 Annals of Internal Medicine

Narrative Review: Hyperkyphosis in Older Persons

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Hyperkyphosis is a widely recognized yet largely ignored condition. Although there are no uniform diagnostic criteria for hyperkyphosis, current studies estimate its prevalence among older adults at 20% to 40%. The causes and consequences of hyperkyphosis are not well understood. Some physicians think that fractures cause hyperkyphosis and that management strategies should focus solely on diagnosis and treatment for osteoporosis. Recent studies, however, demonstrate that many older adults who are most affected by hyperkyphosis do not have vertebral fractures. Hyperkyphosis may be independently associated with an increased risk for adverse health outcomes, including impaired pulmonary function, decreased physical function capabilities, and future fractures. With the growing older population, we now need research that leads to a deeper understanding of the causes, consequences, and treatment of this common condition.

Ann Intern Med. 2007;147:330-338. www.annals.org
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With aging, the sagittal convexity of the normal thoracic spine, known as *kyphosis*, tends to progress (1). Hyperkyphosis, an excess of this process, is often called the *dowager's hump*. Although not precisely known, the prevalence and incidence of hyperkyphosis in older persons is probably between 20% and 40% (2–4). The causes and consequences of hyperkyphosis are not well understood. Most clinicians and laypersons assume that hyperkyphosis results from underlying vertebral fractures; however, vertebral fractures are present in only 36% to 37% of the most severe kyphosis cases (5, 6). Furthermore, hyperkyphosis is not simply an undesirable cosmetic consequence of aging. It may be associated with several adverse health outcomes, such as poor pulmonary and physical function.

Our narrative review presents evidence that hyperkyphosis cannot be fully explained by osteoporosis and that it is a distinct geriatric syndrome deserving of more attention. With increased clinical awareness informed by continued research, physicians can begin to help prevent and treat hyperkyphosis and may avoid or lessen attendant adverse health consequences.

METHODS

We searched MEDLINE and PubMed (OLDMEDLINE for pre-1966) for studies from 1950 through 28 November 2006 by using the following Medical Subject Heading terms and keywords: *kyphosis*, *hyperkyphosis*, and *kyphotic posture*. We reviewed all citations and available abstracts (4734 for *kyphosis*, 77 for *hyperkyphosis*, and 87 for *kyphotic posture*). We classified 618 abstracts as not relevant (n = 408) or warranting detailed consideration of the original article (n = 210). We also excluded reports that were not in English (n = 1365) and those that addressed the following: 1) primary surgical interventions in children or young adults (n = 1386); 2) trauma-induced hyperkyphosis, such as thoracolumbar burst fractures (n = 107); 3) hyperkyphosis caused by chronic diseases, such as Pott disease (n = 558); and 4) other conditions, such as scoliosis or kyphoscoliosis (n = 1108). As we reviewed the remaining publications, we paid attention to study design and sample size, characteristics of the participants, and whether studies addressed factors other than kyphosis that could have influenced outcomes.

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HOW DOES ONE MEASURE KYPHOSIS?

The normal spine has 3 curves in the sagittal plane: cervical lordosis (anteriorly convex), thoracic kyphosis (anteriorly concave), and lumbar lordosis. Kyphosis can be measured from radiographs or with such devices as the kyphometer (7), goniometer (8), inclinometer (9), and flexible ruler (1) (**Figure 1**). Developed first to assess scoliosis angles on spinal radiographs, the Cobb angle was modified to measure kyphosis. Considered the current gold standard measurement, it is calculated by drawing a line at the upper border of the vertebral body, marking the beginning of the thoracic curve (commonly T4), and at the inferior border of the vertebral body, representing the interface between the thoracic and lumbar curves (commonly T12). Perpendicular lines are drawn from these 2 lines, and the angle of their intersection is the Cobb angle (**Figure 2**). Other clinical assessments of kyphosis include qualitative visual measurements (3, 4) and measurement of either the distance from the occiput to wall (10) or the number of 1.7-cm blocks between the head and examination table while the patient is lying flat with the neck in a neutral position (2).

Research has not fully disentangled the differences between clinical and radiologic kyphosis measures. In a study of 26 postmenopausal women (7), independent observers measured kyphosis similarly when they used Debrunner kyphometer, flexicurve-derived kyphosis angle, and radiographic Cobb angle measurements. Intraclass correlation estimates for the measures ranged from 0.87 to 0.92 (7).

Traditionally, the Cobb angle is measured from standing lateral spine films. However, in elderly persons, spinal radiography is usually performed with the patient in the supine position for comfort. Because gravity's effect on posture is lost while supine, the kyphosis angle measured in the lying position may underestimate kyphosis. In a study that compared the standing Debrunner kyphometer angle with a supine radiographic Cobb angle measurement in 120 women age 55 to 80 years (11), the mean difference between the 2 measures was only 4°. The Debrunner method overestimated the Cobb angle slightly, and the intraclass correlation coefficient for the measures was 0.68 (11).

How Does One Define Hyperkyphosis?

In younger populations, normal kyphosis angles range between 20° and 40° (12). In older adults, the mean kyphosis angle is about 48° to 50° in women (6, 13–15) and about 44° in men (6). We know that the angle increases with age (1, 6, 12, 16–26), but we do not have uniformly accepted thresholds for defining either hyperkyphosis or "normal" thoracic spine changes associated with aging.

One longitudinal study of 100 healthy men and women age 50 years or older (mean age, 62 years) reported a mean thoracic angle increase of 3° per decade (27). In a longitudinal study of 10 women (mean age, 77 years) followed for 3 years after a vertebral fracture (24), the mean angle increase was 5.6°. Cross-sectional studies reported that the oldest age groups had the most pronounced increases in kyphosis (12, 21, 23). For example, 1 study of men and women reported mean thoracic kyphosis angles of 26° in persons in their 20s, 53° in those 60 to 74 years of age, and 66° in those older than 75 years of age (23). An ongoing large prospective cohort study will soon provide important longitudinal data on rates of progression in older women (28).

Potential Causes of Hyperkyphosis

Vertebral fractures do not explain all cases of hyperkyphosis (29). Only 36% to 37% of older persons with the worst degrees of kyphosis have underlying vertebral fractures (5, 6). Other postulated causes of hyperkyphosis include postural changes, degenerative disk disease, muscular weakness, ligamentous degeneration, and genetic predisposition (**Figure 3**).

Vertebral Fractures: The Most Cited Cause of Hyperkyphosis

In 1963, 2 publications noted an association between vertebral body wedging and kyphosis (30, 31). In the 1970s, Milne and Lauder (1) developed the flexicurve measurement of kyphosis and quantified the vertebral wedging index from lateral chest radiographs. The wedge deformity index increased with age and explained 42% of the variation in kyphosis in men and 48% in women (29). Other studies reported correlations between wedge angles and kyphosis ranging from 0.45 to 0.78 (14, 18, 19). In studies that compared kyphosis between people with and without vertebral fractures, those with vertebral fractures had worse kyphosis (6, 15, 32).

Postural Changes

Postural changes affecting the cervical, lumbar, and sacral spinal areas and postural flexibility may influence thoracic curvature. For example, investigators have found weak but statistically significant correlations between Cobb angle thoracic kyphosis and cervical lordosis in men ($r = 0.27$; $P < 0.03$) and women ($r = 0.33$; $P < 0.009$) (23). In 300 volunteers age 20 to 70 years, researchers reported a correlation of −0.35 between radiographic measures of thoracic kyphosis and maximum lumbar lordosis ($P = 0.001$) (33). In a study involving 51 women (34), those age 66 to 88 years had greater flexicurve kyphosis than those age 21 to 51 years (mean kyphotic index, 11.1 [SD, 3.9] vs. 7.2 [SD, 2.2] during erect stance). The older women were less able to actively correct their posture from a relaxed to an erect position (34).

Degenerative Disk Disease

A few cross-sectional studies report an association between degenerative disk disease and kyphosis (6, 19, 35). In a study of 100 healthy women age 39 to 91 years (19), investigators found a statistically significant correlation between anterior disk height and kyphosis angle ($r = -0.34$; $P < 0.001$). Using measurements of lateral spine radiographs and mid-sagittal computed tomography films of 93 ex vivo spines from men and women age 18 to 94 years,

Key Summary Points

Hyperkyphosis is a common geriatric condition that affects as many as 20% to 40% of older adults.

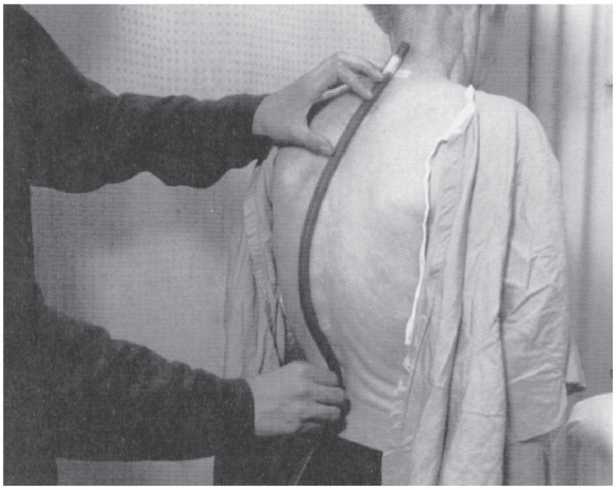
Hyperkyphosis affects both men and women—the lay term *dowager's hump* is a misnomer.

Vertebral fractures are present in only about one third of the older adults with the worst degrees of thoracic curvature.

Hyperkyphosis may be associated with multiple adverse health outcomes, including impaired pulmonary and physical function, fractures, and possibly increased risk for death.

Research about the cause, consequences, and treatment for hyperkyphosis is urgently needed because available evidence is scant and the prevalence of the condition will probably increase as the population ages.

Figure 1. **The flexicurve: a noninvasive measurement of thoracic kyphosis.**



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researchers reported a correlation of −0.52 ($P < 0.001$) between anterior disk wedging and Cobb angle (35). In a third study of 1407 older men and women (6), with each 5°-increase in Cobb angle, participants had a 36% (95% CI, 1.26 to 1.48) increased odds of having degenerative disk disease. These cross-sectional studies did not establish whether degenerative disk disease contributed to or was a consequence of hyperkyphosis.

Muscle Weakness

With 2 exceptions (36, 37), most studies report an inverse correlation between muscle strength and hyperkyphosis (8, 38–42). Although not a direct measure of spinal muscle strength, grip strength measured in 151 men and women age 65 to 85 years correlated with worse kyphosis measured from a lateral photograph ($r = -0.25$; $P < 0.005$) (38). Similar findings of upper-extremity strength and flexicurve-measured kyphosis include a correlation of −0.32 in 47 women volunteers age 50 to 60 years ($P < 0.05$) (39).

Three studies reported a statistically significant association between back-extensor strength and hyperkyphosis in postmenopausal women. Two of these studies found correlations ranging from −0.30 to −0.35 (40, 41). The third study found that, among 25 women, those with hyperkyphosis (Cobb angle, 50° to 55°) had weaker back-extensor muscles (250 N vs. 150 N; $P < 0.05$) than control patients (Cobb angle <35°). No adjustments were made for apparent differences between the groups in age, body size, or physical activity (42). In a study of 189 women age 50 to 80 years, those with weak back-extensor muscles were more likely to have greater kyphosis (58° vs. 51° by goniometer; $P < 0.01$) (8).

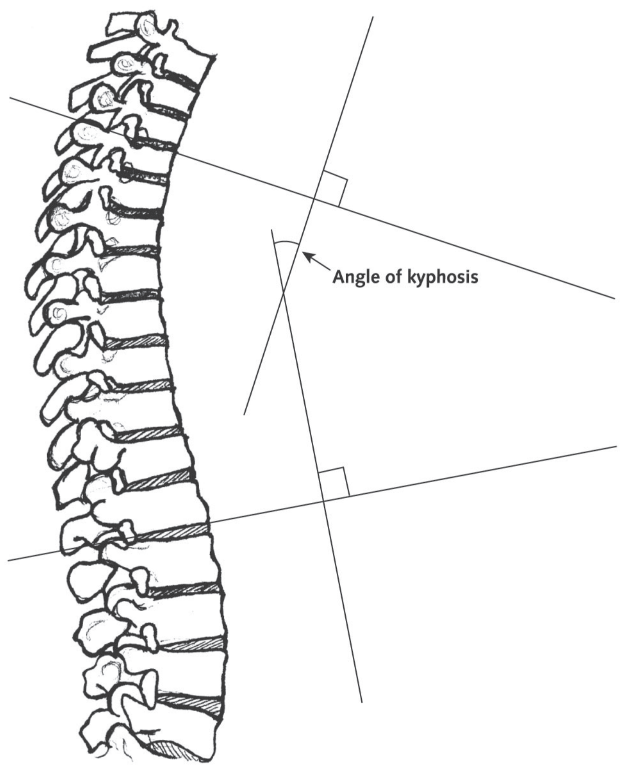
Intervertebral Ligaments

Intervertebral ligaments provide stability to the spine and, with aging, are susceptible to loss of elastic tissue, calcification, and ossification (43). In theory, any of these changes might predispose an aging individual to hyperkyphosis. Indirect evidence that tight ligaments may contribute to hyperkyphosis comes from a study of 11 cadavers, in which segmental transections of the anterior longitudinal ligament from T3 to T7 resulted in a 16° Cobb angle reduction (44).

Genetic or Metabolic Basis of Hyperkyphosis

Early-onset hyperkyphosis occurs in inherited genetic conditions, including osteogenesis imperfecta, the Ehlers–Danlos syndrome, the Marfan syndrome, cystic fibrosis, and Scheuermann disease. Scheuermann disease, the most frequent cause of juvenile hyperkyphosis, is characterized by a thoracic Cobb angle of 45° or greater and/or lumbar kyphosis with associated vertebral wedging, end-plate irregularity, and disk space narrowing (45). The disease is probably inherited (46–49). However, with an estimated population prevalence of 8.3% (50), it cannot account for the large prevalence of age-associated hyperkyphosis. Incomplete penetrance of certain genotypes may lead to milder age-associated hyperkyphosis. In recent studies, older per-

Figure 2. **The Cobb angle of thoracic kyphosis, calculated from a lateral radiograph.**



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sons who reported a family history of dowager's hump were statistically significantly more likely to have greater kyphosis, independent of a family history of osteoporosis, bone mineral density, or vertebral fractures (51–53).

Hyperkyphosis may be an end result of genetic lesions involving genes important for DNA repair and delaying senescence. Several mouse knockout models that develop early senescence have pronounced hyperkyphosis (54–59). Whereas some researchers postulate that hyperkyphosis results from poor posture, results from the mouse studies suggest that gravitational forces may not be an important cause because, unlike humans who stand erect, mice spend their lives in a prone position.

Adverse Health Consequences of Hyperkyphosis

Impaired Pulmonary Function

In a case series of 74 women referred for osteoporosis evaluation, increased Cobb angle was associated with decreased FVC ($R^2 = 0.14$; $P < 0.001$) (60). Three other small cross-sectional studies reported statistically significant negative correlations between hyperkyphosis and vital capacity and/or FEV_1, with values ranging between −0.38 for vital capacity to −0.73 for FEV_1 (61–63). In 323 older community-dwelling persons, those with qualitatively assessed hyperkyphosis had restrictive ventilatory dysfunction, even after adjustment for age, sex, and body mass index (adjusted prevalence odds ratio, 2.3 [CI, 1.1 to 4.80]; $P = 0.02$). After adjustment for age, sex, smoking, and history of chronic bronchitis or asthma, persons with hyperkyphosis were also more likely to have obstructive ventilatory patterns (adjusted prevalence odds ratio, 3.3 [CI, 1.7 to 6.5]; $P < 0.001$) and self-reported dyspnea (adjusted prevalence odds ratio, 2.5 [CI, 1.1 to 5.8]) (64).

Diminished Physical Function

Several cross-sectional studies report an association between hyperkyphosis and poor physical function (3, 40, 65–69). In an unadjusted analysis of 85 osteoporotic women age 50 to 82 years, those with hyperkyphosis reported increased difficulties in bathing and washing (65). In another study of 98 postmenopausal women, those with curviscope-documented hyperkyphosis were more likely to report impaired physical mobility (66).

Among studies of performance-based measures, one involving women age 50 to 60 years found that, with increasing flexicurve kyphosis, bench-press strength decreased ($r = -0.32$; $P < 0.05$) and maximum oxygen uptake decreased ($r = -0.37$; $P < 0.02$) (39). In a study of 55 women, those with osteoporosis and vertebral fractures had greater Cobb angle kyphosis (median, 60°) than those with osteoporosis and no vertebral fractures (median, 43.5°) or selected control patients (median, 37°) (67). They also had greater oxygen consumption and energy expenditure at rest than did those with osteoporosis without vertebral fractures ($P = 0.02$) but not compared with control patients. No adjustments were made for possible confounding (67). In 231 community-dwelling volunteers age 59 to 89 years, after adjustment for age, sex, body mass index, moderate to severe scoliosis, heart rate response to exercise, arthritis, and vertigo, those with hyperkyphosis (assessed qualitatively and as the occiput-to-wall distance) had reduced gait speed ($P = 0.015$) and increased stair-climbing time ($P < 0.001$) (3).

In a Japanese community sample ($n = 237$), persons 80 years of age or older with qualitatively assessed thoracic hyperkyphosis demonstrated slower gait speed (0.53 m/s vs. 0.59 m/s; $P < 0.05$), a slower timed get-up-and-go test result (14.9 seconds vs. 12.5 seconds; $P < 0.01$), and less functional reach (18.4 cm vs. 23.5 cm; $P < 0.001$) than did those classified as having normal posture. No adjustments were made for possible confounding by age and comorbid conditions (68). Of 1578 older U.S. persons, participants with hyperkyphosis defined by blocks had worse grip strength and more difficulty rising from a chair (odds ratios, 1.5 to 3.7) with increasing kyphosis severity compared with those with normal kyphosis. These findings seemed to be independent of age, bone mineral density, and self-reported vertebral fractures (69).

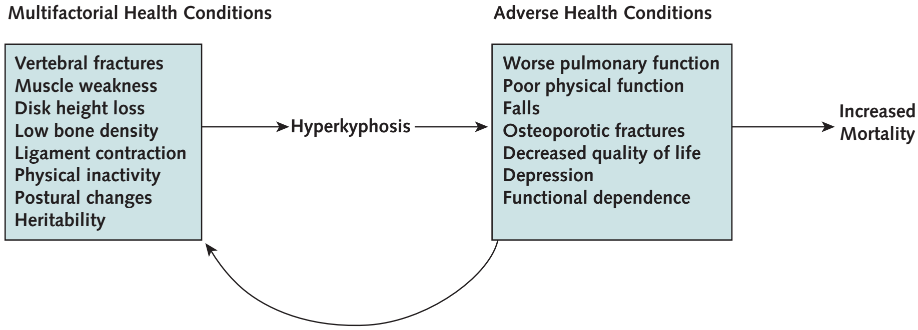
Increased Falls

Some postulate that hyperkyphosis fundamentally alters balance and predisposes persons to falls (42, 70, 71). Some studies challenge this assumption. Among 22 women with osteoporosis diagnosis, there was no association between Cobb angle kyphosis and balance measures (72). Similarly, in 151 older men and women, there was no association between kyphosis and postural sway (38). Studies that have investigated hyperkyphosis and fall risk report conflicting results (9, 70, 73, 74). In the largest study ($n = 1883$), block-measured hyperkyphosis was statistically significantly associated with self-reported injurious falls. However, in multivariable analyses, the risk remained statistically significant only in men. The study was limited by its retrospective design (74). The association between hyperkyphosis and fall risk warrants further investigation.

Increased Fractures

Hyperkyphosis is associated with thoracic vertebral fractures (14, 15, 18, 29). Many presume that fractures lead to hyperkyphosis. However, with forward-bent posture, changes in gravitational loads may increase fracture risk through associations with gait instability and falls. In a large prospective study (75), women with worse Debrunner kyphometer–measured kyphosis had more incident vertebral fractures. This effect seemed to be largely accounted for by preexisting prevalent vertebral fracture, a known fracture risk factor (75). In another large prospective study (76), women with self-reported hyperkyphosis had a statistically significantly increased risk for future hip fracture over 3 years (odds ratio, 3.3 [CI, 1.42 to 7.87]; $P = 0.006$). Although investigators adjusted for some po-

Figure 3. **Postulated causes and consequences of hyperkyphosis in older persons.**



tential confounders in a multivariable analysis, they did not control for underlying vertebral fractures (76). In a case–control study, women with a history of wrist fracture had greater thoracic kyphosis than did age-matched control patients with no previous wrist, hip, or spine fractures ($P <$ 0.001) (77). Finally, in a study of 596 older women followed prospectively over 4 years, women with block-defined hyperkyphosis were at a 1.7-fold increased risk for future fracture (CI, 1.0 to 2.97; $P = 0.049$), independent of age, bone mineral density, or previous fracture, compared with those without hyperkyphosis (78). These findings suggest that hyperkyphosis may be associated with increased fracture risk, independent of osteoporosis.

Other Health-Related Consequences

Age-related hyperkyphosis may be associated with other adverse health effects. Two cross-sectional studies of approximately 350 women reported that those with greater kyphosis had increased odds of having pelvic prolapse (79, 80). Case reports have also shown associations between hyperkyphosis and insufficiency fractures of the sternum (81–85) and dysphagia (86).

Impact on Quality of Life

Of studies that reported associations between hyperkyphosis and back pain, all but 1 reported statistically significant positive associations (15, 65, 87–90). Another study examined osteoporosis and quality of life and reported that after adjustment for age, patients with osteoporosis and self-reported postural changes had increased physical difficulty, made more adaptations in their daily life, and had more fears about the future than did those without osteoporosis (91). Demonstrating that the ill effects of hyperkyphosis are not necessarily due to underlying fractures, women with postural changes and no osteoporosis had statistically significantly more physical difficulty and lifestyle adaptations than did those with a previous fracture and no postural changes.

Increased Deaths

Some studies suggest associations between hyperkyphosis and increased risk for death in older men and women (2, 5, 29, 92). One study reported that older women had an age-adjusted, 2.6-fold (CI, 1.3 to 5.1) increased risk for a pulmonary-related death with each 1-SD increase in kyphosis, but only 38% of those in the top quintile of kyphosis who died a pulmonary-related death had vertebral fractures (5). Two recent cohort studies confirm that hyperkyphosis, independent of vertebral fractures and low bone mineral density, is associated with increased risk for death—in particular, with increased risk for pulmonary death (2, 92).

MANAGEMENT OF HYPERKYPHOSIS

Standard therapies for age-related hyperkyphosis do not yet exist. A plain spine radiograph can rule out underlying osteoporotic vertebral fractures. The presence of fractures would justify the use of bisphosphonates or other osteoporosis therapy. Approximately 2 of 3 patients with hyperkyphosis will not have a vertebral fracture. Those without vertebral fractures should undergo bone density testing. Low bone mineral density (T-score <2.5) would justify starting osteoporosis therapy. We do not know whether treating low bone mineral density can improve hyperkyphosis, but analyses of data from a large randomized clinical trial may soon help clarify whether bisphosphonate therapy administration improves kyphosis (93).

Nonsurgical Interventions

One randomized trial tested whether spinal orthosis improves trunk muscle strength, decreases the kyphosis angle, and improves quality of life in women with known vertebral fractures (94). The investigators reported statistically significant improvement in all measured outcomes and an 11% decrease in the kyphosis angle. Major limitations included a small sample size ($n = 62$) and no mention of whether blinded outcome assessments were made. Another study evaluated the effect of back-strengthening exercises on posture in 60 postmenopausal women and reported no overall differences in either back strength or kyphosis between the intervention and control groups. In a post hoc analysis, women with substantial kyphosis and the greatest increases in back-extensor strength demonstrated a 2.8°-decrease in kyphosis angle (95). The exercise intervention was of reasonable duration (2 years), but the study was small, nonblinded measurements were used, and positive findings were observed mostly in post hoc subgroup analyses. A third trial enrolled 12 women with hyperkyphosis (Cobb angle, 50° to 65°; mean age, 77 years) and 13 female control participants (mean age, 71 years). After a 4-week intervention of wearing a spinal-weighted kypho-orthosis and using a specified back extension and gait program, women with hyperkyphosis demonstrated statistically significant improvement in balance and gait variables. However, the control and intervention groups were of disparate ages and kyphosis improvement and control group outcomes were not reported (96).

Two studies investigated whether spinal flexibility exercises reduced hyperkyphosis in older persons (97, 98). A randomized clinical trial of 210 older adults with impaired cardiorespiratory fitness that compared spinal flexibility plus aerobic training versus aerobic training only found no added benefit of the spinal flexibility training on physical functional outcomes or kyphosis angle (97). The other study was of a 3-month yoga intervention in older women with hyperkyphosis ($n = 21$), in which participants demonstrated improved physical function without kyphosis improvement (98). While neither study demonstrated a kyphosis benefit, clinically significant hyperkyphosis probably develops slowly over years. To be successful, an exercise intervention probably requires long-term implementation.

Surgical Interventions

In the setting of painful vertebral fractures, vertebroplasty and kyphoplasty are minimally invasive procedures that are gaining wider acceptance as effective treatments for intractable pain and possibly kyphosis. Several published case series of both procedures and reviews of cases reported reduced pain, improved physical function, vertebral height restoration of up to 90%, and kyphosis angle correction ranging from 8.5° to 14° (99, 100). No published randomized, controlled trials, however, have evaluated or compared benefits and harms of the procedures.

More invasive surgical interventions for hyperkyphosis are associated with high rates of intra- and perioperative complications (33%). As such, they are generally reserved for patients with documented curve progression, intractable pain, or neurologic compromise (101).

Ongoing Research

Most published studies of hyperkyphosis are cross-sectional and include only a few participants, hampering causal inference and generalizability. The eRA (Electronic Research Administration) Commons Web site (http://commons.era.nih.gov) indicates that 2 National Institutes of Health–funded studies on hyperkyphosis are ongoing. One study funded by the National Institutes of Health–National Institute on Aging prospectively follows 1000 women age 65 years or older over 15 years. It aims to document changes in thoracic kyphosis curvature, identify risk factors for worsening kyphosis, and determine the degree of kyphosis that may be associated with adverse outcomes (such as functional dependence) (28). Because the dowager's hump also affects older men, similar studies of older men are needed. The second ongoing National Institutes of Health–funded study is a randomized clinical trial of a yoga intervention to increase spinal flexibility and decrease the kyphosis degree in older adults with hyperkyphosis (102). Results from the ongoing observational studies and intervention trials should soon provide important information on modifiable risk factors for hyperkyphosis.

Conclusion

In the words of Marcel Proust (103): "The real voyage of discovery consists not in seeking new landscapes but in having new eyes." Hyperkyphosis is an easily recognized and commonly observed postural change associated with aging. Yet remarkably, today's physicians have little knowledge about its causes, consequences, or treatment to offer affected patients. Because the existing overall body of pertinent evidence is very limited, we believe that multidisciplinary research involving basic scientists, clinician researchers, and others is urgently needed to better delineate the causes of age-related hyperkyphosis, confirm and expand knowledge about its prognostic implications, and develop effective prevention and treatments.

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Acknowledgments: The authors thank Paul Mischel, MD, and Arun Karlamangla, PhD, MD, for their insightful comments and suggestions, and John Ramirez, BA, for his help in preparing the manuscript for publication.

Grant Support: By the National Institutes of Health and National Institute on Aging (grants RO1 AG24246 and 1K12AG01004).

Potential Financial Conflicts of Interest: *Consultancies:* D.M. Kado (Kyphon).

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