Kyphosis: Causes, Consequences and Treatments

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Disclosures

None

Roadmap

† Age-related hyperkyphosis
  † Background and significance
  † Causes and correlates
  † Consequences
  † Exercise and therapeutic interventions
  † Recommendations for clinical practice and future research

Background and Significance

† Life expectancy increasing
† Physical disability is not inevitable
† Identify new, potentially modifiable factors
† Develop targeted interventions
Hyperkyphosis Definition

- Hyperkyphosis is an excessive curvature in the thoracic spine
- Alters sagittal plane alignment

Epidemiology of Hyperkyphosis

- Kyphosis increases with age
- Affects 20-40% of older adults
- More common in older women

Measurement of Sagittal Plane Alignment

- Radiographic Cobb angle
- Flexible ruler
- Occiput-to-wall
- Kyphometer
- Block method

Roadmap

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- Consequences
- Exercise and therapeutic interventions
- Recommendations for clinical practice and future research
Primary Correlates of Hyperkyphosis

- Vertebral fractures\(^1,2\)
- Osteoporosis\(^3-5\)
- Degenerative discs\(^6\)
- Family history\(^6,7\)

\(^1\) Ensrud, 1997; \(^2\) Kado, 2013; \(^3\) Fon, 1980; \(^4\) Ettinger, 1994; \(^5\) Schneider, 2004; \(^6\) Kado, 2005; \(^7\) Huang, 2006

Progression of Kyphosis

47 degrees versus 54 degrees

Primary Correlates of Hyperkyphosis

- Musculoskeletal changes
  - Spinal extensor muscle weakness\(^6,7,8\)
  - Spinal extensor muscle attenuation\(^8,9\)
  - Postural stiffness\(^10\)
  - Poor trunk position sense/proprioception\(^11\)

\(^6\) Sinaki, 1996; \(^7\) Mika, 2005; \(^8\) Katzman, 2011; \(^9\) Katzman, 2012 (ASBMR); \(^10\) Hinman, 2004; \(^11\) Granito, 2012
Primary Correlates of Hyperkyphosis

Fat accumulation in the paraspinal extensor muscles

Cross-sectional study of independent predictors of hyperkyphosis in 1,722 community-dwelling men and women 70-80 years old in the Health, Aging and Body Composition Study (Katzman, 2011)

Primary Correlates of Hyperkyphosis

Reduced spinal, shoulder and hip mobility

- Older women are less able to stand erect and actively reduce their kyphosis.¹
- Decreased functional axial rotation occurs with age, reduces physical performance and is associated with greater degree of kyphosis.²
- Flexed posture (hyperkyphosis) associated with shorter pectoral and hip flexor muscles.³

¹Hinman, 2004; ²Schenkman, 1996; ³Balzini, 2003

Primary Correlates of Hyperkyphosis

Greater kyphosis is associated with poor trunk proprioception.

Cross-sectional comparison of thoracic kyphosis degree, trunk muscle strength and trunk proprioception among 20 healthy and osteoporotic elderly women. (Granito, 2012)
Clinical Consequences of Hyperkyphosis

• Increased risk for future fractures
  • Prospective cohort studies
    • 596 community-dwelling women 47–92 years (Rancho Bernardo) over 4 years (Huang, et al., 2006)
      • Approximately 75% increased risk of fracture, independent of age, baseline fracture, BMD
    • 994 community-dwelling women aged 65 at baseline (SOF) over 15 years (Kado, et al., 2013)
      • 31% increased risk of non-spine fracture (95% CI, 1.09 -1.59) after adjusting for BMD, prevalent vertebral fractures, prior history of fractures, and other fracture risk factors


UCSF 10th Annual Osteoporosis: New Insights in Research, Diagnosis, and Clinical Care
Clinical Consequences of Hyperkyphosis

Hyperkyphosis increases risk of injurious falls.
- 1.4 fold increased risk (95% CI: 1.05, 1.91) that increased to 1.5 using a cutoff of ≥2 blocks versus ≤1 blocks (95% CI: 1.10, 2.00) (Kado, 2007)

Greater kyphosis predicts worsening performance times on the Timed Up and Go test, a strong indicator of increased fall risk. (Katzman, 2011)

Balance impairments in women with kyphosis compared to healthy controls. (Sinaki, 2005)

Spinal Flexion and Vertebral Fracture

Flexion increases spinal load during activities of daily living.
- 51% body weight standing
- 173% sit to stand
- 319% lifting 33# from floor

Bone fails sooner at the same load with low bone density. (Myers, Wilson, Bouxsein, 1997)
Scores on the Safe Functional Motion Test (SFM) Predict Incident Vertebral Compression Fracture

Task specific scoring for domains of spine-loading, balance, upper- and lower body strength and flexibility
  - Sit to floor
  - Climb-carry
  - Night walk
  - Sweep
  - Washer/dryer load
  - Pour

For every 10 point increase in SFM test, the odds of future VCF decreased at 1 year by 18% (n=878) and 3 years by 27% (n=503) after adjusting for covariates. (MacIntyre, N, et. al., Submitted for publication)

Clinical Consequences of Hyperkyphosis

- Greater spinal load among high kyphosis group
- 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

Clinical Consequences of Hyperkyphosis

Kyphosis increases spinal load during activities of daily living. Spinal load varies with thoracic kyphosis and sagittal plane alignment. (Bruno, AG, et al., 2012)

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)
**Roadmap**

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**Medications and Surgical Procedures**

- 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 post-menopausal women with osteoporosis (Roux, C, 2010)
- Reduction of radiographic Cobb angle after vertebroplasty and balloon kyphoplasty for vertebral fracture (Theodorou DJ, 2002; Teng, 2003)

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**Exercise for Improving Age-Related Hyperkyphotic Posture: A Systematic Review**

<table>
<thead>
<tr>
<th>Author</th>
<th>Population</th>
<th>Intervention</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abreu, et al., 2012</td>
<td>Elderly women with osteoporosis, N=20</td>
<td>Strengthening quads, triceps, paravertebral and abdominal muscles; 2x/week x 12 weeks</td>
<td>No significant within or between group difference</td>
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<tr>
<td>Baetens et al., 2010</td>
<td>Post-menopausal women receiving 3-monthly IV pamidronate, N=46</td>
<td>Thoracic extension, stretching, erector spine strengthening, manual mobilization and postural exercise; daily for 10 weeks</td>
<td>Significant improvement within intervention group, p=0.01</td>
</tr>
<tr>
<td>Benedetti, MG, et al., 2008</td>
<td>Men and women 65 years and older with flexed posture, N=34</td>
<td>Active spinal extensor strengthening and postural alignment compared to non-specific physical; 2-3 times weekly for 3 months</td>
<td>Significant improvement within intervention group; p=0.001</td>
</tr>
<tr>
<td>Bennell, K, et al., 2010</td>
<td>Men and women 65 years and older with kyphosis ≥ 40 degrees, N=118</td>
<td>Spinal mobilization, low intensity spinal strengthening, postural training compared to no treatment; once a week for 10 weeks</td>
<td>No significant within or between group difference</td>
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<tr>
<td>Greendale, G, et al., 2009</td>
<td>Men and women 65 years and older with kyphosis &gt; 40 degrees, N=118</td>
<td>Modified yoga compared to monthly lunch; 3 times weekly for 24 weeks</td>
<td>Significant between group difference in flexicurve index, p=0.004 and flexicurve angler, p=0.005; no significant between group difference in kyphometer, p=0.64</td>
</tr>
<tr>
<td>Ito, I, et al., 1994</td>
<td>Post-menopausal women, 49-65 years old, N=60</td>
<td>Prone trunk extension compared to usual activity; 30% 1 repetition max for 10 repetitions; 5 times weekly for 2 years</td>
<td>Significant within group difference among those with baseline kyphosis; &gt;34 degrees; significant between group difference, p=0.016</td>
</tr>
<tr>
<td>Schurman et al., 1998</td>
<td>Post-menopausal women with osteoporosis, N=60</td>
<td>Postural exercises (shoulder flexion, wall pushups, scapular adduction); daily for 12 weeks</td>
<td>No significant within or between group differences</td>
</tr>
</tbody>
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**Spinal Flexion and Vertebral Fracture**

- Extension exercise
- Flexion exercise

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*Sinaki & Mikkelsen, 1984*
Spinal Extensor Strengthening May Reduce Incident Vertebral Fractures

Prospective 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 refracture rates and time before refracture after targeted exercise (ROPE) vs. vertebroplasty (PVP) vs. combined ROPE and PVP
* Lowest rate in non-surgical exercise ROPE group (Huntoon, 2008)

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Current/Future Studies

National Institute of Aging (NIA): RCT of a 6-month multimodal exercise intervention to determine the effects on kyphosis

Office of Research on Women’s Health and National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS): Specialized Center of Research to investigate sex differences in musculoskeletal issues across the lifespan – Kyphosis Project

Canadian Institutes of Health Research (CIHR), U of Waterloo: Pilot RCT to test the feasibility of a large multicentre study to evaluate whether tailored home exercise can prevent fractures (primary outcome) in high-risk individuals.

National Taiwan University Hospital – RCT to determine the effects of core muscle training with EMG biofeedback on kyphosis.
**Best Posture and Movement in Daily Activity**

- Photos: Do It Right, American Bone Health, Sherri Betz, PT, GCS
- UCSF 10th Annual Osteoporosis: New Insights in Research, Diagnosis, and Clinical Care

**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

Avoid bending and twisting with a rounded spine

Hip hinge during all activity and movements:

- Neutral spine
- Increase extension in upper spine
- Hinge at the hip
- Strengthen spinal extensors and stabilizers

**Best Posture and Exercise**

- THESE: neutral or extended spine
- AVOID: flexion, rounding, twisting

**Spinal Extension Strengthening Exercises**

- Photos: Do It Right, American Bone Health, Sherri Betz, PT, GCS
- UCSF 10th Annual Osteoporosis: New Insights in Research, Diagnosis, and Clinical Care
**Summary**

- Age-related hyperkyphosis is easily recognized yet rarely treated geriatric syndrome, common among older adults and associated with poor health outcomes.
- Few well-controlled, high quality randomized controlled trials have investigated the effects of exercise on kyphosis.
- Results from several trials suggest that back extensor strengthening may be effective in improving kyphosis.
- Hyperkyphosis and spinal flexion increase spinal load that in turn increases risk for vertebral fractures.
- Best posture, neutral body mechanics and targeted back extension strengthening interventions may reduce spinal load and risk for fractures.

**Next steps**

- Screen patients and identify those with 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

**Let’s practice!**

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