**Osteoporosis and Falls in the Senior Population**

*Osteoporosis* is a disease that weakens bones to the point where they break easily — most often, bones in the hip, backbone (spine), and wrist. Osteoporosis is called a “silent disease” because you may not notice any changes until a bone breaks. All the while, though, your bones had been losing strength for many years. Older woman doing resistance exercises

Bone is living tissue. To keep bones strong, your body breaks down old bone and replaces it with new bone tissue. Sometime around age 30, bone mass stops increasing, and the goal for bone health is to keep as much bone as possible for as long as you can. As people enter their 40s and 50s, more bone may be broken down than is replaced.

A close look at the inside of bone shows something like a honeycomb. When you have osteoporosis, the spaces in this honeycomb grow larger, and the bone that forms the honeycomb gets smaller. The outer shell of your bones also gets thinner. All of this makes your bones weaker.

**Who has osteoporosis?**

*Risk factors and causes*

Although osteoporosis can strike at any age, it is most common among older people, especially older women. Men also have this disease. White and Asian women are most likely to have osteoporosis. Other women at great risk include those who:

Have a family history of broken bones or osteoporosis

Have broken a bone after age 50

Had surgery to remove their ovaries before their periods stopped *(Hysterectomies)*

Had early menopause

Have not gotten enough calcium and/or vitamin D throughout their lives

Had extended bed rest or were physically inactive

Smoke (smokers may absorb less calcium from their diets)

Take certain medications, including medicines for arthritis and asthma and some cancer drugs

Used certain medicines for a long time

Have a small body frame

The risk of osteoporosis grows as you get older. At the time of menopause, women may lose bone quickly for several years. After that, the loss slows down but does continue. In men, the loss of bone mass is slower. But, by age 65 or 70, men and women are losing bone at the same rate.

**What is osteopenia?**

Whether your doctor calls it osteopenia or low bone mass, consider it a warning. Bone loss has started, but you can still take action to keep your bones strong and maybe prevent osteoporosis later in life. That way you will be less likely to break a wrist, hip, or vertebrae (bone in your spine) when you are older.

Can my bones be tested?

For some people, the first sign of osteoporosis is to realize they are getting shorter or to break a bone easily. Don’t wait until that happens to see if you have osteoporosis. You can have a bone density test to find out how strong your bones are.

The U.S. Preventive Services Task Force recommends that women aged 65 and older be screened (tested) for osteoporosis, as well as women under age 65 who are at increased risk for an osteoporosis-related fracture.

A bone mineral density test compares your bone density to the bones of an average healthy young adult. The test result, known as a T-score, tells you how strong your bones are, whether you have osteoporosis or osteopenia, and your risk for having a fracture. ***(Dexa scans give you T-scores)***

**How can I keep my bones strong?**

*Preventing osteoporosis*

There are things you should do at any age to prevent weakened bones. Eating foods that are rich in calcium and vitamin D is important. So is regular weight-bearing exercise, such as weight training, walking, hiking, jogging, climbing stairs, tennis, and dancing.

If you have osteoporosis, avoid activities that involve twisting your spine or bending forward from the waist, such as conventional sit-ups, toe touches, or swinging a golf club.

Those are the best ways to keep your bones strong and healthy. Learn more about keeping your bones strong to prevent falls.

**What can I do for my osteoporosis?**

Treating osteoporosis means stopping the bone loss and rebuilding bone to prevent breaks. Healthy lifestyle choices such as proper diet, exercise, and medications can help prevent further bone loss and reduce the risk of fractures.

But, lifestyle changes may not be enough if you have lost a lot of bone density. There are also several medicines to think about. Some will slow your bone loss, and others can help rebuild bone. Talk with your doctor to see if medicines might work to treat your osteoporosis.

In addition, you'll want to learn how to fall-proof your home and change your lifestyle to avoid fracturing fragile bones.

**Can I avoid falling?**

Six Tips To Help Prevent Falls infographic. Click link in caption to see full transcript.

Read and share this infographic and help spread the word about how to help prevent falls.

When your bones are weak, a simple fall can cause a broken bone. This can mean a trip to the hospital and maybe surgery. It might also mean being laid up for a long time, especially in the case of a hip fracture. So, it is important to prevent falls. Learn how to prevent falls.

**Do men have osteoporosis?**

Osteoporosis is not just a woman’s disease. Not as many men have it as women do, maybe because most men start with more bone density. As they age, men lose bone density more slowly than women. But, men need to be aware of osteoporosis.

Experts don’t know as much about this disease in men as they do in women. However, many of the things that put men at risk are the same as those for women, including family history, not enough calcium or vitamin D, and too little exercise. Low levels of testosterone, too much alcohol, taking certain drugs, and smoking are other risk factors.

Older men who break a bone easily or are at risk for osteoporosis should talk with their doctors about testing and treatment.

For more information about osteoporosis, visit the National Institute of Arthritis and Musculoskeletal and Skin Diseases.

SOURCE: National Institute on Aging (<https://www.nia.nih.gov/health/osteoporosis>)

**Fall-related risk factors and osteoporosis in older women referred to an open access bone densitometry service**

**Abstract**

**Objective:**

Both falls and low bone density are important in the pathogenesis of osteoporotic fractures. Whilst bone density is routinely measured to assess fracture risk, little attention is given to the assessment of fall risk. In this study we have determined the prevalence and explored relationships between fall-related risk factors and osteoporosis in women referred to our open access bone densitometry service.

*Setting:* Teaching hospital in south-west London, UK.

*Subjects:* Older women referred for open access bone densitometry.

*Measurements:* Bone densitometry by dual-energy X-ray absorptiometry and fall risk assessment (visual acuity, ability to do five stand-ups without arm use and ability to perform heel-toe walking).

*Results:* Data for 558 women seen over an 18-month period were examined. Their mean age was 74.8 years (range 65-93). Fall risk and femoral neck (FN) osteoporosis increased with age, with fall-related risk factors being more prevalent than FN osteoporosis at each tertial of age. Women with both FN osteoporosis and fall-related risk factors ranged from 7% in the youngest tertial to 22% in the oldest tertial. In women with FN osteoporosis, increased fall risk was found in 37% in the youngest tertial, increasing to 63% in the oldest tertial.

*Conclusions:* Fall-related risk factors are common in older women referred for open access bone densitometry. We recommend that both bone density and fall risk assessment, using simple screening tests for falls, are essential to determine fracture risk in older people referred for bone densitometry. Subsequent management to reduce fracture risk should be individualized for each patient.

SOURCE: National Library of Medicine (<https://pubmed.ncbi.nlm.nih.gov/15545286/>)

**Why older people get osteoporosis and have falls**

As the world’s population lives longer, the significance of osteoporosis and fractures increases.

In Australia, it is estimated that 4.74 million Australians aged over 50 have osteoporosis, osteopenia (less severe than osteoporosis) or poor bone health. By 2022, it’s estimated this will increase to 6.2 million, with one fracture occurring every 2.9 minutes.

In 2012, the total cost of poor bone health in adults aged over 50 was A$2.75 billion, and 64% of this cost was directly associated with treating and managing fractures.

How The Conversation is different: All our authors are experts.

What is osteoporosis?

Osteoporosis is a condition in which bones become fragile and brittle, leading to higher risk of breakage. This occurs when bones lose minerals such as calcium more quickly than the body can replace them.

In Australia, osteoporosis affects one in three women and one in five men over the age of 50.

Referred to as a “silent” disease, osteoporosis generally has no symptoms and is rarely diagnosed until bones break or fracture. Osteoporosis is the disease and fractures are the outcome we are trying to prevent.

Why do we get osteoporosis as we age?

Our bones are living tissue and are in a continual state of renewal. As we age, more bone is broken down (resorbed) than is replaced by new bone. Thus, our bones get thinner and more fragile as we age. This is particularly true during menopause for women and in men with lower levels of sex steroid hormones such as testosterone.

“Primary osteoporosis” is bone loss that can be attributed to ageing or the known hormonal consequences of ageing, such as the decline in oestrogen and testosterone. These hormones help regulate bone renewal that occurs naturally as we age.

As the level of these hormones decline from about the age of 50 in women and around 60 in men, the rate of bone breakdown is faster than the growth of new bone to replace it. Over time this leads to weaker, thinner bones. In women, the risk abruptly increases from the time of menopause, coinciding with a significant drop in circulating levels of oestrogen.

“Secondary osteoporosis” occurs as a consequence of another disease (such as coeliac disease with associated calcium malabsorption), or as an adverse consequence of therapy for another disease where medication might bring it on.

Thin bones of a poorer quality structure are more likely to break. The vast majority of fractures occur as a result of a fall from standing height. Vertebral or spinal fractures are the exception, frequently occurring without a fall or significant “trigger event”.

**Osteoporosis in Aging**

*Protect Your Bones with Exercise*

Bones feel solid, but the inside of a bone is actually filled with holes like a honeycomb. Bone tissues are broken down and rebuilt all the time. While some cells build new bone tissue, others dissolve bone and release the minerals inside.

As we get older, we begin to lose more bone than we build. The tiny holes within bones get bigger, and the solid outer layer becomes thinner. In other words, our bones get less dense. Hard bones turn spongy, and spongy bones turn spongier. If this loss of bone density goes too far, it’s called osteoporosis. Over 10 million people nationwide are estimated to have osteoporosis.

It’s normal for bones to break in bad accidents. But if your bones are dense enough, they should be able to stand up to most falls. Bones weakened by osteoporosis, though, are more likely to break.

“It’s just like any other engineering material,” says Dr. Joan McGowan, an NIH expert on osteoporosis. If you fall and slam your weight onto a fragile bone, “it reaches a point where the structures aren’t adequate to support the weight you’re putting on them.” If the bone breaks, it’s a major hint that an older person has osteoporosis.

Broken bones can lead to serious problems for seniors. The hip is a common site for osteoporosis, and hip fractures can lead to a downward spiral of disability and loss of independence. Osteoporosis is also common in the wrist and the spine.

The hormone estrogen helps to make and rebuild bones. A woman’s estrogen levels drop after menopause, and bone loss speeds up. That’s why osteoporosis is most common among older women. But men get osteoporosis, too.

“A third of all hip fractures occur in men, yet the problem of osteoporosis in men is frequently downplayed or ignored,” says Dr. Eric Orwoll, a physician-researcher who studies osteoporosis at Oregon Health and Science University. Men tend to do worse than women after a hip fracture, Orwoll says.

Experts suggest that women start getting screened for osteoporosis at age 65. Women younger than age 65 who are at high risk for fractures should also be screened. Men should discuss screening recommendations with their health care providers.

Screening is done with a bone mineral density test at the hip and spine. The most common test is known as DXA, for dual-energy X-ray absorptiometry. It’s painless, like having an X-ray. Your results are often reported as a T-score, which compares your bone density to that of a healthy young woman. A T-score of −2.5 or lower indicates osteoporosis.

There’s a lot you can do to lower your risk of osteoporosis. Getting plenty of calcium, vitamin D, and exercise is a good start, Orwoll says.

Calcium is a mineral that helps bones stay strong. It can come from the foods you eat—including milk and milk products, dark green leafy vegetables like kale and collard greens—or from dietary supplements. Women over age 50 need 1,200 mg of calcium a day. Men need 1,000 mg a day from ages 51 to 70 and 1,200 mg a day after that.

Vitamin D helps your body absorb calcium. As you grow older, your body needs more vitamin D, which is made by your skin when you’re in the sun. You can also get vitamin D from dietary supplements and from certain foods, such as milk, eggs, fatty fish, and fortified cereals. Talk with your health care provider to make sure you’re getting a healthy amount of vitamin D. Problems can arise if you’re getting too little or too much.

Exercise, especially weight-bearing exercise, helps bones, too. Weight-bearing exercises include jogging, walking, tennis, and dancing. The pull of muscles is a reminder to the cells in your bones that they need to keep the tissue dense.

Smoking, in contrast, weakens bones. Heavy drinking does too—and makes people more likely to fall. Certain drugs may also increase the risk of osteoporosis. Having family members with osteoporosis can raise your risk for the condition as well.

The good news is, even if you already have osteoporosis, it’s not too late to start taking care of your bones. Since your bones are rebuilding themselves all the time, you can help push the balance toward more bone growth by giving them exercise, calcium, and vitamin D.

Several medications can also help fight bone loss. The most widely used are bisphosphonates. These drugs are generally prescribed to people diagnosed with osteoporosis after a DXA test, or to those who’ve had a fracture that suggests their bones are too weak. Bisphosphonates have been tested more thoroughly in women, but are approved for men too.

Researchers are trying to develop drugs that increase bone growth. For now, there’s only one available: parathyroid hormone. It’s effective at building bone and is approved for women and men with osteoporosis who are at high risk for having a fracture.

Another important way to avoid broken bones is to prevent falling and occasions for fracture in the first place. Unfortunately, more than 2 million so-called fragility fractures (which wouldn’t have happened if the bones had been stronger) occur nationwide each year. “To reduce the societal burden of fracture, it’s going to take a combined approach of not only focusing on the skeleton but focusing on fall prevention,” says Dr. Kristine Ensrud, a physician-researcher who studies aging-related disorders at the University of Minnesota and Minneapolis VA Health Care System.

Many things can affect the risk for a fall, such as how good a person’s balance is and how many trip hazards are in the environment. The kind of fall matters, too. Wrist fractures often occur when a person falls forward or backward. “It’s the active older person who trips and puts her hand out,” McGowan says. Hip fractures often arise when a person falls to the side. Your hip may be strong enough to handle weight that goes up and down, but not an impact from another direction.

“That’s why exercise that builds balance and confidence is very good at preventing fractures,” McGowan says. For example, she says, tai chi won’t provide the loads needed to build bone mass, but it can increase balance and coordination—and make you more likely to catch yourself before you topple.

NIH-funded researchers are looking for better ways to tell how strong your bones are, and how high your chances are of breaking a bone. For now, though, the DXA test is the best measure, and many seniors, even older women, don’t get it, Ensrud says. If you’re concerned about your bone health, she adds, “Ask your health care provider about the possibility of a bone density test.”

SOURCE: National Institutes of Health (<https://newsinhealth.nih.gov/2015/01/osteoporosis-aging>)

**Balance control in elderly people with osteoporosis**

Osteoporosis is a prevalent health concern among older adults and is associated with an increased risk of falls that incur fracture, injury, or mortality. Identifying the risk factors of falls within this population is essential for the development of effective regimes for fall prevention. Studies have shown that muscle quality and good posture alignments are critical for balance control in elderly individuals. People with osteoporosis often have muscle weakness and increased spine kyphosis leading to vertebral fractures and poor balance control, or even falls. Therefore, improving muscle quality, strengthening weak muscles, and correcting postural alignment are essential elements for the prevention of falls and fractures in older adults with osteoporosis. This review reports the necessary information regarding the critical factors of balance control in older adults with osteoporosis, as well as testing the clinical innovations of exercise training to improve the long-term prognosis of osteoporosis in this vulnerable population.

**Elderly Patients with Osteoporosis and Sarcopenia**

The population of patients with osteoporosis and sarcopenia continues to increase due to the rapid aging of the

population worldwide.1,2 Approximately 500,000 people > 65 years of age have been diagnosed with osteoporosis in Taiwan,3 and 25% of these people have a history of spine or hip fracture.4 Osteoporosis is the most metabolic bone disease, characterized by decreased bone mass and structural deterioration of bone tissue, which leads to

bone fragility and an increased susceptibility to fractures, especially of the spine, hip, and wrist.5 Sarcopenia is

defined as a low muscle mass resulting from age-related muscle loss, and is often combined with osteoporosis.6

Sarcopenia can impair function, which further increases the risk of musculoskeletal injuries and other morbidity,

finally resulting in partial or total loss of independence.

Conflicts of interest:

The authors have no conflicts of interest relevant to this article.

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Several factors are part of the cause in the origin of osteoporosis, which is thought to contribute to sarcopenia.

These contributing factors include a low level of physical activity, a reduction in dietary protein, chronic inflammation, and hormonal changes. These etiologies may account for the association between sarcopenia and osteoporosis.

Therefore, sarcopenia is a risk factor for osteoporosis, and is predominant among individuals with low bone mineral

density (BMD).2,8,9 Moreover, obesity may offer some protection against osteoporosis. Aubertin-Leheudre et al

examined the impact of sarcopenia on BMD in post-menopausal women with obesity and they found that sarcopenia did not influence hip or spine BMD.10 An increased body weight exerts numerous stresses on bone structure,

which may also be beneficial for BMD. Osteoporotic fractures, such as vertebral compression fractures or hip fracture, are usually associated with significant mortality, morbidity, and low quality of life.11 Osteo-porotic fractures have become an enormous burden on health care and health insurance. Thus, the importance of

preventing fractures and fall incidents in elderly people with osteoporosis and sarcopenia should not be underestimated. The most diagnosed combination of vertebral compression fracture included a cluster of women > 52 years of age, with a body mass index 22 kg/m2, and a low frequency of exercise.12 Eighty-two percent of fractures reported in a large study of frail elderly were attributed to falling.13 Rehabilitation goals for osteoporotic fractures are pain reduction, improvement and preservation of musculoskeletal function, reducing fall risk, and optimizing quality of life and independence.14 Hence, fracture and fall prevention is an

important issue for the affected population group. Mechanism of balance control and fall. The definition of a fall is when one experiences an unexpected loss of balance resulting in coming to rest on the floor, ground, or an object below knee level.15 The risk for falls increases with age and is a multifactorial issue. Strong risk factors for falls include fall history, impaired gait, mobility disability, poor vision, vestibulopathy, and reduced muscle strength.16,17 People diagnosed with osteoporosis often experience muscle weakness, poor balance control,18 and postural deformity.19,20 Impaired balance performance of patients with osteoporosis or sarcopenia has been documented in the literature,21e28 although patients may not have “classical motor control” problems that are involved in central nervous system-related disorders.29 The literature has identified that women with osteoporosis have reduced flexibility and mobility that affects their walking, which contributes to a greater risk than in men.30 Control of an upright posture is a complex function achieved through multisensory integration, central motor control, and context-specific response.31 During normal aging, physiological changes occur in one’s visual, vestibular, somatosensory inputs, as well as central processing and muscular effectors.32 Moreover, the inter joint coordination is also affected.33 The reduced congruency between sensory cues combined with physical decline means that upright balance control becomes difficult for older adults (Fig. 1). Musculoskeletal fragility associated with sarcopenia (loss of muscle mass) and osteopenia (loss of bone mass) can result in fall and fracture. The postural alignment usually changes in elderly people with low BMD. Muscle performance might be altered by the loss of muscle mass and strength. Spinal extensor muscle weakness is associated

with hyperkyphosis34 and may limit activities, including

bending, reaching, reduced gait speed, greater difficulty

climbing stairs, and poorer balance.22,30 A flexed posture

(kyphosis) is relatively unstable because the center of mass

(CoM) in the body is shifted closer to the edge of the sup-

port base. Hyperkyphosis changes the joint position sense

because of poor alignment of the joints.19 All these factors

could influence control over the CoM position or center of

pressure and the ability to recover from balance

Figure 1 Mechanism of poor balance control in osteoporosis. CoM Z center of mass.

Balance in people with osteoporosis 335

2,8,910111213141516,171819,202930313233Fig. 13422,3019

perturbation.35,36 The mechanism of the balance control

problem in osteoporosis is shown in Fig. 1. Numerous de-

terminants of each have been identified, but further work

to develop preventative strategies based on these de-

terminants is required.

Age-related alterations of muscle architecture and

activation during upright stance might be associated with

the decreased balance stability documented in elderly

adults. Baudry et al investigated the ultrasonography and

electromyography in young and elderly adults when stood

upright on a force platform with and without vision.37 The

results show that elderly adults increase the stiffness of the

muscular portion of the muscleetendon unit during upright

stance, which may make up for the age-related decrease in

tendon stiffness.

Muscle performance and balance control

Several studies have implicated the key role of deteriora-

tion of musculoskeletal function in older adults for

observed age-related deficits in balance stability con-

trol.38e42 Sarcopenia is a main feature of the aging process.

It is characterized by a reduction in muscle mass and

muscle strength. Sarcopenia is associated with an increased

risk of fractures after a greater predisposition to falls.

Fractures may also result from the accelerated bone

remodeling that increases bone loss and impairs bone

strength. The fractures may also be related to reduced

mechanical muscle strength, which may influence the

response during the fall process. Furthermore, muscle

strength determines the quality of bone modifications such

as density, strength and microarchitecture. Variations in

the ratios of cortical and muscle areas effectuate to various

types of osteoporosis, with varying risks of fractures.43

MacRae et al have documented that lower scores on

manual muscle testing of the hip abductors, knee exten-

sors, knee flexors, and ankle dorsiflexors are significantly

related to an older adult’s fall status.40 Runge and col-

leagues have computed the joint torque from the inverse

dynamic during balance recovery and have found that

ankle, knee, and hip joint torque generally increase as the

velocity of perturbation is raised.44 Controlling the balance

is a major requirement for postural stability. Other factors

should also be considered such as muscle quality and the

ability of force usage.

The potentially modifiable risk factors for poor muscle

strength and quality could be targeted in exercise in-

terventions. Research is needed to determine the threshold

of muscle quality and strength capacity associated with

functional impairments and reduce the associated cascade

of fracture. This information could be used to develop

screening guidelines that would assist clinicians with

intervention timing. Several studies have suggested that

the deterioration of musculoskeletal function in older

adults may play a key role in the observed age-related

deficits in balance stability control.38e42

Kyphotic posture and balance performance

Lower spinal muscle density often presents in osteoporosis

patients, and frequently in those with spinal deformities

such as thoracic kyphosis, it may cause a diminished range

of motion.45 Reduced bone mass in elderly people may

cause progressive microfracture, which may finally lead to

vertebral height loss due to gross vertebral compression

fracture and spine deformities. Postural deformities such as

kyphosis and limited spinal mobility impair the quality of

life in older adults with osteoporosis.46 Forward head

posture, scapula protraction, reduced lumbar lordosis, and

decreased standing height are often present in the patients

associated with hyperkyphosis.30

Hyperkyphosis is the leading cause of sagittal plane

deformity and is associated with impaired mobility, including

reduced gait speed, greater difficulty climbing stairs, and

poorer balance.22,30 Weaker back extensor muscles often

result in deformities of the skeleton such as kyphosis, which

in turn cause modifications to posture and an increased

probability of fall and fracture.45 The resulting center of

gravity modification worsens the control of body balance.

Reduced flexibility and mobility of trunk affects the

walking of people with osteoporosis and contributes toward

a greater risk of falling, which leads to bone fractures.

Flexibility and balance are necessary to counteract the

effects of gravity and other external forces in addition to

the normal sagittal alignment of the spine and adequate

muscle strength. A reduction in range of motion and dete-

rioration in coordination that affects body balance is a

sequence of osteoporosis and aging in general.22 Therefore,

optimal exercise programs to strengthen the back extensors

are important in the management of deformities related to

osteoporosis.

Exercise training for fall prevention

Several clinical guidelines on the management of osteopo-

rosis have highlighted the necessity of exercise.47,48 Exer-

cise improves quality of life, particularly in the domains of

physical function such as balance and pain relief that can

be assessed by the Quality of Life Questionnaire of the

European Foundation for Osteoporosis (QUALEFFO-31).49,50

Bergland et al51 have shown that a 3-month course of cir-

cuit exercises can improve mobility, balance, and the

quality of life for women with osteoporosis and a history of

vertebral fractures. The circuit exercises were performed

twice weekly, which included 10 minutes warm up with

aerobic exercise and 40 minutes walking, stepping, and

posture promoting.51 Burke et al52 have also performed an

8-week balance training with muscle strengthening or

stretching, twice weekly, for 60 minutes a day. Both

strengthening and stretching exercises were effective in

improving postural control when compared to the control

group.52

Kyphotic posture changes the location of the whole body

CoM and could affect the balance stability, therefore,

postural correction has been a focus of exercise training in

osteoporosis patients, especially in those with vertebral

compression fracture. A prospective study observed a

reduced incidence of vertebral compression fractures in

estrogen-deficient women who participated in a back

extensor strengthening program and demonstrated a 10-

year long-term effect.53 These benefits primarily result

from the bone-formation-friendly mechanical simulation

336 W.-L. Hsu et al.

35,36Fig. 13743404445463022,30452247,4849,505151525253

produced by strengthening force. The force prevents or

corrects deformity of the vertebral body by extension of

the anterior longitudinal ligament.

The goals of rehabilitation exercise are prevention of fall

and subsequent new fractures, reduction of kyphosis,

enhancing axial muscle strength, and providing correct spi-

nal alignment. Hyperkyphosis is common following osteo-

porotic vertebral fractures. Correction of kyphosis provides

patients with pain relief, increased mobility, and improve-

ment in quality of life. Spinal extensor strengthening can

reduce the most disfiguring consequences of aging, such as

thoracic hyperkyphosis, vertebral fracture, loss of height,

and pain of the anterior rib cage.54e56 The incidence of new

fractures associated with back extension exercises (16%) is

lower than the incidence related to abdominal flexion ex-

ercises (89%).57 Moreover, back extensor strengthening ex-

ercises can reduce the incidence of osteoporotic

compression fracture significantly in postmenopausal

women over a 10-year period53 and lower the incidence of

new fractures in patients with vertebroplasty.58

Exercise training of the trunk for core stability has become

a well-known fitness trend that has emerged in rehabilitation

programs. The core can be described as a muscular box with

the abdominals in the front, paraspinals and gluteals in the

back, the diaphragm as the roof, and the pelvic floor and hip

girdle musculature as the bottom.59 Popular fitness pro-

grams, such as Pilates, yoga and Tai Chi, follow core-

strengthening principles. This box comprises 29 pairs of

muscles that help stabilize the spine, pelvis, and kinetic

chain during functional movements. Deficient strength in

these muscles results in mechanical instability of the spine

with compressive forces of as little as 90 N.60

Moreover, some evidence in the literature supports the

notion that core-stabilization programs may be used to help

prevent knee injuries in athletics. Leeton et al performed a

prospective study with 140 male and female intercollegiate

basketball and track athletes. They found that athletes

with anterior cruciate ligament injuries experienced ilioti-

bial band syndrome, patellofemoral pain, and stress frac-

tures in the lower extremity, which significantly decreased

strength in hip abduction and external rotation compared

with noninjured athletes.61 Enhanced strength would be

beneficial to upright posture and aid balance while walking,

thereby decreasing the risk of fall and improving quality of

life.53

The sex differences affect the prevalence of osteopo-

rosis, osteoporotic fractures, and fall-related risk factors

for incident fractures.62,63 During aging, less cortical bone

loss occurs in men because there is less endocortical

resorption and cortical porosity in men than women.

Moreover, trabecular bone loss is similar in men and

women, but there is less trabecular architectural disruption

in men than in women. Furthermore, older women expe-

rience more falls than do older men.64 Therefore, weight-

bearing exercise and strengthening exercise should be

emphasized for women with osteoporosis.51,52,65,66

Many people routinely exercise using fitness programs,

such as Pilates, yoga and Tai Chi. However, individuals with

osteoporosis need special consideration, including the ex-

ercise positions. For example, the increased torque pres-

sure applied to vertebral bodies during spinal flexion

exercises may be a risk in yoga or Pilates positions.67e70 Tai

Chi is also used to improve balance ability in older pop-

ulations.71e73 However, Tai Chi does not provide much

loading on weight-bearing joints as expected, which is a

precondition for an effect on bone metabolism.74e81

Assistive device for fall prevention

Besides the exercise training, recent studies have shown

that assistive device can also improve balance.82,83 Spinal

orthoses are commonly prescribed to immobilize the

vertebral compression fracture and relieve pain of osteo-

porotic patients.84 Liaw et al have found that the

KnighteTaylor spinal brace efficiently improves the static

and dynamic balance of patients with osteoporotic verte-

bral compression fracture.82 Spinal bracing can provide

spinal stability by compensating for the weak back extensor

and decreasing painful guarding of the paraspinal mus-

cles.85 The orthoses also provide additional sensory feed-

back to enhance balance. de Morais Barbosa and

colleagues83 have evaluated the effect of foot orthoses on

balance, foot pain, and disability in women with osteopo-

rosis. They have found that the insole with medial arch

support and metatarsal pad are effective for improving

balance and reducing pain.

Conclusions

Mounting evidence has shown that muscle quality and good

posture alignments are crucial for balance control in older

adults. People are diagnosed with osteoporosis often

combining with muscles weakness, and increased spine

kyphosis leading vertebral fractures, and poor balance

control, even falls. Therefore, improving muscle quality,

strengthening weak muscles and correcting postural align-

ment are essential elements for fracture and fall preven-

tion in older adults with osteoporosis. A new paradigm of

treatment approaches for balance control to reduce the

risk of falling and fracture is needed.