Kyphosis: Causes, Consequences

and Treatments

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Roadmap

✿ Age-related thoracic hyperkyphosis
✿ Causes and consequences
✿ Relation to spinal load and vertebral fractures
✿ Exercise and therapeutic interventions for reducing hyperkyphosis, spinal load and associated vertebral fracture risk

Sagittal Plane Alignment

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Disclosures

✿ None
Measurement of Thoracic Kyphosis

- Radiographic Cobb angle
- Clinical tools: Flexible ruler, Occiput-to-wall
- Block method

Epidemiology of Kyphosis

- Kyphosis increases with age\textsuperscript{1,2,3,4,5,6,7,8}
- Defined as >40 degrees\textsuperscript{4,9}
- 20-40% of older adults\textsuperscript{5,7,8}
- More common in women\textsuperscript{7}

Correlates of Hyperkyphosis

\begin{itemize}
  \item \textsuperscript{*}Age and heredity\textsuperscript{1,3,4,5,10}
  \item \textsuperscript{*}Vertebral fractures, low bone mineral density, disc degeneration\textsuperscript{3,4,11,16}
  \item \textsuperscript{*}Decreased shoulder, hip and spinal mobility/spinal proprioception\textsuperscript{2,5,6,8,10}
  \item \textsuperscript{*}Spinal muscle weakness\textsuperscript{2,6,8,10}
  \item \textsuperscript{*}Spinal muscle attenuation\textsuperscript{12}
\end{itemize}

\textsuperscript{1}Ball, 2009; \textsuperscript{2}Ensrud, 1997; \textsuperscript{3}Ettinger, 1994; \textsuperscript{4}Fon, 1980; \textsuperscript{5}Kado, 2004; \textsuperscript{6}Katzman, 2011; \textsuperscript{7}Schneider, 2004; \textsuperscript{8}Takahashi, 2005; \textsuperscript{9}Voutsinas, 1986

Kado, in review

\begin{figure}
\centering
\includegraphics[width=\textwidth]{kyphosis_graph.png}
\caption{Kyphosis Progression in Older Women Over 15 Years}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{kyphosis_correlates.png}
\caption{Correlates of Hyperkyphosis}
\end{figure}
Clinical Consequences of Hyperkyphosis

- Impaired quality of life, physical function, and increased risk of early mortality
- Vertebral fracture risk
- May affect balance and risk for falls
- Slower gait speed, stair climbing, functional reach
- Pulmonary, gastrointestinal and gynecologic dysfunction

References:

Falls and Kyphosis

- Hyperkyphosis increases risk of an injurious fall overall 1.38-fold (CI: 1.05–1.9); 1.48-fold (CI: 1.10–2.00) among those with the worst kyphosis (Kado, 2005)
- Greater kyphosis predicts worse performance times on the Timed Up and Go test, a strong indicator of increased fall risk (Katzman, 2011)
- Balance impairments among osteoporotic-kyphotic women; exercise improved balance and reduced risk for falls (Sinaki, 2005)
- Balance impairment is related to vertebral fracture not kyphosis among individuals with osteoporosis (Greig, 2007)
Fracture Risk and Kyphosis

- Hyperkyphosis increased risk for future fractures approximately 75% (Huang, 2006)
  - independent of age, baseline fracture, bone mineral density
  - prospective cohort study among 596 community-dwelling women 47–92 years
- Possible mechanisms
  - falls or spinal loading

Factors Influencing the Vertebral Fracture Cascade

BMD, Activity and Load Modify Risk of Bone Failure

* Failure in the L2 vertebrae occurs sooner at the same load with low BMD
* Loads vary with common activities of daily living

Predicted Loads on the Lumbar Spine

- Predicted load at L3 vertebrae
  - % body weight (BW) for average sized woman
  - 51% standing
  - 173 % sit to stand
  - 319% lifting 33# from floor
- Loads can increase during activities of daily living
- Spinal load varies with thoracic kyphosis and sagittal plane alignment (Bouxsein, 2006)
Spinal Load and Kyphosis

- 44 subjects mean age 62 years dichotomized into high/low kyphosis
- Standing lateral radiographs captured and digitized
- Biomechanical models estimated multi-segmental load T2-L5

Briggs, 2007

**Spinal Load and Disc Degeneration**

- Disc degeneration predisposes vertebrae to anterior fracture when spine is flexed - stress shielding
- Pollintine, 2004

**Spinal Flexion and Vertebral Fracture**

- Compression loads on the L3 vertebrae increase with 30° of trunk flexion.
  - 2610 N with arms in front, holding 2 kg in each hand (Schultz, 1982)
  - 300 to 1200 N enough to fracture an osteoporotic vertebra (Edmondston, 1997)
  - Practical Application - bend and lift in everyday life with the trunk in relative neutral (adapted from Bookstein and Lindsey, "Osteoporosis – What You Should Know" powerpoint)

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Sinaki & Mikkelsen, 1984
Spinal Flexion and Vertebral Fracture

- Case series of 3 healthy persons with low bone mass developed yoga-induced pain and vertebral fracture
- 87 year-old woman L2 fracture after exercise “a”
- 70 year-old woman T8T9 fractures after “a” and “b”
- 61 year-old woman T4 endplate fracture after “a” and “c”
  
  Sinaki, 2012

Exercise and Kyphosis

- RCT 60 post-menopausal women 49-65 years
- High-intensity spinal strengthening vs. usual activity
- 30% for 10 repetitions; 5 times weekly for 2 years
- Post-hoc analysis: kyphosis reduced significantly among those with Cobb angle >34° and significant spinal weakness at baseline
  
  (Itoi & Sinaki, 1994)

Exercise and Kyphosis

- RCT 118 men and women with kyphosis >40°
- Modified yoga versus monthly luncheon for 6 mos.
- 4-5% improvement in flexible ruler measures of kyphosis
- No significant change in radiographic Cobb angle or physical function

Greendale, 2009

Exercise, Physical Function and Kyphosis

- Uncontrolled trial 21 women 72 ± 4.3 years with kyphosis >50°
- High intensity spinal muscle strengthening, stretching and postural training for 3 mos.
- Kyphosis improved 6°; physical function improved and improvements maintained at 1 year
  
  Katzman, 2007
**Mobilization, Exercise and Kyphosis**

- RCT 20 men/women over 50 with painful vertebral fracture
- Spinal mobilization, low intensity spinal strengthening, postural training versus no treatment for 10 weeks
- No significant improvement in kyphosis (5% inclinometer)
- Physical function improved in Timed Loaded Standing
- Pain reduced and health-related QoL improved
  - Bennell, 2010

**Proprioception and Kyphosis**

- Joint position sense is correlated with degree of kyphosis (Granito, 2012)
- Spinal taping improves kyphosis (Bautmans, 2010; Greig, 2007)
- Weighted kypho-orthosis reduces kyphosis, improves balance (Sinaki, M. 1995)
- Thoracolumbar orthosis reduces kyphosis, improves strength and physical function (Pfeifer, M. 2004)

**Medications, Surgical Procedures and Kyphosis**

- No effect on kyphosis progression over 4 years in the Fracture Intervention Trial study of the effects of alendronate on fracture reduction (Kado, DM, 2008)
- Kyphosis progression reduced over 3 years in studies of strontium ranelate versus placebo among postmenopausal women with osteoporosis (Roux, C, 2010)
- Reduction of radiographic Cobb angle after vertebroplasty and balloon kyphoplasty for vertebral fracture (Theodorou DJ, 2002; Teng, 2003)
Exercise and Vertebral Fractures

Retrospective study 50 postmenopausal women
- Spinal strengthening exercises 5x/wk for 2 years
- Fewer fractures at 10-year follow-up in exercise group
  (Sinaki, 2002)

Retrospective study 57 patients, adults 55 years and older with osteoporosis and vertebral compression fracture
- Compared re-fracture rates and time before re-fracture after targeted exercise (ROPE) vs. vertebroplasty (PVP) vs. combined ROPE and PVP
- Lowest rate in non-surgical exercise ROPE group
  (Huntoon, 2008)

Exercise and Vertebral Fracture

Survival plot showing the proportion of patients without re-fracture at various time points (P<.001); median time to re-fracture PVP: 4.5 months (95% CI, 1.4-9.3); PVP-ROPE: 20.4 mos (95% CI, 2.8 – undefined); ROPE only: 60.4 mos (95% CI, 27.6 – undefined) (P<.001)

(Huntoon, 2008)

Best Posture and Body Mechanics

“Neutral Spine”

Best Posture and Movement in Daily Activity

Photos: Do It Right, American Bone Health, Sherri Betz, PT, GCS
Best Posture and Lifting

Bend and lift with the spine in “neutral”

- Bending and reaching with a round back increases spinal fracture risk if you have:
  - Osteoporosis
  - History of spinal fracture
  - Hyperkyphosis

Hip hinge during all activity and movements

- Neutral spine
- Increase extension in upper spine
- Strengthen spinal extensors and stabilizers

Avoid bending and twisting with a rounded spine

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Summary

- Hyperkyphosis and spinal flexion increase spinal load that in turn increases risk for vertebral fractures
- Best posture, neutral body mechanics and targeted interventions reduce excessive thoracic kyphosis
- High-intensity spinal strengthening exercise appears more effective and may have additional benefits

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Best Posture and Exercise

THESE: neutral or extended spine

Summary:

- Hyperkyphosis and spinal flexion increase spinal load that in turn increases risk for vertebral fractures
- Best posture, neutral body mechanics and targeted interventions reduce excessive thoracic kyphosis
- High-intensity spinal strengthening exercise appears more effective and may have additional benefits

AVOID: flexion, rounding, twisting

Photos: Do It Right, American Bone Health, Sherri Betz, PT, GCS

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Next steps

- Screen patients and identify those with thoracic hyperkyphosis
- Best posture and body mechanics training to improve sagittal plane alignment
- Targeted spinal strengthening exercise to reduce excessive thoracic kyphosis
- Randomized controlled trials of exercise interventions with kyphosis and fracture outcomes

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Let’s practice!!!!!

- *Neutral spine*
- *Hip hinge*
- *Alphabets*