>2.47</td>
<td>.01</td>
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<tr>
<td>Söderlund et al³²</td>
<td>Pain</td>
<td>6</td>
<td>1.00</td>
<td>0.31</td>
<td>3.18</td>
<td>0.00</td>
<td>1.00</td>
<td></td>
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<tr>
<td>Sterling³⁴</td>
<td>Disability</td>
<td>6</td>
<td>7.71</td>
<td>0.91</td>
<td>65.35</td>
<td>1.87</td>
<td>.06</td>
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<tr>
<td>Vetti et al⁴¹</td>
<td>Pain</td>
<td>12</td>
<td>6.17</td>
<td>1.95</td>
<td>19.58</td>
<td>3.09</td>
<td>.00</td>
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</tbody>
</table>

*Odds Ratio and 95% CI*
Factors predicting outcome in whiplash injury: a systematic meta-review of prognostic factors

Pooria Sarrami1,2 · Elizabeth Armstrong3 · Justine M. Naylor3,4 · Ian A. Harris3,4

Fig. 1 Illustration of risk factors and prognostic factors of acute whiplash injury
Factors predicting outcome in whiplash injury: a systematic meta-review of prognostic factors

Pooria Sarrami1,2 · Elizabeth Armstrong3 · Justine M. Naylor2,4 · Ian A. Harris2,4

Table 2

<table>
<thead>
<tr>
<th>Factors</th>
<th>The conclusion of evaluated systematic reviews [and citations]</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>whiplash grades, cold hyperalgesia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-injury anxiety</td>
<td>A [18], A [20]</td>
<td>Associated (based on outdated reviews)(^a)</td>
</tr>
<tr>
<td>Catastrophizing</td>
<td>A [18], A [14], C [20]</td>
<td>Associated (based on outdated reviews)</td>
</tr>
<tr>
<td>Compensation and legal factors</td>
<td>A [16], A [18], L [23]</td>
<td>Associated</td>
</tr>
<tr>
<td>Early healthcare use</td>
<td>A [18], L [23]</td>
<td>Associated (based on outdated reviews)(^a)</td>
</tr>
</tbody>
</table>

\(^a\) Systematic reviews that were published 5 years ago or earlier are considered ‘outdated’
Factors predicting outcome in whiplash injury: a systematic meta-review of prognostic factors

Pooria Sarrami, Elizabeth Armstrong, Justine M. Naylor, Ian A. Harris

Table 3

<table>
<thead>
<tr>
<th>Factors</th>
<th>The conclusion of evaluated systematic reviews [and citations]</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-injury MRI or radiological findings</td>
<td>N [12], N [18]</td>
<td>Not associated</td>
</tr>
<tr>
<td>Collision factors</td>
<td>N [15], N [19], N [18], N [22], C [23]</td>
<td>Not associated</td>
</tr>
</tbody>
</table>

N non-associated, C controversial
Factors predicting outcome in whiplash injury: a systematic meta-review of prognostic factors

Pooria Sarrami1,2 · Elizabeth Armstrong3 · Justine M. Naylor2,4 · Ian A. Harris2,4

Table 4 Factors that were controversial or lacked evidence

<table>
<thead>
<tr>
<th>Factors</th>
<th>The conclusion of evaluated systematic reviews [and citations]</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>A [15], C [18], N [19], N [22], A [23]</td>
<td>Controversial</td>
</tr>
<tr>
<td>Age</td>
<td>N [15], N [19], C [18], N [22], A [23]</td>
<td>Controversial</td>
</tr>
<tr>
<td>Education</td>
<td>A [15], C [18], C [23]</td>
<td>Controversial</td>
</tr>
<tr>
<td>Pain prior to accident</td>
<td>A [15], C [18], C [23]</td>
<td>Controversial</td>
</tr>
<tr>
<td>Genetic factors</td>
<td>L [18]</td>
<td>Lack of evidence</td>
</tr>
<tr>
<td>Coping behaviour</td>
<td>C [18], C [20]</td>
<td>Controversial (based on outdated reviews)</td>
</tr>
<tr>
<td>General psychological distress</td>
<td>A [19], N [20]</td>
<td>Controversial (based on outdated reviews)</td>
</tr>
<tr>
<td>Depressive mood</td>
<td>N [14], A [18], C [20]</td>
<td>Controversial (based on outdated reviews)</td>
</tr>
</tbody>
</table>

A associated, N non-associated, C controversial, L lack of evidence

a Systematic reviews that were published 5 years ago or earlier are considered ‘outdated’
Factors predicting outcome in whiplash injury: a systematic meta-review of prognostic factors

Poornia Sarrami¹,², Elizabeth Armstrong³, Justine M. Naylor²,³, Ian A. Harris²,³


CONCLUSION:

“The most consistent finding of the systematic reviews was the association of post-injury pain and disability with long-term pain and disability.”
## Capturing Pain Intensity

<table>
<thead>
<tr>
<th>Pain Intensity Instrument</th>
<th>Description</th>
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<tbody>
<tr>
<td><em>Verbal Rating Scale (VRS)</em></td>
<td>Patients read over a list of adjectives describing levels of pain intensity and choose the word or phrase that best describes their level of pain. (0-3 score, 3=worst).</td>
</tr>
<tr>
<td><em>Visual Analog Scale (VAS)</em></td>
<td>Patients place a mark on a 10 cm line (on paper, or using a mechanical device), with ends labeled as the extremes of pain (10=worst), to denote their level of pain intensity. A quantifiable score is derived from millimetric measurement (0-100).</td>
</tr>
<tr>
<td><em>Numerical Rating Scale (NRS)</em></td>
<td>Patients verbally (or using a pencil) rate their pain from 0-10 (11-point scale), 0-20 (21-point scale), or 0-100 (101-point scale) to rate their pain intensity (highest score worst).</td>
</tr>
</tbody>
</table>
Quad VAS

• Pain is reported:
  • Right Now
  • Average
  • At its Best
  • At its Worst
80 whiplash subjects (WAD II or III) within 1 mo of injury, and 20 control subjects
- Motor function (cervical range of movement [ROM],
- joint position error [JPE];
- activity of the superficial neck flexors [EMG] during a test of cranio-cervical flexion),
- quantitative sensory testing (pressure, thermal pain thresholds, and responses to the brachial plexus provocation test),
- and psychological distress (GHQ-28, TAMPA, IES)

Conclusions: “Acute whiplash subjects with higher levels of pain and disability were distinguished by sensory hypersensitivity to a variety of stimuli, suggestive of central nervous system sensitization occurring soon after injury. These responses occurred independently of psychological distress. These findings may be important for the differential diagnosis of acute whiplash injury and could be one reason why those with higher initial pain and disability demonstrate a poorer outcome.”
2. Neck Disability Index
Predictors of Poor Prognosis after Acute WAD

#2 predictor that a patient will not fully recover to pre-injury status:

Self-Reported Disability (NDI)
SECTION 1 - PAIN INTENSITY
- I have no neck pain at the moment.
- The pain is very mild at the moment.
- The pain is moderate at the moment.
- The pain is fairly severe at the moment.
- The pain is very severe at the moment.
- The pain is the worst imaginable at the moment.

SECTION 2 - PERSONAL CARE
- I can look after myself normally without causing extra neck pain.
- I can look after myself normally, but it causes extra neck pain.
- It is painful to look after myself, and I am slow and careful.
- I need some help but manage most of my personal care.
- I do not get dressed. I wash with difficulty and stay in bed.

SECTION 3 - LIFTING
- I can lift heavy weights without causing extra neck pain.
- I can lift heavy weights, but it gives me extra neck pain.
- Neck pain prevents me from lifting heavy weights off the floor but I can manage if items are conveniently positioned, i.e. on a table.
- Neck pain prevents me from lifting heavy weights, but I can manage light weights if they are conveniently positioned.
- I can lift only very light weights.
- I cannot lift or carry anything at all.

SECTION 4 - READING
- I can read as much as I want with no neck pain.
- I can read as much as I want with slight neck pain.
- I can read as much as I want with moderate neck pain.
- I can't read as much as I want because of moderate neck pain.
- I can't read as much as I want because of severe neck pain.
- I can't read at all.

SECTION 5 - HEADACHES
- I have no headaches at all.
- I have slight headaches that come infrequently.
- I have moderate headaches that come infrequently.
- I have severe headaches that come frequently.
- I have headaches almost all the time.

SECTION 6 - CONCENTRATION
- I can concentrate fully without difficulty.
- I can concentrate fully with slight difficulty.
- I have a fair degree of difficulty concentrating.
- I have a lot of difficulty concentrating.
- I have a great deal of difficulty concentrating.
- I can't concentrate at all.

SECTION 7 - WORK
- I can do as much work as I want.
- I can only do my usual work, but no more.
- I can do most of my usual work, but no more.
- I can't do my usual work.
- I can hardly do any work at all.
- I can't do any work at all.

SECTION 8 - DRIVING
- I can drive my car without neck pain.
- I can drive my car with only slight neck pain.
- I can drive as long as I want with moderate neck pain.
- I can't drive as long as I want because of moderate neck pain.
- I can hardly drive at all because of severe neck pain.
- I can't drive my car at all because of neck pain.

SECTION 9 - SLEEPING
- I have no trouble sleeping.
- My sleep is mildly disturbed for less than 1 hour.
- My sleep is moderately disturbed for up to 1-2 hours.
- My sleep is greatly disturbed for up to 2-3 hours.
- My sleep is completely disturbed for up to 5-7 hours.

SECTION 10 - RECREATION
- I am able to engage in all my recreational activities with no neck pain at all.
- I am able to engage in all my recreational activities with some neck pain.
- I am able to engage in most, but not all of my recreational activities because of pain in my neck.
- I am able to engage in a few of my recreational activities because of neck pain.
- I can hardly do recreational activities due to neck pain.
- I can't do any recreational activities due to neck pain.
Scoring the NDI

**SECTION 1 - PAIN INTENSITY**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have no neck pain at the moment.</td>
<td>0</td>
</tr>
<tr>
<td>The pain is very mild at the moment.</td>
<td>1</td>
</tr>
<tr>
<td>The pain is moderate at the moment.</td>
<td>2</td>
</tr>
<tr>
<td>The pain is fairly severe at the moment.</td>
<td>3</td>
</tr>
<tr>
<td>The pain is very severe at the moment.</td>
<td>4</td>
</tr>
<tr>
<td>The pain is the worst imaginable at the moment.</td>
<td>5</td>
</tr>
</tbody>
</table>
**SECTION 1 - PAIN INTENSITY**
- I have no neck pain at the moment.
- The pain is very mild at the moment.
- The pain is moderate at the moment.
- The pain is severe at the moment.
- The pain is the worst imaginable at the moment.

**SECTION 2 - PERSONAL CARE**
- I can look after myself normally without causing extra neck pain.
- I can look after myself normally, but it causes extra neck pain.
- It is painful to look after myself, and I am slow and careful.
- I need some help but manage most of my personal care.
- I do not get dressed, I wash with difficulty and stay in bed.

**SECTION 3 - LIFTING**
- I can lift heavy weights without causing extra neck pain.
- I can lift heavy weights, but it gives me extra neck pain.
- Neck pain prevents me from lifting heavy weights off the floor but I can manage if items are conveniently positioned, i.e. on a table.
- Neck pain prevents me from lifting heavy weights, but I can manage light weights if they are conveniently positioned.
- I can lift only very light weights.
- I cannot lift or carry anything at all.

**SECTION 4 - READING**
- I can read as much as I want with no neck pain.
- I can read as much as I want with slight neck pain.
- I can read as much as I want with moderate neck pain.
- I can't read as much as I want because of moderate neck pain.
- I can't read as much as I want because of severe neck pain.
- I can't read at all.

**SECTION 5 - HEADACHES**
- I have no headaches at all.
- I have slight headaches that come infrequently.
- I have moderate headaches that come infrequently.
- I have moderate headaches that come frequently.
- I have severe headaches that come frequently.
- I have headaches almost all the time.

**SECTION 6 - CONCENTRATION**
- I can concentrate fully without difficulty.
- I can concentrate fully with slight difficulty.
- I have a fair degree of difficulty concentrating.
- I have a lot of difficulty concentrating.
- I have a great deal of difficulty concentrating.
- I can't concentrate at all.

**SECTION 7 - WORK**
- I can do as much work as I want.
- I can only do my usual work, but no more.
- I can do most of my usual work, but no more.
- I can't do my usual work.
- I can hardly do any work at all.
- I can't do any work at all.

**SECTION 8 - DRIVING**
- I can drive my car without neck pain.
- I can drive my car with only slight neck pain.
- I can drive as long as I want with moderate neck pain.
- I can't drive as long as I want because of moderate neck pain.
- I can hardly drive at all because of severe neck pain.
- I can't drive my car at all because of neck pain.

**SECTION 9 - SLEEPING**
- I have no trouble sleeping.
- My sleep is slightly disturbed for less than 1 hour.
- My sleep is moderately disturbed for up to 3 hours.
- My sleep is greatly disturbed for up to 6-7 hours.
- My sleep is completely disturbed for up to 2-3 hours.

**SECTION 10 - RECREATION**
- I am able to engage in all my recreational activities with no neck pain at all.
- I am able to engage in all my recreational activities with some neck pain.
- I am able to engage in most, but not all of my recreational activities because of pain in my neck.
- I am able to engage in a few of my recreational activities because of neck pain.
- I can hardly do recreational activities due to neck pain.
- I can't do any recreational activities due to neck pain.

**SCORE**
20/50 = 40%
Predictors of Poor Prognosis after Acute WAD

Figure 1. Predicted neck disability index (NDI) trajectories with 95% confidence limits and predicted probability of membership (%). Suggested cutoffs for the NDI are: 0% to 8% (no pain and disability); 10% to 28% (mild pain and disability); 30% to 48% (moderate pain and disability); 50% to 68% (severe pain and disability) and more than 70% complete disability. Reproduced with permission from Sterling et al.³
Risk factors for persistent problems following acute whiplash injury: update of a systematic review and meta-analysis.


### Neck Disability Index Greater Than 15

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome</th>
<th>Follow-up, mo</th>
<th>Odds Ratio</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>z Value</th>
<th>P Value</th>
<th>Odds Ratio and 95% CI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherton et al(^1)</td>
<td>Pain</td>
<td>12</td>
<td>2.65</td>
<td>1.59</td>
<td>4.39</td>
<td>3.76</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Nederhand et al(^28)</td>
<td>Disability</td>
<td>6</td>
<td>20.24</td>
<td>4.34</td>
<td>94.36</td>
<td>3.83</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Sterling(^34)</td>
<td>Disability</td>
<td>6</td>
<td>59.50</td>
<td>12.10</td>
<td>292.57</td>
<td>5.03</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>13.24</td>
<td>1.68</td>
<td>104.36</td>
<td>2.45</td>
<td>.01</td>
<td></td>
</tr>
</tbody>
</table>
The association between neck pain, the Neck Disability Index and cervical ranges of motion: a narrative review

J Can Chiropr Assoc 2011; 55(3)

Emily R. Howell, BPHE (Hons), DC*
<table>
<thead>
<tr>
<th>Study</th>
<th>Design strength</th>
<th>Design limit</th>
<th>Measure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vernon 2008</td>
<td>41 NDI and WAD studies Review</td>
<td>Review done by NDI author himself (could have some bias)</td>
<td>NDI</td>
<td>NDI most widely used and strongly validated self-rated disability measure for neck pain; best outcome predictor (especially of longer term physiological dysfunction and physical impairment)</td>
</tr>
<tr>
<td>Kaale et al 2005</td>
<td>N = 92 chronic grade 2 WAD patients &amp; 30 controls Case control study</td>
<td>Controls were being treated by physical therapist for other conditions (not specified); controls slightly older than WAD patients.</td>
<td>MRI, NDI</td>
<td>Transverse ligament and posterior atlanto-occipital membrane lesions relate to NDI scores.</td>
</tr>
<tr>
<td>Pereira et al 2008</td>
<td>N= 30 WAD and 30 controls Case control study</td>
<td>WAD patients older, had more driving experience, had higher composite driving tasks scores and used more assistance with driving than controls; measures were taken in laboratory and not in real driving context;</td>
<td>NDI, GHQ-28, IES-R, TSK, DHQ, CROM (with Fastrak), cervical joint position sense, smoother pursuit neck torsion test</td>
<td>WAD had CROM deficits (more so in flexion, extension and rotation); moderate correlation between driving task scores and pain and disability levels</td>
</tr>
<tr>
<td>Stewart et al 2007</td>
<td>N = 132 chronic WAD patients Cohort study</td>
<td>Baseline and 6 weeks follow-up measurement (after 12 session of exercise program); used diary (not supervised exercise).</td>
<td>NDI, pain intensity, bothersomeness, SF-36, PSFS, FRS, Copenhagen Scale, SF-36 physical summary</td>
<td>NDI and other region-specific measures no more responsive than other general disability measures; region-specific measures are easy to administer and score and are relevant to neck pain population</td>
</tr>
<tr>
<td>Vernon et al 2009</td>
<td>N = 107 chronic WAD Cross-sectional correlation design</td>
<td>Pain and disability status of sample higher than previous studies; referral bias of obtaining subjects; no-fault insurance system jurisdiction;</td>
<td>NDI, TSK, pain VAS, pain diagram</td>
<td>Fear avoidance beliefs and pain amplification have some moderate influence on self-reported disability (and NDI scores) in WAD subjects; Pain diagram correlates with NDI scores</td>
</tr>
</tbody>
</table>
3. WAD Grade
Table 15
Croft’s Grades of Injury

<table>
<thead>
<tr>
<th>Grades</th>
<th>Severity</th>
<th>Anatomical and Clinical Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>minimal</td>
<td>no limitation of range of motion, no ligamentous injury, no neurological symptoms</td>
</tr>
<tr>
<td>II</td>
<td>slight</td>
<td>limitation of range of motion, no ligamentous injury, no neurological findings</td>
</tr>
<tr>
<td>III</td>
<td>moderate</td>
<td>limitation of range of motion, some ligamentous injury, neurological findings present</td>
</tr>
<tr>
<td>IV</td>
<td>moderate to severe</td>
<td>limitation of range of motion, ligamentous instability, neurological findings present, fracture or disc derangement</td>
</tr>
<tr>
<td>V</td>
<td>severe</td>
<td>requires surgical treatment and stabilization.</td>
</tr>
<tr>
<td>STI classification</td>
<td>Grade I</td>
<td>Grade II</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>No physical neck/upper back sign(s)</td>
<td>No physical neck/upper back musculoskeletal signs:</td>
<td>Neck/upper back musculoskeletal signs:</td>
</tr>
<tr>
<td></td>
<td>• Decreased ROM</td>
<td>• Decreased ROM</td>
</tr>
<tr>
<td></td>
<td>• Point tenderness</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
“Having a WAD grade of 2 or 3 at inception increased the odds of being in the high-risk group 2-fold (OR = 2.00; 95% CI: 1.48, 2.71) compared to those with a WAD grade of 0 or 1.”

“A WAD grade of 3 increased the odds of being in the high-risk group (OR = 2.43; 95% CI: 1.88, 3.15) when compared to those with a WAD grade of 2.”
Risk Factors for Persistent Problems Following Acute Whiplash Injury: Update of a Systematic Review and Meta-analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome</th>
<th>Follow-up, mo</th>
<th>Odds Ratio</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>z Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hartling et al</td>
<td>Pain</td>
<td>12</td>
<td>1.80</td>
<td>1.04</td>
<td>3.10</td>
<td>2.11</td>
<td>.03</td>
</tr>
<tr>
<td>Sterner et al</td>
<td>Disability</td>
<td>16</td>
<td>2.17</td>
<td>1.23</td>
<td>3.83</td>
<td>2.67</td>
<td>.01</td>
</tr>
<tr>
<td>Atherton et al</td>
<td>Pain</td>
<td>12</td>
<td>1.23</td>
<td>0.71</td>
<td>2.13</td>
<td>0.73</td>
<td>.47</td>
</tr>
<tr>
<td>Berglund et al</td>
<td>Pain</td>
<td>12</td>
<td>2.61</td>
<td>1.88</td>
<td>3.62</td>
<td>5.71</td>
<td>.00</td>
</tr>
<tr>
<td>Kivioja et al</td>
<td>Pain</td>
<td>12</td>
<td>3.36</td>
<td>0.43</td>
<td>26.56</td>
<td>1.15</td>
<td>.25</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>2.00</td>
<td>1.48</td>
<td>2.71</td>
<td>4.50</td>
<td>.00</td>
</tr>
</tbody>
</table>

Odds Ratio and 95% CI*
Risk Factors for Persistent Problems Following Acute Whiplash Injury: Update of a Systematic Review and Meta-analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome</th>
<th>Follow-up, mo</th>
<th>Odds Ratio</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>z Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherton et al⁹</td>
<td>Pain</td>
<td>12</td>
<td>1.18</td>
<td>0.37</td>
<td>3.80</td>
<td>0.28</td>
<td>.78</td>
</tr>
<tr>
<td>Berglund et al²</td>
<td>Pain</td>
<td>12</td>
<td>2.57</td>
<td>1.96</td>
<td>3.38</td>
<td>6.77</td>
<td>.00</td>
</tr>
<tr>
<td>Hartling et al⁹</td>
<td>Pain</td>
<td>12</td>
<td>7.97</td>
<td>0.37</td>
<td>169.42</td>
<td>1.33</td>
<td>.18</td>
</tr>
<tr>
<td>Kivioja et al²²</td>
<td>Pain</td>
<td>12</td>
<td>2.43</td>
<td>1.88</td>
<td>3.15</td>
<td>6.72</td>
<td>.00</td>
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</tbody>
</table>

...
Risk Factors for Persistent Problems Following Acute Whiplash Injury: Update of a Systematic Review and Meta-analysis
**TABLE 2**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Number of Studies</th>
<th>Fail-Safe N</th>
</tr>
</thead>
<tbody>
<tr>
<td>High pain intensity (greater than 5.5/10)†</td>
<td>11</td>
<td>405</td>
</tr>
<tr>
<td>Female†</td>
<td>14</td>
<td>109</td>
</tr>
<tr>
<td>Report of headache at inception†</td>
<td>5</td>
<td>64</td>
</tr>
<tr>
<td>Lower education (less than postsecondary)†</td>
<td>7</td>
<td>48</td>
</tr>
<tr>
<td>High NDI (greater than 14.5/50)†</td>
<td>3</td>
<td>39</td>
</tr>
<tr>
<td>WAD grade 2 or 3†</td>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td>WAD grade 3 (versus 2)</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>Preinjury neck pain</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Report of low back pain at inception</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Abbreviations: NDI, Neck Disability Index; WAD, whiplash-associated disorder.

*Fail-safe N is not calculated for nonsignificant predictors. Fail-safe N can be interpreted as the number of studies with negative or nonsignificant results that would need to be included in the database to nullify the positive results found here.

†Robust to publication bias based on: fail-safe N greater than 5 times the included study’s criterion.
4. Initial ROM
ROM and Prognosis in WAD Cases

• Evidence shows a correlation between ROM and physical impairment and disability in cases of persistent WAD...
• Found that reduced ROM 3 months after whiplash injury was a good predictor of persistent pain and disability 2 years after injury.

• “Our findings suggest that the symptoms of whiplash injury have both physical and psychological components, and that the psychological response develops after the physical damage.”

• “Both physical and behavioural responses to these injuries are established in most cases within three months of injury. This suggests that the greatest potential for influencing the natural history of the syndrome is within this period.”

A comparison of physical characteristics between patients seeking treatment for neck pain and age-matched healthy people.

Jordan A, Mehlhen J, Ostergaard K.

- There is a reduction in primary ROM in persons with WAD, when comparison was made with matched asymptomatic persons.
- “the greatest relative muscular deficiencies seem to be in the extensor muscle group. Additionally, most patients exhibit a significant decrease in active ROM during extension.”
Cervical Range of Motion Discriminates Between Asymptomatic Persons and Those With Whiplash

Paul T. Dall’Alba, BPhty (Hons), Michele M. Sterling, MPhty, Julia M. Treleaven, BPhty, Sandra L. Edwards, MPhtySt, and Gwendolen A. Jull, PhD

- 89 asymptomatic (41 men, 48 women; mean age 39.2 years)
- 114 patients with persistent whiplash-associated disorders (22 men, 93 women; mean age 37.2 years)

- The discriminant analysis resulted in correct categorization of 90.3% of participants (sensitivity 86.2%, specificity 95.3%)

- “The results of the present study indicate that ROM was a significant discriminator between asymptomatic persons and those with persistent WAD. This discriminative ability strengthens the case for using ROM as an indicator of physical impairment.”
• 15 healthy men and 15 healthy women
• Compared Zebris vs dual digital inclinometry (DI) CROM obtained 2 times, 7 days apart
• No significant differences (Coefficient of Variations) were found between the Zebris- and DI measures
• No significant difference in test-retest values of DI
• ICC’s for individual movements ranged from 0.82-0.94
AMA Guides 5th ed
AMA Guides 5th ed

- DRE (Diagnosis-Related Estimate) vs ROM method
- Only “Rate” an individual when they have reached MMI
- Use ROM method when condition is NOT caused by an injury or when an injury is not well represented by a DRE category
AMA Guides 5th ed

• Use ROM method for injuries to more than one level in same spinal region and in certain individuals with recurrent pathology
• Use ROM method if cause of condition cannot be determined
AMA Guides 5th ed

- Loss of Motion Segment Integrity, Translation
  - >3.5 mm cervical
  - >2.5 mm thor
  - >4.5mm lumb
- DRE Category IV (25-28%) or V (35-38%)
AMA Guides 5th ed

• Loss of Motion Segment Integrity, Rotation
• 11° cervical
• DRE Category IV (25-28%) or V (35-38%)
Loss of Motion Segment Integrity, Rotation

- $>15^{\circ}$ @ L1/2, L2/3, L3/4
- $>20^{\circ}$ @ L4/5
- $>25^{\circ}$ @ L5/S1
- DRE Category IV (20%)
AMA Guides 5th ed

- ROM Method—3 Components:
  - ROM of spine region
  - Accompanying Dx (Table 15.7)
  - Any spinal nerve deficit

- Whole person impairments obtained by combining all 3 components (p602)
  - Must have permanent anatomic and/or physiologic residual dysfunction
AMA Guides 5th ed

- ROM Method—DUAL Inclinometry
  - Mandatory Warm-Up
    - 2x Flex/Ext  2x Lat Flex  2x Axial Rot  1x Flex/Ext
  - 3 Consecutive measurements—take average
  - If avg measure is <50°, all 3 must fall within 5° of the mean
  - If avg measure is >50°, all 3 must fall within 10% of the mean
  - Repeat test until consistency is obtained (max of 6 attempts)
AMA Guides 5th ed

- ROM Method—DUAL Inclinometry
  - Use maximum motion for each movement from a valid set to use in the AMA Tables
  - Combine ROM, Dx, nerve deficit for EACH region, if applicable and combine using p. 604
Measuring Cervical ROM—Age Factor

Three groups of females were compared:
- 22 aged 15 to 18 years (adolescents),
- 25 aged 20 to 30 years (young adults), and
- 16 aged 35 to 45 years (mid-aged women).

Used Optoelectric Measurement

CONCLUSION: In healthy females, between 15 and 45 years old, cervical ROM in the principal planes decrease (except for rotation), but these variations are NOT statistically significant (P > 0.05).
• 337 healthy volunteers
• 171 females and 166 males
• Ranging in age from 11 to 97 years
• 40 subjects (20 females and 20 males) in each of the nine age groups, except for the 90- to 97-year-old age group (14 subjects)
<table>
<thead>
<tr>
<th>Age Group (y)</th>
<th>No. of Subjects</th>
<th>Extension</th>
<th>AROM (°)</th>
<th></th>
<th></th>
<th></th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>SD</td>
<td>Range</td>
<td>X</td>
<td>SD</td>
<td>Range</td>
<td>X</td>
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<tr>
<td>11–19</td>
<td>Male</td>
<td>20</td>
<td>85.6</td>
<td>11.5</td>
<td>61–106</td>
<td>46.3</td>
<td>6.7</td>
<td>33–60</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>20</td>
<td>84.0</td>
<td>14.9</td>
<td>56–110</td>
<td>46.6</td>
<td>7.3</td>
<td>35–60</td>
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<td>20–29</td>
<td>Male</td>
<td>20</td>
<td>76.7</td>
<td>12.8</td>
<td>60–108</td>
<td>41.4</td>
<td>7.1</td>
<td>30–58</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>22</td>
<td>85.6</td>
<td>10.6</td>
<td>65–111</td>
<td>42.8</td>
<td>4.6</td>
<td>34–56</td>
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<td>30–39</td>
<td>Male</td>
<td>20</td>
<td>68.2</td>
<td>12.8</td>
<td>36–92</td>
<td>41.2</td>
<td>10.3</td>
<td>20–60</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>21</td>
<td>78.0</td>
<td>13.8</td>
<td>52–102</td>
<td>43.6</td>
<td>7.9</td>
<td>30–60</td>
</tr>
<tr>
<td>40–49</td>
<td>Male</td>
<td>20</td>
<td>62.5</td>
<td>12.2</td>
<td>40–90</td>
<td>35.6</td>
<td>8.0</td>
<td>18–53</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>22</td>
<td>77.5</td>
<td>13.2</td>
<td>45–102</td>
<td>40.8</td>
<td>9.3</td>
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<td>50–59</td>
<td>Male</td>
<td>20</td>
<td>59.9</td>
<td>10.4</td>
<td>39–74</td>
<td>34.9</td>
<td>6.6</td>
<td>22–48</td>
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<tr>
<td></td>
<td>Female</td>
<td>20</td>
<td>65.3</td>
<td>16.0</td>
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<td>35.1</td>
<td>6.0</td>
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<td>60–69</td>
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<td>20</td>
<td>57.4</td>
<td>10.5</td>
<td>42–82</td>
<td>30.4</td>
<td>4.7</td>
<td>20–39</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>20</td>
<td>65.2</td>
<td>13.3</td>
<td>44–90</td>
<td>34.4</td>
<td>8.1</td>
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<tr>
<td>70–79</td>
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<td>20</td>
<td>53.7</td>
<td>14.4</td>
<td>20–86</td>
<td>25.0</td>
<td>8.4</td>
<td>10–38</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>20</td>
<td>54.8</td>
<td>10.2</td>
<td>34–70</td>
<td>26.9</td>
<td>6.7</td>
<td>16–40</td>
</tr>
<tr>
<td>80–89</td>
<td>Male</td>
<td>20</td>
<td>49.4</td>
<td>11.5</td>
<td>28–68</td>
<td>23.5</td>
<td>6.8</td>
<td>14–43</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>18</td>
<td>50.3</td>
<td>14.5</td>
<td>20–72</td>
<td>22.6</td>
<td>7.1</td>
<td>10–40</td>
</tr>
<tr>
<td>90–97</td>
<td>Male</td>
<td>6</td>
<td>52.3</td>
<td>17.2</td>
<td>22–68</td>
<td>22.0</td>
<td>6.6</td>
<td>14–30</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>8</td>
<td>54.5</td>
<td>18.1</td>
<td>20–74</td>
<td>26.6</td>
<td>8.1</td>
<td>12–38</td>
</tr>
</tbody>
</table>
Table 3. Descriptive Statistics for Active Range of Motion (AROM) of Left and Right Rotation of the Neck

<table>
<thead>
<tr>
<th>Age Group (y)</th>
<th>No. of Subjects</th>
<th>AROM (°)</th>
<th>Right</th>
<th>AROM (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Left</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>SD</td>
<td>Range</td>
</tr>
<tr>
<td>11–19 Male</td>
<td>20</td>
<td>72.3</td>
<td>7.0</td>
<td>55–88</td>
</tr>
<tr>
<td>11–19 Female</td>
<td>20</td>
<td>70.5</td>
<td>9.8</td>
<td>50–88</td>
</tr>
<tr>
<td>20–29 Male</td>
<td>20</td>
<td>69.2</td>
<td>7.0</td>
<td>52–83</td>
</tr>
<tr>
<td>20–29 Female</td>
<td>22</td>
<td>71.6</td>
<td>5.7</td>
<td>62–85</td>
</tr>
<tr>
<td>30–39 Male</td>
<td>20</td>
<td>65.4</td>
<td>9.1</td>
<td>50–82</td>
</tr>
<tr>
<td>30–39 Female</td>
<td>21</td>
<td>65.9</td>
<td>8.1</td>
<td>52–84</td>
</tr>
<tr>
<td>40–49 Male</td>
<td>20</td>
<td>62.0</td>
<td>7.6</td>
<td>44–74</td>
</tr>
<tr>
<td>40–49 Female</td>
<td>22</td>
<td>64.0</td>
<td>7.9</td>
<td>50–80</td>
</tr>
<tr>
<td>50–59 Male</td>
<td>20</td>
<td>58.0</td>
<td>8.8</td>
<td>40–70</td>
</tr>
<tr>
<td>50–59 Female</td>
<td>20</td>
<td>62.8</td>
<td>8.4</td>
<td>40–74</td>
</tr>
<tr>
<td>60–69 Male</td>
<td>20</td>
<td>56.6</td>
<td>6.7</td>
<td>40–66</td>
</tr>
<tr>
<td>60–69 Female</td>
<td>20</td>
<td>59.7</td>
<td>9.1</td>
<td>36–70</td>
</tr>
<tr>
<td>70–79 Male</td>
<td>20</td>
<td>49.7</td>
<td>8.8</td>
<td>30–64</td>
</tr>
<tr>
<td>70–79 Female</td>
<td>20</td>
<td>50.1</td>
<td>7.9</td>
<td>39–61</td>
</tr>
<tr>
<td>80–89 Male</td>
<td>20</td>
<td>46.8</td>
<td>9.2</td>
<td>31–70</td>
</tr>
<tr>
<td>80–89 Female</td>
<td>18</td>
<td>50.5</td>
<td>10.7</td>
<td>32–70</td>
</tr>
<tr>
<td>90–97 Male</td>
<td>6</td>
<td>45.2</td>
<td>16.8</td>
<td>26–74</td>
</tr>
<tr>
<td>90–97 Female</td>
<td>8</td>
<td>53.5</td>
<td>7.5</td>
<td>46–70</td>
</tr>
</tbody>
</table>
Cervical ROM in Elderly


Cervical range of motion in the elderly.

Kuhlman KA

Author information

Abstract
This study was conducted to establish normative cervical range of motion values for the elderly and to compare those values to standard young adult cervical range of motion values. Differences in range of motion between men and women were also assessed. A gravity goniometer was used to measure six cervical motions in 42 subjects aged 70 to 90 years and 31 subjects aged 20 to 30 years. The elderly group had significantly less motion than the younger group for all six motions measured (p < .001). A comparison of the mean range of motion values between the two groups found that the elderly group had approximately 12% less flexion, 32% less extension, 22% less lateral flexion, and 25% less rotation. The elderly group also had a wider variation of cervical range of motion values as compared to the younger group. Women had greater cervical range of motion values than men in both age groups.
Cervical ROM—Testing Protocol

Used an ultrasound-based system

Protocol A: reciprocal-intermittent testing (pause @ neutral)
Protocol B: reciprocal-continuous testing (no pause)
Protocol C: consisted of three repetitions of the same primary direction with a break between two consecutive primary directions.
Protocol D: Three sets of six randomly ordered primary directions

CONCLUSION: A, B, C all okay. Protocol D underestimates

The effect of measurement protocol on active cervical motion in healthy subjects.

Dvir Z, Werner V, Peretz C.
What About ROM Tests that are Normal? Who does that help?
DynaROM: Establishing need for care, with normal MRI, normal CT, Normal X-rays and Normal ROM
ROM, sEMG & WAD

Combine Range of Motion and Dynamic sEMG shows ROM & Muscle Guarding: Crucial to “Seal” the Case.

Normal Range of Motion, No bracing (normal sEMG)

Normal ROM, Abnormal Muscle Bracing: Establishes ROM without Dynamic sEMG (“guarding” lacks clinical accuracy

Top graph shows Lumbar Muscle activity. Bottom graph shows Range of Motion. Graph to right proves that normal ROM can be accompanied with guarding and bracing.

injurv
The ability of the device to evaluate for “soft tissue injury”: Patented !!!!

United States Patent
Marcarian

Patent No.: US 9,808,172 B2
Date of Patent: Nov. 7, 2017

Systems and Methods for Performing Surface Electromyography and Range-of-Motion Test

Inventor: David Marcarian, Seattle, WA (US)

References Cited

U.S. Patent Documents

(Continued)
A soft-tissue-injury diagnostic system for diagnosing soft tissue injury within a patient includes a set of hand-held inclinometers configured and arranged for measuring angles formed between a first inclinometer disposed in proximity to a patient joint and a second inclinometer disposed distal to the joint during controlled patient movements of the joint. A plurality of measuring electrodes are coupleable in proximity to the patient’s spine along the body portion that moves along the joint. The measuring electrodes are configured and arranged for measuring action potentials along patient muscle groups during the controlled patient movements of the joint and transmitting the measured action potentials to a dynamic surface electromyograph (“sEMG”) module. A hub receives and processes data from the inclinometers and the dynamic sEMG module. A visual display is configured and arranged for receiving and displaying the processed data.
The Journal of Physiology
Volume 129, Issue 1, 28 July 1955, Pages 184-203

The function of the erectors spinae muscles in certain movements and postures in man (Article)
Floyd, W.F., Silver, P.H.S.
Flexion-Relaxation Phenomenon

- The flexion–relaxation (FR) phenomenon, a normal pattern in muscle activation, originates from the lumbar region and is defined as an electrical silence response in the erector spinae muscles during a full forward-bending trunk posture (Floyd and Silver, 1951).

- The causes of this phenomenon were seen as transferring extensor moment from superficial erector spinae to passive paraspinal structures or deep muscle such as quadratus lumborum.
Flexion-Relaxation Phenomenon
Explore the relationship between pain-related fear, angle of flexion, and EMG activity

Pain-related fear is significantly associated with decreased lumbar flexion in persons with CLBP

Pain-related fear influences the FRR both through its association with maximal muscle activity during flexion, as well as increased muscle activity in full flexion
Attached Electrode Dynamic sEMG
Left Lumbar Blue, Right Lumbar Red

Graphed Range of Motion.
Shows “Quality” of Motion, not just end point value.

FR Ratio (FRR): Mean at extension TO Mean at FR (N=3:1 to 4:1)
Show Guarding and Pain Even if End-ROM Point is Normal
22 women with chronic neck pain (VAS 20.9 mm) vs 21 healthy controls
Avg age 23 yo, avg cervical flexion 50° and 51°
Measured ROM using electrogoniometers simultaneously with and SEMG on cervical erector spinae
Fig. 3 Normalised SEMG activity of CES muscles in different phases of movement. Phase 1 Maintain the starting position. Phase 2 Complete cervical flexion. Phase 3 Sustain cervical full flexion. Phase 4 Extension with return to the starting position.
Flexion–relaxation ratio in computer workers with and without chronic neck pain

Carina Ferreira Pinheiro\textsuperscript{a,b,1}, Marina Foresti dos Santos\textsuperscript{a,c,1}, Thais Cristina Chaves\textsuperscript{a,b,d,*,1}
Cervical Flexion-Relaxation Phenomenon

Fig. 2. Electromyography signal showing task phases and flexion-relaxation phenomenon during the 3-s full flexion hold phase (phase 3). Phases: Phase 1 - Rest (5 s); Phase 2 - Flexion (3 s); Phase 3 - Full Flexion (3 s); Phase 4 - Re-extension (3 s).
20 asymptomatic male computer workers
Average age 23
Table 1  Descriptive statistics for the active cervical range of motion and the FR ratio

<table>
<thead>
<tr>
<th>Cervical range of motion</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>59.2±12.9</td>
</tr>
<tr>
<td>Extension</td>
<td>68.4±8.0</td>
</tr>
<tr>
<td>Right lateral flexion</td>
<td>42.7±8.0</td>
</tr>
<tr>
<td>Left lateral flexion</td>
<td>46.6±10.1</td>
</tr>
<tr>
<td>Right rotation</td>
<td>64.5±10.3</td>
</tr>
<tr>
<td>Left rotation</td>
<td>69.3±7.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FR ratio</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right side</td>
<td>2.60±1.11</td>
</tr>
<tr>
<td>Left side</td>
<td>2.54±1.08</td>
</tr>
</tbody>
</table>
• Small study comparing asymptomatic computer users in early 20’s vs late 20’s
• The cervical FRR in the late 20s computer users (1.2±4.8) was significantly lower compared with the cervical FRR in the early 20s computer users (2.2±1.0).
• Cervical flexion (degrees) was equal between groups
• FRP doesn't occur in shrugged shoulder position
• Induced fatigue (Sorenson protocol) causes earlier onset of FRP
Fig. 2. Raw EMG and head flexion/extension data for one of the subjects during four experimental conditions.
Load and speed effects on the cervical flexion relaxation phenomenon

Jean-Philippe Pialasse\textsuperscript{1,3*}, Danik Lafond\textsuperscript{1}, Vincent Cantin\textsuperscript{1}, Martin Descarreaux\textsuperscript{2}

- Studying the load and speed on cervical FRP EMG and kinematic parameters
  - 5s,3s,5s vs 2s,3s,2s
- Also assessed FRP repeatability
- Load affected FRP, speed had no effect
- Moderate to excellent repeatability for the kinematics was observed in all phases
14 Chronic NP vs 14 control (no neck pain)
- Measured at baseline and 4 weeks later
- Pain gr: FRR=1.93 +/-0.8, and 1.73 +/-0.61 at 4-wks
- Pain gr: intraclass correlation coefficient (ICC) was 0.83 (95% CI 0.67–0.92)
- Control gr: FRR=4.09 +/-1.58 at baseline and 4.27 +/-.71 on retest 4 weeks late
- Control gr: ICC was 0.89 (95% confidence interval 0.76–0.95)
"The cervical extensor muscles exhibit a consistent flexion-relaxation phenomenon in healthy control subjects and the measurement is highly reproducible when measured 4 weeks apart in both controls and chronic neck pain patients."

"The FRR in neck pain patients is significantly higher than in control subjects suggesting that this measure may be a useful marker of altered neuromuscular function."
Novel Electromyographic Protocols Using Axial Rotation and Cervical Flexion-Relaxation for the Assessment of Subjects With Neck Pain: A Feasibility Study

James W. DeVocht, DC, PhD a,*, Kalyani Gudavalli, PT, MS b, Maruti R. Gudavalli, PhD c, Ting Xia, PhD d
• Cervical FRP was conducted as reported in the literature with the participants seated, except that they started with the head fully flexed instead of being erect.
• Data were also collected with participants laying prone, starting with their head hanging over the edge of the table.
• Additional data were collected from cervical paraspinal and sternocleidomastoid (SCM) muscles while the seated participants rotated their head fully to the right and left.
Devocht, et al 2016...

Used MyoVision sEMG technology w/out ROM

Fig 1. Participant performing axial rotation to the left showing the EMG electrodes attached for the right paraspinal and sternocleidomastoid muscles with the ground attached over the right clavicle.

Fig 2. Participant in the starting prone position for flexion-relaxation with the head over the end of the table and fully relaxed.
Fig 4. Plot of EMG data taken from the left and right cervical paraspinal muscles while performing cervical axial rotation by first rotating right and then left, repeated 3 times. The vertical lines indicate borders of regions where the maximum peak values are determined by a custom Microsoft Excel macro.
Table 1  Means and SDs of EMG Ratios for FRR and ARR of 4 Assessment Protocols for 5 Participants With Neck Pain (P) and 5 Controls Without Neck Pain (C)

<table>
<thead>
<tr>
<th>Method</th>
<th>Group</th>
<th>Both Sides Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRR: sitting</td>
<td>C</td>
<td>2.7 (1.4)</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>1.5 (0.6)</td>
</tr>
<tr>
<td>FRR: prone</td>
<td>C</td>
<td>2.9 (1.0)</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>1.8 (1.0)</td>
</tr>
<tr>
<td>ARR: paraspinals</td>
<td>C</td>
<td>2.6 (0.7)</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>2.0 (1.2)</td>
</tr>
<tr>
<td>ARR: SCMs</td>
<td>C</td>
<td>5.4 (2.2)</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>2.6 (2.3)</td>
</tr>
</tbody>
</table>

ARR, axial rotation ratios; FRR, flexion-relaxation ratio; SCM, sternocleidomastoid; SD, standard deviation.
Coding for ROM Testing

- 1st visit using 9920x code—cannot bill for computerized ROM
- Perform visual estimation day 1… order computerized ROM w/without SEMG
- Day 2, do computerized dual inclinometry ROM w/without simultaneous SEMG (dynaROM)
Coding for ROM Testing

• 95851 - Range of motion measurements and report (separate procedure); each extremity (excluding hand) or each trunk section (spine)
  – 2 Units if doing cervical and lumbar regions
• 95852 - Range of motion measurements, and report, hand, with or without comparison with normal side.
  
• If w/ E&M code, can try using modifier -25
  – CCI edits will bundle them
Coding for SEMG

- 96002, dynamic surface electromyography, during walking or other functional activities
- 96004, Physician review and interpretation of comprehensive dynamic surface electromyography during walking or other functional activities, with written report
Denials for Dynamic SEMG

This denial is based upon an incomplete reference of the American Academy of Neurology and the American Association of Neuro Muscular & Electrodiagnostic Medicine (AANEP), giving a date of 2008 in your denial letter. A pubmed search of 2008 for the AANEP gives a paper that was published in the journal “Muscle & Nerve”.¹ This paper was a review of the literature that included papers from 1994-2006 and included a review of 53 papers on the diagnostic utility of sEMG. The authors state, “The present review concludes that sEMG may be useful to detect the presence of neuromuscular disease (level C rating, class III data).” ¹ Therefore, your interpretation of this article and referencing it as justification that the sEMG testing and interpretation should not be covered, is inaccurate and unrepresentative of the findings and therefore, incorrect.

In addition, an additional Systematic Review article on this topic has been published since 2007. This study reviewed original papers not included in the 2008 paper by the AANEP.¹ This is a 2014 systematic review of the literature by Mohseni Bandpei.² The investigators reviewed 178 studies and included 12 studies published between 2000 and 2012 in the publication. They concluded, “The results suggest that there seems to be a convincing body of evidence to support the merit of surface EMG in the assessment of paraspinal muscle fatigue in healthy subject and in patients with LBP.”²

Based upon a consensus of the literature, we are appealing the decision to deny payment for sEMG with simultaneous range of motion (96002), and the interpretation/reporting of the findings (96004).

REFERENCES:


5. Hyperalgesia
Cold hyperalgesia as a prognostic factor in whiplash associated disorders: A systematic review

Robert Goldsmith a, Chris Wright b, Sarah F. Bell a, Alison Rushton b

- 6 prospective studies on 4 cohorts were identified and reviewed.
- “Findings from all four cohorts supported cold hyperalgesia as a prognostic factor in WAD.”
- “There is moderate evidence supporting cold hyperalgesia as a prognostic factor for long-term pain and disability outcome in WAD.”
Quantitative and Qualitative Responses to Topical Cold in Healthy Caucasians Show Variance between Individuals but High Test-Retest Reliability

Penny Moss*, Jasmine Whitnell, Anthony Wright

School of Physiotherapy and Exercise Science, Curtin University of Technology, Perth, Western Australia
How to Determine Cold Hyperalgesia in Practice

TSA-II: NeuroSensory Analyzer

https://medoc-web.com/products/tsa-ii/
Technical and measurement report

An investigation of the use of a numeric pain rating scale with ice application to the neck to determine cold hyperalgesia

Samuel Maxwell b, Michele Sterling a
Short-term test-retest-reliability of conditioned pain modulation using the cold-heat-pain method in healthy subjects and its correlation to parameters of standardized quantitative sensory testing

Julia Gehling, Tina Mainka, Jan Vollert, Esther M. Pogatzki-Zahn, Christoph Maier and Elena K. Enax-Krumova
Sixty-three participants with chronic Whiplash Associated Disorder (WAD) (grade II and III)
Laboratory testing equipment vs. ICE CUBE with reported pain intensity (NRS) after 10 s of ice application at the same sites.
- Apply ice cube to skin, hold for 10 sec, ask 0-10
  - Trapezius, Cervical Paraspinal
  - Perform 3X… take average
• “Pain sensation on ice application was significantly better than chance in discriminating between cold hyperalgesic and non-cold hyperalgesic sites (AUC 0.822 (95% CI 0.742–0.886); p < 0.0001).”
• “A pain intensity rating of >5 gave a positive likelihood ratio of 8.44 suggesting that if this value is reported, clinicians could be suspicious of the presence of cold hyperalgesia.”
6. Expectation of Recovery
Expectations for recovery were measured with a numerical rating scale (NRS 0–10) where the respondents were asked to rate “how likely it was that he/she would have a complete recovery”.

The anchors were labeled “not likely” (0) and “very likely” (10).
After controlling for severity of physical and mental symptoms, individuals who stated that they were less likely to make a full recovery (NRS 5–10), were more likely to have a high disability compared to individuals who stated that they were very likely to make a full recovery (odds ratio [OR] 4.2 [95% confidence interval (CI) 2.1 to 8.5].

For the intermediate category (NRS 1–4), the OR was 2.1 (95% CI 1.2 to 3.2).

“Individuals’ expectations for recovery are important in prognosis, even after controlling for symptom severity”
We found moderate strength of evidence to suggest that sensory hypersensitivity and somatization pre-morbidly, or higher sensory sensitivity and low expectation of recovery at the acute stage of pain are predictors of altered central pain modulation in some musculoskeletal pain conditions.
Correlation between expectations of recovery and injury severity perception in whiplash-associated disorders

Robert Ferrari† and Deon Louw

"After adjusting for the effect of sociodemographic characteristics, post crash symptoms as well as pain, prior health status, and collision-related factors, those who expected to get better soon recovered over three times as quickly (hazard rate ratio=3.62, 95% CI 2.55–5.13)."
If they can put a man on the moon, they should be able to fix a neck injury: a mixed-method study characterizing and explaining pain beliefs about WAD

Geoff P. Bostick, Cary A. Brown, Linda J. Carroll & Douglas P. Gross
7. Initial Emotional State
Premise—Recovery following a whiplash injury is varied:

- approximately 50% of individuals fully recover,
- 25% develop persistent moderate/severe pain and disability, and
- 25% experience milder levels of disability.
An increased probability of developing chronic moderate/severe disability was predicted in the presence of older age and initially higher levels of NDI and hyperarousal symptoms (PDS) (positive predictive value [PPV] = 71%). The probability of full recovery was increased in younger individuals with initially lower levels of neck disability (PPV = 71%).
Hyperarousal symptoms form 1 of the 3 necessary clusters of symptoms in the diagnosis and presentation of posttraumatic stress disorder (PTSD).

It occurs when a person’s body suddenly kicks into high alert as a result of thinking about their trauma. Even though real danger may not be present, their body acts as if it is, causing lasting stress after a traumatic event.

- sleeping problems
- difficulties concentrating
- irritability
- anger and angry outbursts
- panic
- constant anxiety
- easily scared or startled
- self-destructive behavior (such as fast driving or drinking too much)
- a heavy sense of guilt or shame
Posttraumatic Diagnostic Scale (PDS)

Journal of Traumatic Stress, Vol. 6, No. 4, 1993

The PDS is a 49-item self-report measure recommended for use in clinical or research settings to measure severity of PTSD symptoms related to a single identified traumatic event.

Reliability and Validity of a Brief Instrument for Assessing Post-Traumatic Stress Disorder

Edna B. Foa,1 David S. Riggs,1 Constance V. Dancu,1 and Barbara O. Rothbaum1

https://eprove.mapi-trust.org/instruments/posttraumatic-diagnostic-scale-r#member_access_content
The PDS has four sections.
• Part 1: trauma checklist.
• Part 2: respondents are asked to describe their most upsetting traumatic event. Questions specifically ask about when it happened, if anyone was injured, perceived life threat, and whether the event resulted in helplessness or terror.
• Part 3: assesses the 17 PTSD symptoms. Respondents are asked to rate the severity of the symptom from 0 ("not at all or only one time") to 3 ("5 or more times a week / almost always").
• Part 4: assesses interference of the symptoms.
Clinical Prediction Rule

Several RCT’s are underway looking at coordinating care with a specialist in trauma-focused behavioral therapy in combination with traditional care.
Multidimensional associative factors for improvement in pain, function, and working capacity after rehabilitation of whiplash associated disorder: a prognostic, prospective outcome study

Felix Angst¹*, Andreas R Gantenbein¹, Susanne Lehmann¹, Françoise Gysi-Klaus¹, André Aeschlimann¹, Beat A Michel² and Frank Hegemann¹
“Pain relief, improved physical function and working capacity were circularly associated with each other. This empirical finding supports the existence of a corresponding hypothetical circle as postulated by previous studies, clinical experience and intuition. Coping (catastrophizing and ability to decrease pain) and depression may act as important effect modifiers in this circle.”

For improved function at discharge, reduction of catastrophizing was the most important predictor (explained variance 19.4%).
Cognitive Behavioral Therapy: Based on Bio-Psychosocial Model

• Bio-psychosocial model: introduced by Fordyce in 1976
  • Nociceptive structures are held responsible for the pain awareness of the patient
  • Also emphasizes the role of psychologic and social factors in the development and maintenance of symptoms

• This can lead to a response in one of the following three response systems that characterize emotional experiences:
  • the psychophysiological system such as feelings, increase muscle tension, etc.;
  • the cognitive system, such as thoughts, catastrophizing, fear, etc.; and
  • the motor system such as pain behavior, disuse syndrome, etc.
As DC’s we don't do CBT. But can we change the way we communicate and set goals for patients during care to help with the psychosocial side of injuries?
Comparison of the effectiveness of a behavioural graded activity program and manual therapy in patients with sub-acute neck pain: Design of a randomized clinical trial

Jan J.M. Pool\textsuperscript{a,b,*}, Raymond W.J.G. Ostelo\textsuperscript{a,c}, Albere J. Köke\textsuperscript{d}, Lex M. Bouter\textsuperscript{c}, Henrica C.W. de Vet\textsuperscript{a}

Core elements:

(1) decrease in the pain behavior and increase in “well” or “healthy” behavior;
(2) improving function and not the reduction of pain;
(3) the patient is responsible for the treatment and has an active role; and
(4) the therapist acts as a coach
Teach the patient that pain is not solely the result of underlying tissue damage, but is also influenced by:

- the patient’s expectations, beliefs, and fear, as well as
- activity levels and home and work environment.

The patient is then taught that it is safe to move the cervical spine or other parts of the body.
Choose 2 ADL’s that are most impacted by the pain and must be performed…

Example: Walking duration

The quotas should always be exactly followed, neither over-performed nor under-performed.

Thus there is a shift from pain-contingency (baseline) to time-contingency (quotas) management.

Positive reinforcement is a key principle in operant conditioning theory.

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Fig 3. Walking in a behavioral-graded activity program. Time, Walking time; baseline, baseline measurement; pre-set goal, patient goal for time he or she wants to walk; quotas, time contingent gradually increased quotas toward the preset goal.
8. Muscular Fatty Infiltration
Predictive Factor: Muscular Fatty Infiltration

• Background:
  • The aging process causes skeletal muscle mass to decrease and be replaced by noncontractile connective tissue (sarcopenia).
  • Due to a reduction in both number and size of muscle fibers, mainly the fast twitch muscle fibers, Type IIX, and is to some extent caused by a slowly progressive neurogenic process.
  • Associated with stroke, spinal cord injury, diabetes, and COPD. MRI, MR spectroscopy, or US can measure fatty infiltration in a noninvasive manner.
Muscular Fatty Infiltration

Proposed Physiology...

- Expression of fat cells is the result of an injury induced inflammatory response and the subsequent increase in DNA synthesis of the many different cells within the peri-muscular connective tissue e.g. mast cells, satellite cells, muscle precursor cells, fibroblasts and preadipocytes.
- These cells, after injury, are responsible for secreting pro-inflammatory cytokines that could stimulate their trans-differentiation into adipose tissue.

Chronic WAD: Muscular Fatty Infiltration

- Quantification: semiquantitative or quantitative
  - Semiquantitative: Sørensen et al. [Acta Radiologica, 2006] visually graded fatty infiltration using the standard criteria in adults:
    - 0 (no fat), 1 (slight infiltration), and 2 (severe infiltration) if present at one or more lumbar levels.
  - Kalichman et al. [JSDT 2016] defined the assessment as more quantitative:
    - Grade 1: a normal muscle condition, fatty infiltration up to 10% of the muscle’s CSA;
    - Grade 2: moderate muscle degeneration, 10–50% of fatty infiltration;
    - Grade 3: severe muscle degeneration, >50% of fatty infiltration.
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Figure 2: An example of different fatty infiltration grades in lumbar paraspinal muscles observed on a lumbar spine CT, imaged with a 64-slice CT scanner (Philips Medical, Brilliance Power 64). (a) A 23-year-old male; (b) a 61-year-old male; (c) a 72-year-old female.
# Normal Values Low Back

## Table 1: Cross-sectional area of back muscles and association with LBP.

<table>
<thead>
<tr>
<th>Research</th>
<th>Modality</th>
<th>Participants</th>
<th>Segments measured</th>
<th>Level of measurement</th>
<th>Position</th>
<th>Orientation of cross section</th>
<th>CSA multifidus (cm²)</th>
<th>CSA erector spinae (cm²)</th>
<th>Association with LBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dunnick et al. [30]</td>
<td>CT</td>
<td>25 healthy volunteers</td>
<td>L3, L4, L4, L4, L3, L4, L4</td>
<td>Superior endplate</td>
<td>Supine</td>
<td>Adjacent to the vertebral endplate</td>
<td>4.7 ± 1.4</td>
<td>6.3 ± 1.4</td>
<td>A significant difference between the two groups, especially at the L4 inferior endplate. Healthy individuals have a larger CSA of the multifidus.</td>
</tr>
<tr>
<td>Hides et al. [31]</td>
<td>US</td>
<td>10 young male elite cricketers with LBP</td>
<td>L2, L3, L3, L3, L5, L2, L5, L5</td>
<td>Spinosus process of the vertebra</td>
<td>Prone</td>
<td>Between the spinous process and the lamina</td>
<td>3.4 ± 1.4</td>
<td>5.1 ± 1.9</td>
<td>Multifidus muscle atrophy can exist in highly active, elite athletes with LBP. Specific retraining resulted in an improvement in multifidus CSA that was concomitant with pain decrease.</td>
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<tr>
<td>Stokes et al. [19]</td>
<td>US</td>
<td>68 females</td>
<td>L4, L4, L5, L5</td>
<td>Prone with flattened lumbar lordosis</td>
<td>Between the spinous process and the lamina</td>
<td>5.6 ± 1.3</td>
<td>6.7 ± 1.0</td>
<td>Smaller multifidus CSA in chronic LBP patients than in controls at all postures.</td>
<td></td>
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<tr>
<td>Chan et al. [27]</td>
<td>US</td>
<td>12 asymptomatic men</td>
<td>L4</td>
<td>Vertebral lamina</td>
<td>Prone</td>
<td>6.36 ± 0.99</td>
<td>7.16 ± 0.10</td>
<td>There was no significant asymmetry of the multifidus at spinal level above, same level, or level below the disc herniation.</td>
<td></td>
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<tr>
<td>Fortin et al. [33]</td>
<td>MRI</td>
<td>13 individuals with recurrent nonspecific LBP and 13 asymptomatic individuals</td>
<td>L3-L4, L4-L5, L5-S1</td>
<td>The center of each intervertebral disc</td>
<td>Supine</td>
<td>Perpendicular to the muscle mass</td>
<td>6.5 ± 1.4</td>
<td>9.6 ± 2.1</td>
<td>No different in CSA between individuals with LBP and controls.</td>
</tr>
<tr>
<td>Niemelinen et al. [32]</td>
<td>MRI</td>
<td>126 asymptomatic men</td>
<td>L3-L4, L4-L5, L5-S1</td>
<td>Not described in the manuscript</td>
<td>Supine</td>
<td>Not described in the manuscript</td>
<td>7.3, L4, 6.9</td>
<td>10.1, L4, 9.5</td>
<td>Paraspinal muscle atrophy of &gt;10% was commonly found in men without a history of LBP. This suggests caution in using level- and side-specific paraspinal muscle asymmetry to identify subjects with LBP and spinal pathology.</td>
</tr>
<tr>
<td>Stone et al. [31]</td>
<td>MRI</td>
<td>10 older adults with chronic LBP, age 60–90 y</td>
<td>L2, L3, L4, L5</td>
<td>Through vertebral body</td>
<td>5.44 ± 0.94</td>
<td>18.76 ± 4.46</td>
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</tbody>
</table>

LBP: low back pain, CSA: cross-sectional area, Rt: right side, and Lt: left side.
All of the groups entered the study at 4-week post-injury with similar levels of MFI.

However, the group with poor functional recovery at 6-months uniquely demonstrated increased MFI between 4-weeks and 3-months post-injury and these changes persisted at 6-months.
- Found a relationship between high initial pain and MFI was mediated by the presence of PTSD symptoms at 4-weeks post-injury.
Conclusions: muscle degeneration occurs soon after injury but only in those patients with poor functional recovery.

MFI values were significantly higher in the severe group when compared to the recovered/mild group at 2-weeks and 3-months.

The ROC analysis indicated that MFI levels of 20.5% or above resulted in a sensitivity of 87.5% and a specificity of 92.9% for predicting outcome at 3 months.
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Expectations in WAD Cases after 3 Months

Clinical state is more difficult to improve after pain has been present >3 months…

WHY??
Pain Becomes “Chronic”

• “central sensitization” is an umbrella term comprising a multitude of different mechanisms taking place in the dorsal horn of the spinal cord, ascending and descending pathways in the dorsal column, the brainstem and pain centers in the forebrain, all leading ultimately to amplification of innocuous and painful stimuli and to the extension of receptive fields
• Module 2: March 23-24 (Denver, CO)
• Module 3: June 1-2 (Denver, CO)
• Module 4: September 7-8 (Denver, CO)
• Module 5: November 2-3 (Denver, CO)
• Module 6: Home Study/Certification Exam