Age-related hyperkyphosis: 
*Are we destined to stoop with aging?*

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I have nothing to disclose.

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Roadmap

- Background and significance of age-related hyperkyphosis
- Kyphosis, sagittal alignment and spinal load
- Exercise and therapeutic interventions to reduce kyphosis
- Recommendations for clinical recognition and physical therapy treatment of hyperkyphosis

Background and Significance

- Age-related thoracic hyperkyphosis
  - is common and affects up to 40% older adults
  - associated with adverse health outcomes
  - may be modifiable
- Population living longer with physical disability
- Identifying and treating hyperkyphosis may improve health outcomes

Kyphosis

Kyphosis is a normal sagittal plane convexity of the thoracic spine that progresses with age. A thoracic curvature greater than 40° --- the 95th percentile of normal for young adults --- is defined as hyperkyphosis.

Thoracic kyphosis progresses with age

- Birth-30 years 20° to 29°
- Progresses after age 40, more rapidly in women
- Approximately 5° per decade after age 50

Prevalence of Cobb angle hyperkyphosis is greatest in older white women

- Cobb angle 3° to 5° higher in older women (Health ABC and Rancho Bernardo)
- Prevalence is 20-40% in older adults
  - Varies by sex and race (Health ABC):
    30% in white women, 26% in black women,
    17% in white men, 11% in black men

Measurement of thoracic kyphosis

**Radiographic:**
- Occiput-to-wall Cobb
- Kyphometer

**Flexible ruler**
- (flexicurve)

**Block method**

Other tools...

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Prevalence of Cobb angle hyperkyphosis is greatest in older white women, however...

- **Men more likely to have hyperkyphosis using block method, suggesting different phenotypes of kyphosis**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low bone mineral density/BMD loss</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Prevalent/incident vertebral fractures</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Degenerative disc disease</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Paraspinal muscle weakness</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Low paraspinal muscle attenuation</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Diffuse idiopathic skeletal hyperostosis</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Scheuermann’s disease</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Vertebral fractures, osteoporosis and kyphosis are linked but not synonymous

• 2/3 of men and women with most severe kyphosis had no evidence of underlying vertebral fractures or osteoporosis (Rancho Bernardo)

• Degenerative disc disease, not vertebral fractures, was the most common finding associated with kyphosis

Schneider, et al., J Rheumatol, 2004

Hyperkyphosis is associated with potentially modifiable neuromuscular impairments

Spinal weakness
Poor spinal extensor muscle quality
Loss of flexibility in:
• spinal extension
• functional axial rotation
• shoulders, hips (shorter pectoral, hip flexor muscles)
• hamstrings (sway-back posture)
Poor trunk proprioception

Hyperkyphosis is associated with weakness of back extensor muscles in older women

Cross-sectional study of 65 women, age 48-65 years with osteoporosis; negative correlation of strength and kyphosis

Hyperkyphosis is associated with fat accumulation in paraspinal extensor muscles

- 1172 men and women, aged 70-80 years (Health ABC)
- No difference in muscle cross-sectional area in normal versus hyper-kyphosis
- Fat infiltration in the multifidus muscle
- Better attenuation in multifidus muscle (less fat) associated with reduced risk of hyperkyphosis
Hyperkyphosis: Impairs physical function

2,777 women aged 55-80 years (FIT)
• Increasing kyphosis predicts worsening performance on the Timed Up and Go test, an indicator of increased fall risk

2,363 men mean age 79 years (MrOS)
• Poor lower extremity physical function: chair stands, walking speed, narrow walk, leg extension power

Other impairments in gait, stair-climbing, functional reach, vital capacity


Hyperkyphosis: Reduces quality of life

• Physical difficulty, more adaptations
• Greater generalized fears
• Less satisfaction with subjective health, family relationships and their lives in general
• Qualitative decrease in self-confidence

Sangtarash F, Osteoporos, Int, 2015; Martin, et al., Bone, 2002; Takahashi, et al., Osteoporos Int, 2005
Hyperkyphosis: A risk factor for fracture

- **596 community-dwelling women 47–92 years (Rancho Bernardo) over 4 years**
  Greater kyphosis increased all fracture risk by 75%

- **994 community-dwelling women aged 65 at baseline (SOF) over 15 years**
  Greater kyphosis increased non-spine fracture risk by 30%
  (95% CI, 1.1-1.6)

**Mechanisms not well defined**

Huang, et al., J Bone Miner Res, 2006; Kado, et al., J Bone Miner Res, 2014;

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Hyperkyphosis: A risk factor for falls

- **1.5 fold increased risk (95% CI:1.1,2.0) of injurious fall past year among those with hyperkyphosis (Rancho Bernardo)**

- **2 fold increased odds (95% CI 1.1,4.5) of incident falls among those with greater thoracic kyphosis (Amsterdam out-patient geriatric clinic)**

**Controversy remains around kyphosis, balance and falls**

Kyphosis increases load in the vertebrae


- **44 subjects mean 62 years with standing lateral spine radiographs dichotomized high/low thoracic kyphosis**
  - Greater flexion moment, net compression and shear forces in high kyphosis group in upright stance
  - Multi-segmental loads and trunk muscle forces higher throughout spine in high kyphosis group
  - Linear relationship between magnitude of load & kyphosis

Greater thoracic kyphosis and poor sagittal plane alignment increase spinal load


**Mechanical model of relaxed standing and standing with 5 kg weight in each hand to estimate spinal load**
- Load increased with kyphosis and holding 5 kg
- Loads mitigated in compensated and congruent posture
Trunk flexion and anterior loading increases compressive forces in the spine
Iyer, et al., Clin Biomech, 2010

Spinal load and bone mineral density modify vertebral fracture risk

<table>
<thead>
<tr>
<th>Activity</th>
<th>BMD (g/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sit up from sitting</td>
<td>1.5 0.6 0.4 0.3 0.2 0.2 0.2</td>
</tr>
<tr>
<td>Lift 15 kg knees straight</td>
<td>2.6 1.1 0.7 0.5 0.4 0.3 0.3 0.3</td>
</tr>
<tr>
<td>Lift 15 kg w/ deep knee bend</td>
<td>2.1 0.9 0.6 0.4 0.3 0.3 0.2</td>
</tr>
<tr>
<td>Lift 30 kg knees straight</td>
<td>3.7 1.5 1.0 0.7 0.6 0.5 0.4 0.4</td>
</tr>
<tr>
<td>Lift 30 kg w/ deep knee bend</td>
<td>3.0 1.3 0.8 0.6 0.5 0.4 0.3 0.3</td>
</tr>
<tr>
<td>Open window w/ 50 N of force</td>
<td>1.1 0.5 0.3 0.2 0.2 0.1 0.1</td>
</tr>
<tr>
<td>Open window w/ 100 N of force</td>
<td>1.4 0.6 0.4 0.3 0.2 0.2 0.2</td>
</tr>
<tr>
<td>Tie shoes sitting down</td>
<td>1.4 0.6 0.4 0.3 0.2 0.2 0.2</td>
</tr>
</tbody>
</table>

- Estimated ratio of load (applied) to strength (failure) for L3 during activities of daily living; estimates for average cohort 65 and older 65 kg
- Higher loads and lower BMD increase failure

Spinal extension exercise may reduce incident vertebral fracture
Sinaki & Mikkelsen, Arch Phys Med Rehabil 1984

- 59 postmenopausal women with spinal osteoporosis and back pain referred for extension, flexion, combined flexion and extension, or no exercise
- Incident vertebral fractures 1-6 years
- Fewest with extension (16%)
- Most with flexion (89%)

Good movement strategies reduces risk of vertebral fracture
MacIntyre, N, et al., Osteoporos Int, 2014

Safe Functional Motion (SFM) test assesses movement strategies during activities of daily living in adults 50 years and older, n=878.

- 60% of the tasks include spinal loading and balance domains
  - Sit-floor, climb-carry, sweep, load washer/dryer, night walk
- Odds of future vertebral fracture decreased 18% at 1 year and 27% at 3 years, for every 10 point increase in SFM score.
Summary

• Hyperkyphosis is associated with spinal muscle weakness, impaired physical function, falls and fractures
• Hyperkyphosis, sagittal alignment and flexion stress increase spinal load
• Spinal load increases vertebral fracture risk

Spinal extensor strengthening may improve kyphosis, physical function and health-related QoL

• Uncontrolled trial; 21 women 72 ± 4.3 years with kyphosis >50°
• High intensity spinal muscle strengthening, stretching and postural training for 3 months
• Kyphosis improved 6°
• Physical function improved
Systematic review of exercise for improving age-related hyperkyphotic posture
Bansal, Katzman & Giangregorio, Arch Phys Med & Rehabil, 2014

• Results: 8 of the 13 studies reported improvements in 1 or more kyphosis measures
• Limitations:
  • inconsistent definition of kyphosis
  • varied outcome measures
  • different use of usual versus erect posture
  • small sample sizes

Systematic review of exercise for improving age-related hyperkyphotic posture
Bansal, Katzman & Giangregorio, Arch Phys Med & Rehabil, 2014

• Results: Positive effects observed in 3 of the 4 high-quality studies (RCT) report improvement in some measure of kyphosis after targeted spine extension exercise.
• Appears low intensity exercise effective and high intensity exercise effective when kyphosis is greater than 34 degrees and the spinal extensor muscles are weak.
• Support for an adequately designed randomized controlled trial examining the effect of exercise on hyperkyphosis.
Spinal extensor strengthening exercise may reduce kyphosis and incident vertebral fractures

Sinaki, et al., Bone. 2002
Prospective trial 50 postmenopausal women
Back strengthening exercises 3x/wk for 2 years

Results: Kyphosis and relative risk of fracture reduced in the back exercise group vs. control

Fewer fractures at 10-year follow-up in exercise group

Retrospective study of 57 patients older than 55 with osteoporosis and non traumatic compression fracture

Results: A targeted exercise program (ROPE) after vertebroplasty (PVP) significantly decreased fracture recurrence.

Refracture rates lower in the exercise only group vs the PVP-only group and PVP-ROPE

Median time before refracture after (PVP): 4.5 months; (PVP-ROPE): 20.4 months; (ROPE only): 60.4 months

Summary of Evidence

• Hyperkyphosis is a risk factor for adverse health outcomes
  • May not have prior clinical or radiographic vertebral fracture
  • Increased risk for falls
  • Increased risk for fractures
  • Increased spinal load
  • Increased vertebral fracture risk among those with low bone density or prior vertebral fracture

• Targeted exercises and training may reduce kyphosis and its adverse effects
Next week in the clinic

- Observe your patient and identify excessive spinal curvature
- Note changes in height
- Observe posture during movement as they walk, remove shoes, get out of chair
- Note fracture history and risk factors for fracture
- Ask about falls in the past year
- Decide if follow-up is indicated for suspected vertebral fracture or a referral for physical therapy

PHYSICAL THERAPY CLINICAL RECOMMENDATIONS

- For individuals with hyperkyphosis
  - Advise about risks of flexion stress on the spine
  - Encourage use of best posture during ADLs and exercise
  - Recommend spinal extension strengthening
PHYSICAL THERAPY CLINICAL RECOMMENDATIONS

- For individuals with hyperkyphosis, osteoporosis and prior vertebral fracture, referral to physical therapy
  - Postural alignment and kyphosis: flexible ruler, occiput to wall, block method
  - Body mechanics during ADLs and exercise
  - Fall risk: balance, home safety
  - Spinal muscle strength and flexibility

PHYSICAL THERAPY CLINICAL RECOMMENDATIONS

- Physical therapists treat patients with hyperkyphosis, osteoporosis and prior vertebral fracture
  - Multicomponent exercise program including resistance training (spinal extensor strengthening exercise)
  - Balance training
  - Flexibility in the spine and extremities to increase extension
  - Instruction in best posture during exercise and ADLs
Next Steps: Randomized controlled trials of exercise interventions

**National Institute of Aging (NIA):**
Study of hyperkyphosis, function and exercise (SHEAF) RCT of a 6-month multimodal exercise intervention (spine strength, functional mobility) to determine effects on kyphosis, physical function and HRQoL

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

**Canadian Institutes of Health Research, U of Waterloo:**
Pilot RCT to test the feasibility of a large multicenter study to evaluate whether tailored home exercise with targeted spinal extension strengthening can prevent vertebral fractures (primary outcome) in high-risk individuals with vertebral fracture.

**Fracture Intervention Trial** (re-analysis of prior data)
Investigating whether baseline kyphosis predicts incident vertebral fractures
Summary

• Age-related hyperkyphosis is common, easily recognized geriatric syndrome
• Hyperkyphosis is associated with poor health outcomes
• Hyperkyphosis, poor sagittal alignment, spinal flexion increase spinal load and risk for vertebral fractures
• Spinal extensor muscle strengthening reduces hyperkyphosis and vertebral fracture risk
• Studies are underway to determine effects of targeted exercise on kyphosis, physical function and incident vertebral fractures

Resources

• www.nof.org
  – Health professionals guide to rehabilitation of the patient with osteoporosis
• American Bone Health
  ▪ https://americanbonehealth.org/what-you-should-know/exercise
• www.geriatricspt.org/store/
  – Stand Tall™ exercise video
• wellness@ptrehab.ucsf.edu (email)
  – Stand Tall™ revised exercise video
Questions?

Healthy Aging for Older Adults