

Yoga for Osteoporosis: Well Woman Yoga review

Osteoporosis is a disease in which bones become less dense, predisposing them to fractures. There are no obvious symptoms of the disease. Often, people are unaware they have it unless they're tested for it, or unfortunately, they find out after they break a bone.

A small study in 2009 by Loren Fishman, MD, found that practicing yoga can actually increase bone density if done consistently and properly. This led to the claim that "yoga builds bones". Yoga also improves balance and flexibility, which can prevent falls and therefore prevent fractures.

The Yoga figuring in the studies documented below consists of selected Asanas. Loren Fishman is the authority on Yoga for Osteoporosis in the US. Recent cautions suggest that adapted yoga practices of the kind that is advocated in Well Woman Yoga can be effective and safer.

Fishman, Loren M. 2009. Yoga for Osteoporosis: A Pilot Study. Topics in Geriatric Rehabilitation: July-September 2009 - Volume 25 - Issue 3 - p 244–250. doi: 10.1097/TGR.0b013e3181b02dd6

See article by Eva Smith 2013 (Appendix)

A key book focused on yoga

Drs. Loren Fishman and Ellen Saltonstall. 2010. Yoga for Osteoporosis: The Complete Guide. W. W. Norton & Company Inc, New York.

Book description: A comprehensive, user-friendly medical yoga program designed for the management and prevention of osteoporosis, with more than four hundred illustrations.

Osteoporosis leads to painful fractures due to loss of bone mass; yoga strengthens bones without endangering joints: it stands to reason that yoga is the perfect therapy for osteoporosis. Forty-four million Americans suffer from low bone mass, and osteoporosis is responsible for more than 1.5 million fractures annually. Drugs and surgeries can alleviate pain, but study after study has shown that exercise is the best treatment, specifically low-impact, bone-strengthening exercises—hence, yoga.

In this comprehensive and thoroughly illustrated guide, Loren Fishman and Ellen Saltonstall, who between them have seven decades of clinical experience, help readers understand osteoporosis and give a spectrum of exercises for beginners and experts. Classical yoga poses, as well as physiologically sound adapted poses, are presented



with easy-to-follow instructions and photographs. The authors welcome readers of all ages and levels of experience into the healing and strengthening practice of yoga. 321 illustrations.

A few facts from the book:

- Bone loss is unavoidable as you get older, but osteoporosis is not. The earlier you start building up your bone mass, the lower your risk!
- Nearly 60% of adults age 50 and older suffer from thinning bones and are at greater risk of fractures and yes, that includes your yoga students!
- One in two women and up to one in four men will break a bone in their lifetime due to osteoporosis.
- For women, the incidence is greater than that of heart attack, stroke and breast cancer combined.
- Preliminary research indicates that yoga can help when taught and practiced the right way

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Yoga: Another way to prevent osteoporosis? A dozen yoga poses, performed daily, may increase bone density

Harvard Women's Health Watch, May 2016

Like most of us, you may have become accustomed to thinking that only common weight-bearing exercises—walking, running, jumping, and lifting—provide enough stress on your bones to maintain or increase their density. So a scientific paper titled "Twelve-Minute Daily Yoga Routine Reverses Osteoporotic Bone Loss" came as a surprise. And it appeared to offer women another option to build bone.

The researchers who designed the study noted that yoga's established benefits—including better balance and coordination—protect against falling, a major cause of osteoporotic fractures. They wanted to determine whether the yoga poses they selected might also increase bone density by imposing force on the spine and hips.

They recruited 741 people who joined the study on the Internet between 2005 and 2015. The participants were asked to submit dual energy x-ray absorptiometry (DEXA) scans of their hips and spines, and other lab tests, at the beginning of the study. They also received DVDs with instructions for the yoga poses and were asked to log their yoga activity online.

The logs indicated that 227 participants, 202 of whom were women, practiced the routine at least every other day for two years. Their average age was 68 when they entered the study, and 83% had lower-than-normal bone density. The DEXA scans they submitted at the end of the study showed significant increases in bone density in the spine. Hip bone density increased, too, but not significantly. None of the participants reported bone fractures or other injuries caused by doing yoga.

What do the results mean?

Though promising, the study, published in 2015 in Topics in Geriatric Rehabilitation, doesn't provide conclusive evidence that yoga can reverse bone loss. The researchers acknowledged its drawbacks: less than one-third of the study's participants adhered to the yoga routine by practicing the poses at least every other day throughout the study, and just 43 submitted complete actual DEXA reports at the beginning and end of the study. "It gives one a reason to be cautiously optimistic, but a more complete study should be done," says Dr. Marian Hannan, professor of medicine at Harvard Medical School, whose research includes the effects of biomechanics on physical function.

Dr. Hannan notes the participants were also self-selected, not randomly enrolled. In other words, they wanted to practice yoga. "Would the results be equally promising in people who were simply assigned to do yoga?" she asks. Yoga is a mind-body activity, and to get the most benefit requires full engagement.

Want to try this yoga routine?

The poses practiced in the study are illustrated below. Each pose should be held for 30 seconds and followed by a 30-second pause.

If you already practice yoga, you may be familiar with these poses. If you haven't done yoga before, but think it's worth giving the routine a try, you should take lessons from a professional yoga instructor to learn beginners' versions of the poses and ensure you are doing them properly to avoid injury. Study participants were advised to seek an instructor of Iyengar yoga, which emphasizes body alignment and breath control.

The DVD used in the study, which also demonstrates adaptations of the poses that are easier for beginners, is available from sciatica.org, a website maintained by Dr. Loren Fishman, the lead investigator of the study.





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A recent caution we need to be aware of:

Risks of strong yoga practice for osteoporosis sufferers and for prevention. A study carried out at the Mayo Clinic, February 2019.

Yoga postures that flex the spine beyond its limits may raise the risk of compression fractures in people with thinning bones, according to research from Mayo Clinic. The results appear in *Mayo Clinic Proceedings*.

Researchers at Mayo Clinic and elsewhere have described injuries from yoga. This study examines injuries in people with osteoporosis and osteopenia -- conditions characterized by low bone density.

Osteoporosis is a disease in which bones become thinner and more porous from loss of mineral content. Bone loss that has not reached the stage of an osteoporosis diagnosis is called osteopenia.

Researchers reviewed the health records of 89 people - mostly women - referred to Mayo Clinic from 2006 to 2018 for pain they attributed to their yoga practice. Some were new to yoga. Others had practiced for years. They had pain in the back, neck, shoulder, hip, knee or a combination.

Patients identified 12 poses they said caused or aggravated their symptoms. The most common postures involved extreme flexing or extending of the spine. Researchers used patients' health records, medical exams and imaging to confirm and categorize the injuries as soft tissue, joint or bone injuries.

Researchers identified 29 bony injuries, including degeneration of disks, slippage of vertebrae and compression fractures. The latter appeared to be related to postures that put extra pressure on the vertebra and disks.

"Yoga has many benefits. It improves balance, flexibility, strength and is a good social activity," says Mehrsheed Sinaki, M.D., a Mayo Clinic physical medicine and rehabilitation specialist and the study's senior author. "But if you have osteoporosis or osteopenia, you should modify the postures to accommodate your condition. As people age, they can benefit by getting a review of their old exercise regimens to prevent unwanted consequences."

Patients who incorporated recommendations to modify their movements reduced their pain and improved their symptoms.

In a separate commentary, Edward Laskowski, M.D., co-chair of Mayo Clinic Sports Medicine, called on providers, patients and yoga teachers to work together to produce an individualized exercise prescription that considers the yoga student's medical history to protect against injury and provide optimal benefit.

The authors noted study limitations. The patients were seen in a musculoskeletal clinic at a tertiary care center, which makes generalizations difficult. Researchers received follow-up reports on 22 patients, as most lived out of state.

Journal Reference:

 Melody Lee, Elizabeth A. Huntoon, Mehrsheed Sinaki. Soft Tissue and Bony Injuries Attributed to the Practice of Yoga: A Biomechanical Analysis and Implications for Management. Mayo Clinic Proceedings, 2019; DOI: 10.1016/j.mayocp.2018.09.024

Mayo Clinic. "People with osteoporosis should avoid spinal poses in yoga, study says." ScienceDaily. ScienceDaily, 21 February 2019. <www.sciencedaily.com/releases/2019/02/190221095111.htm>.





Well Woman Yoga guidelines for practice with women at risk of osteoporosis or affected by this condition

Exercise is an important component of the treatment plan for people with osteoporosis, but certain movements can increase the risk of fracture. Always check with your doctor to make sure it's safe to proceed with exercise. In severe cases of osteoporosis, which are rare, yoga may not be advisable at all.

WellWoman Yoga puts priority on elongating the spine. We follow the view put forward in the Mayo Clinic study that spinal extension exercises are safer than flexion exercises in reducing the risk of fractures in osteoporosis and that strong abdominal curls are to be avoided.

Even though recommending twisting poses for osteoporosis is considered controversial, Well Woman Yoga follows Dr. Fishman's view that in all her research, she has never seen twisting poses cause fractures.

"Twisting poses would be helpful to put some pressure on the spine. The bones respond to the pressure by building more bones. You want to put pressure on the bones, but you don't want to put too much pressure on the vertebrae," says Fishman. Mild twists like the seated twisting poses apply gentle pressure to the bones without harming the vertebrae.

Well Woman Yoga introduces innovative uses of yoga to prevent and alleviate osteoporosis:

- the use of safe props (chairs against wall, bolsters)
- rhythmic dynamic adaptations of Asanas for spinal extension, with full breath cycles
- the Birthlight original practices of isometric and isotonic practices (with and without rebozos, individually or in pairs or circles)
- the use of sound

Do's

- Use Well Woman Progressions. Start slowly and gradually increase difficulty and duration of poses as you build strength and endurance.
- Implement poses that improve leg strength such as mountain pose, chair pose, and Warrior II. Always keep your spine in a neutral position when performing these poses.
- Practice poses that strengthen your back, usually involving some gentle back bending. These poses include sphinx, baby cobra, and bridge.
- Include poses that encourage weight bearing by your hands. Examples of these include tabletop back and adapted downward-facing dog using a chair or window sill.
- Practice poses that improve balance, such as tree pose. Use Birthlight Yoga Walk variations of yoga balances.
- Always move in and out of poses slowly. Use Birthlight transitions to move from standing to all fours, sitting, lying down and back up.
- Always focus on your breathing, enjoying the feeling of calm strength that comes with doing yoga.
- Be clear about your limitations and never force any movement or posture, always stop before your full range of motion.
- Gentle supported backbends in restorative yoga are beneficial.

Don'ts

- All poses that require spinal flexion. This means poses that cause the back to round. This position places forces on the spine that can lead to compression fractures. In general, full-forward bending should be avoided.
- Sit-ups and crunches also place a great deal of stress on the spine. These should be avoided. Abdominal and core strengthening can be accomplished safely in other poses.
- Poses that place all of the weight on the hands, such as a handstand, can put the student at an increased risk of a wrist fracture.
- Full backbends.
- Extreme twists.
- Unsupported inversions.

Yoga, Vertebral Fractures, and Osteoporosis: Research and Recommendations

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Abstract

ARTICLE

Background: Osteoporosis is characterized by decreased bone density that leaves bones fragile and highly susceptible to fracture. Globally, 1 in 3 women and 1 in 5 men older than 50 will suffer from an osteoporotic fracture, and those individuals will experience a considerably higher risk of postfracture mortality than will the general population. Gentle, weight-bearing exercises such as yoga can help prevent or cease the progression of osteoporosis, however, there is insufficient data regarding which yoga poses present the least risk and are most beneficial to individuals with reduced bone density. Objectives: Review the extant literature about the risks and benefits to the spine of particular forms of movement and consider recommendations relative to the practice of yoga. Methods: A review of the PubMed, Medline, and Cochrane databases was conducted that identified manuscripts published between 1966 and 2011 about topics related to osteoporosis and spinal movement. Conclusions: Movements involving spinal flexion can increase risk for vertebral compression fractures; however, a combination of mild spinal flexion and extension may prove beneficial. Moderate, weight-bearing activities that strengthen the muscles supporting the spinal column, promote balance, improve posture, and enhance quality of life appear to be of greatest benefit. Ample evidence supports the importance of varied spinal movement for preserving the health and strength of the vertebral bodies. Exercise modifications suitable for high-risk individuals may be counterproductive for those at low risk for vertebral fractures. Yoga therapists are cautioned to not apply a one-size-fits-all approach when working with this population. Well-designed empirical studies are needed to further our understanding of which yoga poses present the least risk and are of greatest benefit to individuals with osteoporosis.

Key Words: yoga, osteoporosis, yoga therapy, vertebral fractures, safe movements for the spine, yoga and osteoporosis

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Osteoporosis is characterized by excessive loss of bone protein and mineral content, particularly calcium, that leads to decrements in bone mass and strength. As bones weaken the y become fragile, brittle, and highly susceptible to fracture. In the case of severe osteoporosis, the event precipitating a fracture is often unknown (National Osteoporosis Foundation, 2008).

Osteoporosis represents a considerable public health problem, with 44 million people in the United States being at risk for developing the disease. Globally, 1 in 3 women and 1 in 5 men older than age 50 will eventually experience an osteoporotic fracture. The risk of fracture increases with age, with 3 of 4 fractures of the hip, spine, or wrist occurring in people age 65 and older (International Osteoporosis Foundation). In the United States, 50% of the 1.35 million fractures reported annually are vertebral compression fractures (Longo, Loppini, De naro, Maffulli, & Denaro, 2011). Osteoporotic fractures of the hip and spine have been linked to higher mortality rates, but it remains unclear whether this is an independent effect or a function of comorbid illness and poor health status commonly found in elderly persons with osteoporosis (Teng, Curtis, & Saag, 2008).

Osteoporotic fractures of the hip and wrist are most commonly precipitated by trauma, such as a fall (Nguyen, Pongchaiyakul, Center, Eisman, & Nguyen, 2005). In contrast, the vertebral bodies of individuals with osteoporosis are very fragile, such that even a nontraumatic event, such as a sneeze, can result in a vertebral compression or wedge fracture. The risk of fracture is even greater for those who have incurred previous vertebral fractures (Briggs, Greig, & Wark, 2007).

Gentle, weight-bearing exercise can help prevent or cease the progression of osteoporosis (Sinaki, Fitzpatrick, Ritchie, Montesano, & Wahner, 1998). Weight-bearing and strengthbuilding activities stimulate new bone growth and help improve posture, balance, and range of motion. There is considerable controversy as to which exercises are beneficial and which constitute a risk for injury, however. Individuals with osteoporosis are often instructed to avoid flexion or twisting of the spine during exercise, and even in activities of daily living. Because spinal flexion and twisting commonly occur in yoga classes, there is a pressing need for yoga therapists and yoga teachers to understand which types of movements are safe for people with osteoporosis and osteopenia and to communicate this knowledge to their students.

The goals of this literature review were to (a) review the literature about the risks and benefits to the spine of particular forms of movement, (b) examine the importance of spinal movement for health, and (c) present an overview of recommendations for exercises targeting spinal movement for individuals with osteoporosis and osteopenia.

Literature Review

Spinal Movement, Posture, and Risk for Vertebral Fracture

We used the PubMed, Medline, and Cochrane databases to conduct a comprehensive search for pertinent manuscripts published between 1966 and 2011. Publications in which various combinations of the key words osteoporosis, vertebral compression fractures, axial rotation, flexion, twisting, torque, extension, back extensors, vertebral loading, trabecular bone, www.IAYT.org *exercise*, and *rehabilitation* were considered. All relevant articles we re examined and their bibliographies were searched for additional references.

This investigation revealed that the majority of osteoporos is research has focused on drug interventions intended to reverse or prevent the loss of bone mass. Surgical interventions, such as kyphoplasty and verte plasty, which are often used to treat pain resulting from vertebral compression fractures, have also been widely studied. In addition, the role of exercise relative to buildingbone mass or preventing bone loss has received attention.

Relative to the overall literature, very little research has been conducted to examine the effectiveness of physical rehabilitation measures designed specifically to prevent spinal fractures for individuals with osteoporosis. The majority of proposed exercise strategies have been designed to elicit a sufficient weight-bearing load on the bones to stimulate growth without creating excessive strain or risk for fracture (Sinaki, 2007). Although physical activity is recognized as central to maintaining musculoskeletal health, strong bones, and balance among those with osteoporosis, a great deal remains to be learned about which types of spinal movement constitute a risk for fracture and which provide the greatest benefit (Pratelli, Cinotti, & Pasquetti, 2010).

In this review of the literature we report what is known regarding the safety of various types of spinal movements (i.e., flexion, extension, axial rotation, lateral side bending) for individuals with osteoporosis.

Spinal flexion. Before the mid-1980s, spinal flexion exercises were often recommended to alleviate back pain related to vertebral fractures (Sinaki, 2007). Flexion of the spine was thought to be useful to relieve contractions of the paraspinal muscles that surround the vertebral bodies. This belief was challenged by a study that demonstrated that flexion exercises (e.g., forward bending with a rounded spine, abdominal crunches from a supine position) were associated with an increased incidence of vertebral fractures (Sinaki & Mikkelsen, 1984). In the study, 59 women age 49 to 60 years with osteoporosis of the spine and back pain were divided into four groups. The first group performed spinal extension exercises, the second engaged in spinal flexion exercises, the third conducted a combination of spinal extension and flexion exercises, and the fourth was a no-exercise group who received heat and massage. Comparison of pre- and postexercise radiographs revealed a statistically significant between-groups difference in the number of spinal fractures. In the flexion-only group, 89% of participants incurred new fractures, compared with 67% of participants in the no-exercise group, 53% in the combined extension and flexion group, and 16% in the extension-only group (Sinaki & Mikkelsen, 1984). These findings suggest that an exercise regimen characterized exclusively by flexion exercises increases the risk for development of spinal fractures for women with osteoporosis.

The morphology of vertebrae helps explain this finding. Spinal flexion increases anterior vertebral compression; studies have shown that the anterior structure of a vertebra is weak relative to the overall vertebral body, making it vulnerable to compression fractures (Papadakis, Sapkas, Papadopoulos, & Katonis, 2011). Spinal flexion also leads to increased pressure in the vertebral discs, which can be translated to the anterior portion of the vertebral bodies, thus increasing the risk of wedging and fracture in people with osteoporosis (Sinaki, 2007). These biomechanical properties of the vertebrae may cause movements that involve spinal flexion to increase the risk of vertebral fractures (Duan, Seeman, & Turner, 2001).

There is some evidence that older adults with reduced bone density may be vulnerable to spinal fracture during yoga poses that involve spinal flexion. In a recent case study, 3 healthy individuals age 61, 70, and 87 with reduced bone mass who reported yoga-induced pain or vertebral compression fractures were assessed. All practiced *Halasana* (plow pose), during which the weight of the lower extremities and pelvis was distributed toward a flexed thoracic spine and neck. The author concluded that reduced bone mineral density could account for less than 50% of fracture risk, with the remaining risk being associated with posture, degenerative changes of the spine, torque of the spine, muscle weakness, and falls (Sinaki, 2012).

Spinal extension. Spine extensor muscle strength is important for retaining healthy posture and normal spinal curves (Si naki, Itoi, Rogers, Bergstralh, & Wahner, 1996). Strong back extensor muscles provide extrinsic support for the spine, and there is evidence that strengthening the back extensors may decrease the long-term risk of vertebral fractures (Sinaki et al., 2002). Excessive thoracic kyphosis may also be linked to weakening of spinal extensor muscles (Mika, Unnithan, & Mika, 2005). Several studies provide evidence that strengthening the spinal extensor muscles is associated with decreased thoracic kyphosis, which can be an independent risk factor for fractures (Itoi & Sinaki, 1994; Sinaki et al., 2002).

Spi nal extensor muscles tend to be compromised in women with osteoporosis, suggesting that weakness of back extensors may precede and/or contribute to compression fractures of the spine (Sinaki, Khosla, Limburg, Rogers, & Murtaugh, 1993). Strong spinal extensor muscles have been shown to be a significant contributor to spinal range of motion (Miyakoshi et al., 2005). Low-intensity, back-strengthening exercises are associated with reported quality of life improvement for people with osteoporosis (Hongo et al., 2005), with higher quality of life being related to stronger spinal extensor muscles and inceased range of motion.

Most important, strengthening the back extensors may provide long-term protection against vertebral fractures, independent of bone mineral density. Sinaki et al. (2002) examined the effects of a back-strengthening program on bone mineral density for a group of healthy, Caucasian, postmenopausal women. Although no significant differences in bone mineral density were detected for those who exercised and those who did not during the initial 2-year study, data obtained during an 8-year follow-up, when the women were between ages 58 and 75, revealed that those in the back-strengthening group had fewer fractures than did those in the control group (Sinaki, 2007). At the 8-year mark, individuals in the no-exercise control group evidenced 3 times the rate of vertebral compression fractures than did those in the exercise group. As a result, investigators posited that bone mineral density might not be the only predictor of vertebral fractures, and that the strength of the muscles supporting the spine may be another significant contributing factor.

Rotation and lateral side bending. Very little data exist about specific types of exercise that might be most beneficial for individuals with compromised bone density (Pratelli et al., 2010). This lack of empirical evidence is most pronounced with regard to effects and safety of axial rotation and lateral flexion of the spine.

Studies designed to assess the effects of axial rotation on intervertebral discs have linked axial rotation to an increased risk of low back strain or intervertebral disc injury, particularly when combined with flexion and weight bearing, for example while bending over and lifting combined with spinal rotation (Kumar, 2004; Kumar & Narayan, 2006).

Professionals in the yoga or fitness community who work with individuals with osteoporosis often strongly advise against axial rotation, even to the point of avoiding it in daily activities (Hathaway, 2012; Meeks, 2012). However, although axial rotation has been shown to increase the risk of low back strain or intervertebral disc injury, there is no empirical evidence of a link between axial rotation performed during exercise and the risk for vertebral fractures. Tangentially, one case study found a potential link between the sudden twist of a golf swing and fracture risk (Ekin & Sinaki, 1993), but the biomechanics of golfing are vastly different than those used in yoga or other exercises involving axial rotation.

Researchers conducting an ongoing study of the effects of yoga practice for individuals with osteoporosis are examining weight-bearing yoga postures that involve axial rotation. The sample includes more than 500 registered participants with more than 30,000 cumulative practice hours. To date, no vertebral fractures resulting from the yoga practice have been reported (Fishman, 2012).

Postural alignment as an independent risk factor for spinal fracture. It is important to examine the safety of spinal movements relative to postural alignment. Postural misalignment can independently exacerbate spinal flexion and increase the risk for vertebral compression fractures (Keller, Harrison, Colloca, Harrison, & Janik, 2003).

Many individuals with osteoporosis exhibit increased thoracic kyphosis, or hyperkyphosis. This pronounced flexion of the thoracic spine increases the vertebral compression load and the risk for compression fractures (Pfeifer et al., 2004). As the degree of kyphosis increases, the compressive stress on the anterior portion of the vertebrae is magnified. Kyphosis of 41.7 degrees is associated with a 19% increase in compressive force and a 40% increase in spinal extensor force at T7/T8 (Papadakis et al., 2011). Hyperkyphosis was previously thought to be caused by osteoporotic vertebral fractures; however, it is also prevalent in people without vertebral fractures, and the condition is also frequently associated with degenerative disc disease and muscle weakness (Schneider, von Muhlen, Barrett-Connor, & Sartoris, 2004).

Hyperkyphosis is an independent risk factor for vertebral and hip fractures, particularly for elderly women (Katzman, Wanek, Shepherd, & Sellmeyer, 2010). It is also associated with reduced breath capacity and increased mortality. There is good evidence that hyperkyphosis and activities involving spinal flexion are associated with an increased risk for vertebral fractures, irre spective of bone loss (Campbell, Robertson, Gard ner, Norton, & Buchner, 1999). In individuals with hyperkyphosis, exercises involving flexion are likely to further intensify the anterior compression of thoracic vertebrae, yielding an elevated risk for fractures. As such, postural forces can predispose an individual to vertebral fractures when the anterior translation of the upper part of the spine increases the compressive load.

Movement and Spine Health

There is general consensus that frequent, gentle to moderate weight-bearing activity offers the greatest benefit to individuals with bone loss (Chan, Anderson, & Lau, 2003). Some have recommended gentle spinal rotation as an important contributor to spine health (Fishman & Saltonstall, 2012). The literature reviewed in the following sections provides evidence that varied movements of the spine are critical to maintaining overall spine health and to reducing vertebral fractures.

Activity, bone loss, and regeneration. Bones conform to the environmental conditions placed upon them. Osteoblasts lay down new bone material, and osteoclasts reabsorb unhealthy tissue (Turner, 1999; Turner & Pavalko, 1998). Bone strength is linked to bone mass and to the internal structure of trabecular bone. Trabecular bone constitutes the major portion of the bone and is the inner part that surrounds marrow spaces (Kreider & Goldstein, 2009). The structure of trabecular bone is influenced by mechanical stress and is sensitive to the nature and quality of the forces placed upon it (Barak, Lieberman, & Hublin, 2011). It is quite porous, not as strong as cortical bone, and more susceptible to the effects of osteoporosis.

Osteogenic loading refers to the use of impact force to stimulate the development of bone tissue and muscle fiber. It is highly site specific. In one study of the effects of osteogenic loading, participants performed weight-lifting exercises on one side of the body. An increase of 3% to 4% in bone mass of the wrist and hip was found on the weight-lifting side after 12 months, compared with the no-exercise side (Kerr, Morton, Dick, & Prince, 1996). Site-specific effects of osteogenic loading on the spine have also been found. Increased lumbar trabecular bone mineral density was detected for individuals participating in a 1-year training program for the psoas muscles, compared with those performing exercises that targeted the deltoids only (Revel, Mayoux-Benhamou, Rabourdin, Bagheri, & Roux, 1993). These results suggest that exercises intended to strengthen muscles that support the spine may be useful to prevent or ameliorate the effects of vertebral bone loss.

Wolff's Law posits that the internal structure of bone adapts commensurate with the form and function of each of the stressors placed upon it (Frost, 1994). There is evidence that bone is anisotropic, meaning that its physical strength varies along different axes. Increased physical activity places a mechanical load on bones, which stimulates bone tissue formation. Conversely, inactivity is associated with bone loss (Frost 1997; Takata & Yasui, 2001). The microarchitecture of the trabecular bone within the vertebrae is constantly remodeling based on the demands placed upon it. This remodeling enables bones to optimally withstand loads associated with habitual use (Homminga et al., 2004).

According to the Utah Paradigm of Skeletal Physiology (Jee, 2000), inactivity leads to reduced bone mass and bone strength. In the absence of sufficient use, bone remodeling turns off and disuse-mode remodeling turns on (Frost, 1997). Immobility has been linked to local bone loss (Alexandre & Vico, 2011; Saltzstein, Hardin, & Hastings, 1992), which is evidenced dramatically in astronauts, for example, who demonstrate bone loss during long-duration spaceflights. The majority of astronaut bone loss occurs in heavy load-bearing areas, such as the hip and spine, which are exposed to the greatest mechanical stress under the earth's gravity (Lang et al., 2004; Zhao et al., 2010).

Muscle strength is also a protective factor against fracture, with muscle contraction relieving some of the strain of overloading, thus protecting bone from fracture (Burr, 2011). Studies have found site-specific positive exercise effects in bone mass density from weighted exercise (Zehnacker & Bemis-Dougherty, 2007), suggesting that weak or atrophied muscles around the spine might leave the vertebrae more vulnerable. Similarly, low-back extensor strength has been shown to have an inverse relationship with high bone mass density (Briggs, Greig, Wark, Fazzalari, & Bennell, 2004). A German study of 237 postmenopausal women with osteoporosis found significant associations between trunk muscle strength and reductions in the Spine Deformity Index, which is a measure of the number and severity of vertebral fractures (Pfeifer et al., 2001).

In short, there is considerable evidence that load-bearing activities are essential for bone and spine health. Inactivity and limited spinal movement are likely to weaken the internal trabecular structure of the vertebrae and result in greater risk for vertebral fractures. Immobility has been linked to localized bone loss, and lack of trunk muscle strength has been linked to an increased number of vertebral fractures.

The site-specific nature of bone regeneration, along with the anisotropic properties of the vertebrae, suggest that limiting the normal repertoire of spinal movement might weaken the capacity of vertebrae to withstand movement and make them more susceptible to fracture.

Movement and intervertebral disc health. Preserving the health of the intervertebral discs is critical to avoiding common age-related impairments (Buckwalter, 1995). The loss of integrity of the intervertebral discs can potentially contribute to vertebral fracture risk by causing abnormal load distributions in adjoining vertebrae (Briggs et al., 2004).

As with the bony vertebrae, the intervertebral discs require motion for optimal health. These discs are the largest avascular structures in the body, meaning that nutrients and waste products are exchanged through diffusion from the vertebrae rather than blood exchange (An, Masuda, & Inoue, 2006). This process is facilitated during sitting or standing load-bearing activities, during which fluid and molecules are transferred from the discs into the vertebrae. Fluid and molecules flow back into the discs in supine positions. Changes in pressure that occur between lying down, standing up, and sitting create a dynamic exchange between the vertebral discs and vertebrae.

Discs require varied movement and dynamic loading of the spine for optimal health. There is evidence that vertebral loading that occurs during activity may improve disc metabolism (Chan, Ferguson, & Gantebein-Ritter, 2011). Although in vivo measurement of disc pressure is difficult, preliminary experiments indicate that muscle activity increases disc pressure, and that frequently changing bodily positions promotes the flow of fluids to and from discs. In the absence of sufficient pressure or movement, the nucleus pulposus, or center of the vertebral disc, loses valuable proteins (Chan et al., 2011). As with bones, intervertebral discs benefit the most from dynamic, moderate, weight-bearing exercise.

Trunk flexibility. Most fractures are the result of falls (Bell, Talbot-Stern, & Hennessy, 2000). There is a higher correlation between falls and fractures than between low bone density and fractures, suggesting that the relationship between osteoporosis and fractures is complex (Jarvinen, Sievanen, Khan, Heinonen, & Kannus, 2008). Stiffness of the trunk is asso ciated with reduced postural control, reduced balance, and increased risk for falls (Reeves, Everding, Cholewicki, & Morrisette, 2006). In addition, the combined inflexibility of hip and trunk muscles is related to loss of balance (Gruneberg, Bloem, Honegger, & Allum, 2004).

One factor influencing loss of trunk mobility is lack of movement, suggesting that activities that benefit hip and trunk flexibility may improve postural control and balance.

Summary

Spinal mobility is a significant factor in maintaining the health of the spine's components, including the vertebrae, muscles, discs, and joints. Spinal articulation is central to reducing the risk of fractures, and movement of the spine is necessary for keeping the trunk muscles strong and flexible to maintain balance and diminish the risk of falls. Movement of the spine is also important for maintaining functional health, range of motion, and the ability to perform activities of daily living.

Recommendations for Spinal Movements in Current Therapeutic Practice

The Canadian Medical Association's clinical practice guidelines for people with osteoporosis include resistance training and/or weight-bearing aerobic exercises, movement to enhance core stability to counteract the effects of postural abnormalities or weakness, and exercises that focus on balance control or balance and gait training (Papaioannou et al., 2010). These recommendations were based partly on a study of physiotherapistsupervised group exercises that included regular stretching of the hip flexors, hip extensors, lumbar extensors, and the vertebral column, along with strength, posture, and balance exercises (Angin & Erden, 2009). In this study, 43.8% of the women who had osteoporosis-level bone density at the beginning of the program had increased bone density to osteopenia levels by the end of the 21-week program. Although exercise must be modified for those with osteoporosis, results of this study suggest clear benefits of regular movements that emphasize spinal strength, flexibility, posture, and balance.

On the basis of the literature reviewed, we recommend specific approaches to exercises and modifications for individuals with osteopenia or osteoporosis. They are described in the following paragraphs.

There is sufficient evidence to support the contention that yoga teachers and therapists must exercise caution when working with individuals with reduced bone density. Movements emphasizing flexion of the thoracic spine are contraindicated for people with osteoporosis (Chan et al., 2003; Papaioannou et al., 2010; Sinaki, 2012; Sinaki & Mikkelsen, 1984). This is particularly the case for individuals with hyperkyphosis.

Although there are risk factors associated with spinal flexion in standing or seated forward-bending yoga poses, the risk can be minimized if flexion occurs at the hip joint with the spine kept straight. One yoga intervention designed for individuals with osteoporosis and osteopenia provides excellent examples of modified postures in which flexion occurs at the hip rather than the spine, reducing the potential for vertebral compression fractures (Fishman & Saltonstall, 2012). Because many individuals do not have the body awareness needed to distinguish between forward flexion from the hip versus from the spine, great care should also be taken to first teach awareness of the difference between these two movements when working with at-risk individuals.

It is important to consider that individuals with a severe hyperkyphotic posture are in permanent spinal flexion. Instructions to bend forward from the hip instead of the spine will not afford the necessary protection for these individuals. At the same time, postures using hip flexion that stretch the hamstrings are an important component of preventing hyperkyphosis and other postural imbalances, because tight hip extensors distort the alignment of the pelvis, which often results in a compensatory increase in kyphosis (Benedetti, Berti, Presti, Frizziero, & Giannini, 2008). The focus should be on supine poses involving hip flexion, which can better isolate hip flexors (Shipp, 2012).

Exercise programs that combine spinal flexion and extension have been shown to be beneficial to individuals with o steoporosis (Si naki & Mikkelsen, 1984). This suggests that the relationship between movement involving spinal flexion and fracture risk is complex, and that more research is needed to fully understand the unique and conjunct risks and benefits of these movements. The literature suggests that people with o steoporosis can benefit from streng thening spinal extensor muscles, which may also prevent hyperkyphosis and its concomitant risk of vertebral compression fractures. Gentle prone or standing yoga postures involving spinal extension can offer a beneficial weight-bearing challenge for individuals with o steoporosis and hyperkyphosis. The literature does not provide sufficient or conclusive evidence regarding the risks and benefits of spinal movement involving rotation relative to the risk of vertebral fracture for individuals with osteoporosis or osteopenia. This suggests that the most prudent approach for yoga teachers, therapists, and practitioners is to exercise a considerable degree of caution. Concurrently, it is important to consider extant findings that inactivity and lack of movement of the spine can contribute to the risk of fracture vis-a-vis muscle weakness, lack of spinal mobility, and compromised balance. The absence of loading of the spine in certain directions may further weaken the internal structure of the vertebral bodies and compromise their strength. As such, varied spinal movement appears to be essential for spine health and maintenance of the vertebral strength.

Based on this understanding, it is important to consider that some form of spinal movement is needed to retain vertebral strength, trunk flexibility, spinal range of motion, and the strength of the muscles supporting the vertebrae. People with lower degrees of fracture risk may be adversely served by recommendations to avoid movement of the spine (including axial rotation) that are a part of of daily living (Shipp, 2012).

Conclusions

Shipp (2012) suggests the following criteria to identify individuals with higher risk of vertebral fractures. First, individuals with osteoporosis who have lost more than 1.5 inches in height are likely to have prevalent vertebral fractures, which in turn will put them at much greater risk for subsequent fractures. Second, as noted earlier, those with marked hyperkyphosis who are unable to perform flexion poses with a straight spine should be considered at high risk for vertebral fractures. Supine, nonweight-bearing movements of the spine are the best course of action for these individuals.

There is no one-size-fits-all approach when working with individuals with osteopenia or osteoporosis. Individuals with low risk for spinal fractures, such as those with osteopenia or without a history of vertebral fractures, might be ill served by eliminating yoga postures necessary to maintain the health and strength of the vertebral bodies. At the same time, extreme care should be taken when working with individuals who are at high risk for fractures.

Although preliminary studies have shown yoga to improve balance for older adults (Schmid, van Puymbroeck, & Koceja, 2010) and for postmenopausal women with osteoporosis (Tuzun, Aktas, Akarirmak, Sipahi, & Tuzun, 2010), welldesigned empirical studies are needed to further our understanding of which yoga poses present the least risk and are of greatest benefit to individuals with osteopenia and osteoporosis. In lieu of these data, moderate weight-bearing activities that strengthen the muscles supporting the spinal column, that improve posture, promote balance, and enhance quality of life are likely to be of greatest benefit.

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