Understanding the role of work in back pain & pathology

*Michele Crites Battie*
Today:

- The injury model of LBP
- Constitutional, behavioral and environmental factors influencing back pain and pathology
- When and how do we move on when new knowledge no longer fits old beliefs?
- The importance of case definition
Workers’ Compensation Paradigm:

- Work tasks/exposures are defined as causal
- Structural or tissue damage is inferred
- Medical testimony (or evidence) of injury is required
An Injury Model of Back Pain

Repetitive trauma/ Cumulative loading

Tissue damage / ‘wear & tear’

desiccation, narrowing, herniation…

Pain

Disability
Challenges to the cumulative or repetitive injury model:

‘Best evidence’ suggests modest or absent effects of routine physical activity/loading
The Twin Spine Study
Contributions to a Different View of Disc Degeneration

Michele Crites Battié Department of Physical Therapy
Exposure-Discordant Twin Model

- To minimize challenges of measurement & confounding
- Controls for age, gender, genetic influences
- Many other suspected and unknown confounding factors
Smoking-discordant MZ twin study:

• 20 twin pairs
  • Based on Finnish Twin Cohort health survey data

• In-depth interview
  • Smoking history (~32 pack-years discordant)
  • Occupational, sport and leisure exposures
  • Other possible confounding factors

• 0.5 Tesla MRI
Reader 2 - Mean Disc Degeneration Scores for Smokers and Non-Smokers by Spinal Level

- L1-L2
- L2-L3
- L3-L4
- L4-L5
- L5-S1

Mean Disc Degeneration Score

- Non-Smoker
- Smoker
Further Twin Studies:

- Subjects came from the Finnish Twin Cohort
- In-depth interview
  - Occupational, sport and leisure exposures
  - Medical & back pain history
- Blood/DNA sample
- Basic anthropometrics
- Lumbar RoM & strength
- MRI (1.5 T)
- DXA
Modest, if any, influences of long-term exposure to primary suspected risk factors

- Heavy Smoking - small (-) effect
- Heavy occupational physical demands - small (-) or equivocal effects
- Weight lifting sport had small (-) effect
- Sedentary vs. moderate work demands – small (+) effect
- Endurance exercise – no apparent effect
- Driving (WBV) - no apparent effect
Challenging the cumulative injury model: Positive effects of greater body weight on disc degeneration

Tapio Videman, Laura E. Gibbons, Jaakko Kaprio, Michele C. Battié
We viewed the effect of body mass on discs as ‘cumulative loading’

- Body mass loads the lumbar discs during upright activities.
- As an adult, the trunk is typically the largest mass ‘handled’.
- The accuracy of loading in terms of body mass is superior compared to other loading histories.
Subjects and Methods

- 44 male ‘identical’ twin siblings with mean discordance in body weight ~ 30 lbs

- **Quantitative** measures based on spine MRI
  - Disc signal and height narrowing

- BMD of lumbar vertebra block*
## Difference within pairs*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>P-value**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disc signal (CSF-adjusted)</td>
<td>+0.2</td>
</tr>
<tr>
<td>Quantitative disc height (L1-4)</td>
<td>+0.6</td>
</tr>
<tr>
<td>BMD: L1 - L4 (g/cm²)</td>
<td>+0.07</td>
</tr>
</tbody>
</table>

*Heavier minus lighter sibling (positive difference favors heavier twin)

**Paired t-test
The findings suggest that more routine loading in the form of body weight is not harmful for the disc based on MRI, and may even delay disc degeneration slightly.

*Extreme obesity was not studied.

Videman et al, Spine J, 2009
The role of back injury or trauma in lumbar disc degeneration
An exposure-discordant twin study

M. Hancock, M.C. Battie, T. Videman, L. Gibbons

Spine, 2010
Subjects and Methods

• 38 male ‘identical’ twin pairs discordant for recalled back injury*

• Quantitative measures based on spine MRI
  • Signal intensity & disc height narrowing
  • Greatest difference in DD at any one level (localized effect)
  • Mean score for all lumbar levels

• Confounding considered & time since injury
A. Disc height at maximum difference (mm)

B. Signal intensity at maximum difference

- One injury
- Two injuries
Causal assessment of workplace manual handling or assisting patients and LBP: Results of a systematic review

- Summarized the best available evidence, using a Bradford-Hill framework to assess causation
- 32 studies met eligibility criteria, 9 of high quality
- They concluded, “It appears unlikely that workplace manual handling or assisting patients is independently causative of LBP in the population of workers studied.”

Roffey et al., Spine J, 2010
Challenges to the cumulative or repetitive injury model:

- ‘Best evidence’ suggests modest or absent effects of physical loading

  The body’s ability to adapt to routine loading (occup. vs sports med. paradox)
Challenges to the cumulative or repetitive injury model:

- ‘Best evidence’ suggests modest or absent effects of physical loading
- The body’s ability to adapt to routine loading (occup. vs sports med. Paradox)
- Occurrence rates of LBP and “back injury” vs. trends in occupational loading
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- Occurrence rates of LBP and “back injury” vs. trends in occupational loading
- Genetic influences
Similarities in Degenerative Findings
on Magnetic Resonance Images
of the Lumbar Spines of Identical Twins*

BY MICHELE CRITES BATTIŒ, PH.D., DAVID R. HAYNOR, M.D., PH.D., LLOYD D. FISHER, PH.D., KEVIN GILL, M.D., LAURA E. GIBBONS, M.S., SEATTLE, WASHINGTON, AND TAPIO VIDEMAN, M.D., DR.MED.SCI., JYVÄSKYLÄ, FINLAND

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1995 Volvo Award in Clinical Sciences
Determinants of Lumbar Disc Degeneration
A Study Relating Lifetime Exposures and Magnetic Resonance Imaging Findings in Identical Twins

Michele Crites Battie, PhD,* Tapio Videman, MD, DrMedSci,†‡ Laura E. Gibbons, MS,§ Lloyd D. Fisher, PhD,‖ Hannu Manninen, MD, PhD,¶ and Kevin Gill, MD#
Determinants of Disc Degeneration

N = 230
Age = 35-69 years

Spine, 1995
Heritability Estimates

Classic twin study of primarily women:
(154 DZ twin pairs & 172 MZ pairs)

74% heritability est. for lumbar disc deg.
73% heritability est. for cervical disc deg.

*Note: phenotype (DD summary score – bulging, narrowing, signal*, osteophytes)*

Sambrook et al, Arthritis & Rheumatism, 1998
Classic Twin Study with Multivariate Analyses

- 152 MZ and 148 DZ male twin pairs
- Examined disc degen. by phenotype and level

Battié et al, Spine 2008
RESULTS

- Heritability estimates of ~50% for disc degeneration, depending on phenotype and lumbar level.

- Disc desiccation, narrowing and bulging had a primarily common genetic pathway.

- There was substantial difference in genetic and environmental effects by lumbar level.

- Implications for phenotypes/gene hunting?
Determinants of the Progression in Lumbar Degeneration
A 5-Year Follow-up Study of Adult Male Monozygotic Twins
Tapio Videman, MD, PhD,* Michele C. Battie, PhD,* Samuli Ripatti, PhD,† Kevin Gill, MD,‖
Hannu Manninen, MD, PhD,§ and Jaakko Kaprio, MD, PhD∥

Spine, 2006

Progression of lumbar disc degeneration over a decade: a heritability study
Frances M K Williams, Maria Popham, Philip N Sambrook, Annette F Jones, Tim D Spector, Alex J MacGregor

Arthritis & Rheumatism, 2011
Heritability of Low Back Pain and the Role of Disc Degeneration

Michele C. Battie, Tapio Videman, Esko Levälahti, Kevin Gill, Jaakko Kaprio

Pain, 2007
The Primary Goals

1) estimate the magnitude of genetic vs. environmental effects on various definitions of back pain problems.

2) examine whether genetic effects on back pain are mediated through genetic effects on disc degeneration.
Back pain case definition?

1) Frequency (12 months)
2) Pain intensity (12 months)
3) Disability days (12 months)
4) Duration of worst episode
5) Intensity of worst episode
6) Did you have to go to bed rest for > day?
7) Back surgery or hospitalized due to back?
Main Findings

- Moderate heritability estimates found for BP were (30-46%), however...

- A minority of the genetic influences on LBP ($\leq 25\%$) was due to the same genetic influences on disc degeneration (narrowing).
Possible Genetic Mechanisms

- Synthesis and breakdown of disc’s biochemical and structural constituents (ECM)
- Anthropometrics & other properties affecting vulnerability to forces or nutritional compromise
- Behaviors associated with risk
- Neurological factors initiating or sustaining pain
- Pain perception and psychological characteristics affecting pain reporting, …
Searching for Susceptibility Genes

Gain insight into the biological mechanisms underlying LBP/pathology

Lead to novel diagnostic and intervention approaches
A complex genetic architecture…

- polygenic
- gene-gene, gene-env. Interactions
- effects of noncoding regions…

“The more we look, the more complicated it gets.”

Eric Green (NHGRI, 2011)
In conclusion:

- It is time to move beyond the injury model of low back pain & pathology.
Clinical Implication:

*Be cautious with attribution!*

Attributing findings of disc degeneration and pathology to occupational exposures is likely to be incorrect and may create inaccurate perceptions of fault.
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Driving of motor vehicles as a risk factor for acute herniated lumbar intervertebral disc

- case-control study (N=217), matched on age, gender health care seeking, of patients with surgical, probable and possible disc herniation

- males who spent >50% work time driving, ~3x more likely to have DH
- drivers more likely to have DH than non-drivers

Kelsey & Hardy, 1975
Am J Epidemiol
“Degenerative Disc Disease”

“Among the factors associated with its occurrence are age, gender, occupation, cigarette smoking, and exposure to vehicular vibration. The contribution of other factors such as height, weight, and genetics is less certain.”

Frymoyer, Lumbar disk disease: epi. Instr Course Lect;41;1992
Occupational disease no. 2110
“diseases of the lumbar spine from disc degeneration caused by long-term (mainly vertical) whole-body vibration exposure”
“uncontrolled confounding factors may have affected the results in all studies, and the conclusions about the causal role of WBV for the observed injuries and/or disorders therefore becomes uncertain.”

Kjellberg et al, 1994
54 yr. old, male bus driver with severe degenerative changes
Occupational Driving and Lumbar Disk Degeneration

M.C. Battié, T. Videman, H. Manninen, L. Gibbons, K. Gill, M. Pope, J. Kaprio

The Lancet, 2002
Subjects and Driving Exposure

- 45 male pairs, 36-69 years old

- Mean discordance, 23 years of 6 hrs./day of occupational driving (5.4X)

- Discordance in WBV exposure would likely be greater based on vehicle types
MRI findings investigated:

- Loss of signal intensity
- Disc narrowing
- Bulging & herniation
- Annular tears
- Osteophytes
- Endplate irregularities
Results

• No statistically significant differences were found between groups, with the exception of disc herniations that were more frequent in non-drivers (p=0.04).

• No overall tendency for greater degeneration seen among drivers.

Battié et al, The Lancet; 2002
Lifetime discordance in co-twins' driving hours

Drivers' degeneration compared to co-twins' (percent)
Recent reviews:


Vibration - risk factor or treatment?
Related policies endure...

‘Disability awards are provided to 98% of Long Island Railroad workers at the time of retirement presumably as a result of WBV throughout their lifetime as an employee.’

Bible et al, 2012
Spine
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Case definition… critically important to understanding

- Imaging findings/pathology?
- Reports of back pain or radiating leg pain?
- Health care seeking?
- Claims filing?
The disc as a culprit in low back pain …
Disc degeneration-related clinical phenotypes

“Degenerative Disc Disease”

Loss of structural and functional integrity of the disc, associated with pain or discomfort

“a degenerate disc that is also painful”

Adams & Roughly, 2006
Degenerative disc disease:

“the pathoanatomical differences between those that are diseased (a source of pain, disability, etc.) and those that are just aging asymptotically have not been discovered, and a connection between such pathology and pain/disability is unclear.”

Weiner, Spine 2007
DDD – An important clinical concept!

- Representative National Inpatient Sample

- Similar to prior decades fusion rates continued to rise (outpacing increases in other common procedures)

- 7.9-fold increase in overall costs of fusion nationally

- Degenerative Disc Disease – leading diagnosis assoc. with fusion in 2008

Rajaee et al, Spine 2011
DDD phenotypes used in gene association studies (2000-2012):

“lumbar disc disease”:
- “discogenic sciatica” with severe, unilateral pain radiating below the knee
- back pain with radiological confirmation of lumbar disc disease on MRI
- 4-point ordinal classification of disc signal on MRI regardless of back pain history.

“degenerative disc disease”:
- showed a similar lack of consistency
- observations of disc signal loss, narrowing, bulging or osteophytes, (irrespective of back symptom history)
- to chronic low back pain with a diagnosis of DDD for which spine surgery was planned.
DDD – How ever did we get here?

- 1947 - Captain Gilbert Fletcher’s study of 600 veterans of WWII

- Over next few decades ‘DDD’ was seldom used and typically restricted to patients with symptomatic spinal disorders for which the disc was a suspect.

- ~1975 use of ‘DDD’ was no longer reserved for symptomatic disc-related disorders

- The term was used widely in the 1980’s forward…
The challenge:

- Clinical phenotype of DDD (concept & definition) requires serious attention
- We need to develop a common language
- Until then, miscommunication, confusion & delayed progress
In summary…

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