**MODULE 3: Osteoporotic Fractures, Clinical Measures & Research**

**3.1** **The Effect of Osteoporosis**

**3.1.1 *The “Typical” Osteoporosis Patient***

Osteoporosis has been called a paediatric disease with geriatric consequences. However, it is easy to assume that an older, frailer person with a kyphotic posture is clearly a ‘typical’ osteoporosis patient. The danger of this assumption is that in fact you may be missing crucial populations who really need to be screened and/or receive clinical intervention by you and your medical colleagues!

Consider these populations who are known to be affected by osteoporosis:

* Post-menopausal women with a fragility fracture
* Medication-induced osteoporosis (chronic glucocorticoid usage)
* Female athlete triad (disordered eating, amenorrhea, low BMD)
* Anorexia nervosa (90% have low BMD at one site)
* Systemic diseases (bowel disorders, RA, endocrine disorders, uncontrolled diabetes, long-term asthmatics)
* Low sex hormone levels in both men and women
* Men aged 50-79, approximately 5% have OP, while over 80 that increases to 20%
* Pediatric populations (e.g., children with CP, spina bifida Duchenne’s MD, those on long-term glucocorticoid therapy or immobilized).

Can you think of a patient you have seen in the last 3-6 months who may have fallen into one of these categories?

**Did you ask about their bone health?**

**Did you about their risk factors (Module 1)?**

**Did you prescribe exercise for them?**

Consider what you might do differently next time, now that you know what a ‘typical’ person with osteoporosis could really look like!

**Take-home message:** *Osteoporosis affects more populations than you often think of –so always think bone health!*

What does the person look like in your clinical setting, typically? Consider the following characteristics of your patient with osteoporosis:

* Age
  + Comorbidities
  + Cognitive abilities
  + Balance impairment/falls risk
* Postural changes
  + With or without presence of fractures
  + Soft tissue alterations
  + Strength losses
* Presence of low-trauma fractures
  + Location
  + Severity
  + Affect on ADLs
* Presence of Secondary Osteoporosis
  + Contributors?
  + Risk factors for fracture?

**Why do the above factors matter?**

Consider the following three scenarios and for each one, decide how your exercise recommendations would vary and why:

1. Two women diagnosed with osteoporosis (exact same BMD) but one is aged 45 and one is aged 71.
2. Two men diagnosed with osteoporosis, same age, one with confirmed vertebral fractures & kyphotic posture, one without.
3. Two women, same age, with a similar kyphotic posture, neither with any confirmed fractures, one with a BMD of -1.2, the other with a BMD of -2.4.

**Take-home message:**

*Planning exercise & activity recommendations for patients with osteoporosis does not follow a recipe.*

*Individualization of the program will benefit them*

*more than categorization!*

***3.1.2. Implications of Fractures***

As noted previously, the most typical fracture sites in an osteoporotic patient are the hip, wrist and vertebra. Other common sites may also include the following according to recent research27

|  |  |
| --- | --- |
| **Women** | **Men** |
| Vertebral fractures  Hip fractures  Wrist-forearm fractures Humeral fractures Other femoral fractures Rib fractures  Pelvic fractures  Clavicular, scapular, sterna fractures  Tibial and fibular fractures | Vertebral fractures  Hip fractures  Wrist-forearm fractures Humeral fractures Other femoral fractures Rib fractures  Pelvic fractures  Clavicular, scapular, sterna fractures |

Fractures, regardless of the location, have an impact on our patients in many ways: pain, functional limitations, reduced movement, development of complications (sometimes life- threatening), prolonged impact physically, mentally and socially.

For example, below are the clinical consequences that have been attributed to vertebral fractures42

|  |  |  |  |
| --- | --- | --- | --- |
| **Symptoms** | **Signs** | **Function** | **Future Risks** |
| * Back Pain (acute/chronic) * Sleep Disturbance * Anxiety * Depression * Decreased Self Esteem * Fear of future: Falls and Fractures * Reduced QOL * Early Satiety | * Height Loss * Kyphosis * Decreased Lumbar Lordosis * Protuberant Abdomen * Reduced Lung Function * Weight Loss | * Impaired ADL’s * Difficulty Fitting * Clothes * Difficulty bending, lifting, descending stairs, cooking | * + Increased Risk of Fracture * Increased * Risk of Death |

With regards to hip fracture and consequences of morbidity and mortality, the following has been found in the current literature:

* Hip fractures frequently lead to disability.
* More than 26 percent of individuals suffer a hip fracture become disabled in the following year, as the fracture results in disabilities that are in addition to those functional losses that would ordinarily occur in frail elderly adults.
* Due primarily to dementia and the inability to walk independently, nearly one out of five require long-term nursing home care.
* The risk of dying varies by fracture type, 20 percent of all hip fracture patients die within a year1.

**Take-home message:**

*Hip & vertebral fractures are the most common osteoporotic fractures…with the greatest impact*

*on morbidity & mortality.*

*Prevention of these fractures can be life-saving.*

**3.1.3. *Measuring the Silent Fracture***

It bears repeating some of the facts and statistics reviewed in Module 1, with respect to vertebral fractures in particular:

* A 50-year-old woman has a 40% chance of developing hip, vertebral or wrist fractures during her lifetime.36
* Patients are at highest risk for subsequent fracture in the first few months following a vertebral fracture. 26
* 1 in 4 women who have a new vertebral fracture will fracture again within one year.31
* Both vertebral and hip fractures are associated with an increased risk of death.

It has been noted that more than 60% of vertebral fractures are ‘silent’ in nature, that is not accompanied by any overt pain or immediate structural changes20. Even more striking is that while these are by far the most common type of fracture in the osteoporotic population, the majority (66%) do not gain clinical attention.47

There are four easy, clinical measures that can help identify these silent fractures.

1. **Historical Height Loss (HHL)**

As the name suggests, this refers to the amount of height that an individual has lost over his or her lifetime. Simply calculate the difference between a person’s tallest height recalled against their current measured height.

Ensure accurate current height measures by:

* using wall-mounted devices if possible
* careful positioning of patient each time (where the inferior border of the bony orbit is in line with the groove at the top of the tragus of the ear)
* repeat measures 3 times (repositioning each time) and average to the closest millimeter

*Practice guidelines suggest that individuals over age 60 with >6cm HHL and individuals under age 60 with >4cm HHL be referred for spine radiographs as this is indicative of present vertebral fractures.*

1. **Prospective Height Loss (PHL)**

For patients being followed over time by a clinician, changes in height between subsequent visits can be monitored (up to a 3-year time frame).

*Presence of vertebral fractures is indicated with a loss of >2cm PHL measure.*

1. **Wall-Occiput Distance (WOD)**

This measure is useful in the presence of frank or developing kyphosis. Since postural compensatory changes may be present, it is important to reveal the upper back, and position the patient against the wall such that:

* back and heels are against the wall
* facing straight ahead
* a measurement of the distance between the wall and occipital prominence is made

*WOD greater than 5 cm is indicative of a vertebral fracture in the thoracic spine.*

1. **Rib-Pelvic Distance (RPD)**

Vertebral fractures in the lumbar spine can also cause postural changes and compensations. The distance between the ribs and pelvis (iliocostal distance) can be measured to assess this postural change. In order to measure this:

stand behind patient (who is also standing)

palpate the bottom ribs and iliac crest in the mid-axillary line

determine the vertical distance between the rib and iliac crest by either fingerbreadths or measurement of skin markings.

*An RPD of less than 2 fingerbreadths or 3.6cm suggests the presence of a vertebral fracture, likely in the lumbar region.*

*Adapted from two articles by Kerry Siminoski MD published in the Spring & Winter 2005 issues of Osteoporosis Update.47*

**Bottom Line Caution:**

No single physical exam finding can rule in osteoporosis or fracture without further testing. The above measures are easy clinical tests which would identify patients who may benefit from early screening/BMD testing.

**Assessment Tools:**

Guidelines for BMD testing are outlined in detail in Module 1. In brief, the following can be applied:

1. Everyone 65+ is recommended to have a BMD test
2. Patients over the age of 50, with risk factors for fracture should have BMD testing
3. Younger men or women (under 50) with a disease or condition associated with low bone mass or bone loss should have BMD testing
4. Clinically determine management decisions using the 10-year absolute fracture risk assessment tools CAROC and/or FRAX

In addition, the following tools have been identified in current research9a to be sensitive and valid in assisting the clinician to make decisions regarding BMD testing.

1. **Osteoporosis Risk Assessment Instrument (ORAI)**

Calculation of score – points given for:

age: 15pts if 75+; 9 pts if 65-74; 5 pts if 55-65

weight: 9pts if <60kg; 3 if 60-69.9kg

2pts if not currently taking estrogen

Interpretation of score9b:

recommend BMD if ORAI >8

low risk: <9; medium risk: 9-17; high risk: >17

1. **Osteoporosis Self-Assessment Tool (OST)29a**

Calculation of score:

0.2 x (weight in kg-age in years)

truncate to yield integer

Interpretation of score:

recommend BMD if OST<2

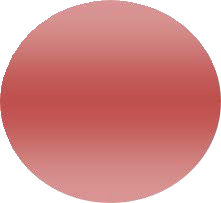
low risk: >1; medium risk: -3 to 1; high risk: <-3

**Take-home message:**

*Using valid measures for OP screening is best. No one measure will CONFIRM the presence of osteoporosis, merely provide an indicator for further testing (i.e., BMD).*

**3.2 Current Research on Vertebral Fractures –Implications for ADLs & Rehabilitation**

**3.2.1 *How do fractures develop?***



**NORMAL ABNORMAL**

**ABNORMAL FORCE NORMAL FORCE BONE FRACTURE BONE**

Of course, development of vertebral fractures is not entirely that simple. Below is a possible explanation of the more complex process, derived from current research findings7,14,49

Habitual slouching posture, repetitive lifting, or ADLs which encourage flexion of spine

Move the line of gravity anterior to vertebral body increasing flexion moment

Increases spinal extensor muscle activity to counter the flexion moment

10-fold increase in compressive forces on anterior portion of vertebral bodies in thoracic region

Extensor muscle contraction further increases vertebral compression loads & accounts for 92-100% of stress on spine

Resulting MICROFRACTURES of anterior vertebral bodies

PRESENCE of suboptimal bone density

ANTERIOR WEDGING & FRACTURE DEVELOPMENT OF POSTURAL KYPHOSIS

The development of thoracic kyphosis has many impacts on a person with osteoporosis. A few key research findings have been summarized below:



• Briggs8; 2- Campbell10; 3- Cortet12,13; 4- Ensrud 15; 5-Edmondston14a, 6- Sinaki 48

***The current evidence appears to support the proposal that flexed postures & repeated flexion may result in adverse events like falls and fracture in people with poor vertebral bone quality.***

**3.2.2 *Is There Evidence for Extension Exercises?***

***Laying the Foundation…***

In an early exercise study, Sinaki and Mikkelsen51, investigated the effects of 4 different exercise programs on small groups of postmenopausal women with spinal osteoporosis and back pain. Their results demonstrated that the group whose program emphasized lumbar extension exercises had significantly less spinal fractures compared to a similar group who performed flexion exercises, combined extension/flexion exercise or none at all.

*Although these results were promising, it is important to note that this was not a*

*randomized controlled trial and the numbers in each group were fairly small.*

***Follow-Up Research…***

A study which included a 10-year follow up focused on the long-term effect that a two-year progressive resistance back extension program had on post-menopausal, ***healthy*** women. Their results revealed that compared to the control group at the 10-year follow-up, those women performing extension exercises had significantly less fractures, greater back extensor strength, than those women not exercising at all.50 Of note, both groups demonstrated similar decreases in BMD and increases in kyphosis at the 10-year follow-up compared to baseline. This study provided no information regarding randomization or allocation concealment and 23% of participants were lost to follow-up, so results should be interpreted with caution.

***More Recent Work...***

Gold et al.,19 conducted a randomized controlled trial (modified cross-over) using 185 post- menopausal, older women with vertebral fractures. The intervention was a 6-month monitored exercise class and coping classes followed by 6-month of self-maintenance. Exercises included stretches to increase back extension, hip extension & shoulder flexion. Progressive strengthening exercises focused on back extensors, axial muscles groups (i.e., traps), abdominals & hip muscles. Instruction on safe exercise, body mechanics for ADLs and optimal posture was provided. Ultimately, analysis of results indicated that the intervention group showed improvement in the outcomes of trunk extension strength during Phase I but it declined during the self-maintenance phase. *The authors concluded* *that older women with vertebral fractures can improve trunk extension strength but that the sustainability of these gains are linked to continued intervention*.

Hongo et al.,23 investigated the effect of low-intensity back extension exercises with an RCT involving 80 postmenopausal women with osteoporosis. The exercise group performed one set of ten repetition of a simple isometric back extension (from prone) daily. At the 4-month follow-up point, both groups had significantly increased their back extensor strength compared to baseline with a significant difference noted between groups as well. QOL measures improved significantly in the exercise group only. *It appears that simple, low-intensity exercises can have a significant impact on both back extensor strength and quality of life.*

Papaioannou et al.41 conducted an RCT with 74 postmenopausal women with at least one vertebral fracture to determine the effect of a 6 –month home exercise program on quality of life. The exercise group completed a minimally supervised program including strengthening with resistance bands, stretching and aerobics (walking commonly) for 60 minutes, 3 times per week. At the 12-month follow-up, the exercise group had demonstrated significant gains in quality of life, with greater correlations of QOL gains found with higher adherence. Investigators reported no significant changes in bone density at the hip or vertebrae.

**Research Summary #1:**

*An osteoporotic vertebral fracture may simply be a ‘weak’ vertebral bone being loaded during activities of daily living. 29,35,37*

**Research Summary #2:** *Reduction or avoidance of anterior compressive forces in the presence of damaged or at-risk vertebrae at the very least prevents further damage.*

**3.2.3 *What About Changing Posture?***

Briggs et al.,7,8 have stated in their research that it is important for therapists’ treatment plans to include specific strengthening modalities to reduce vertebral loading and that interventions aimed at minimizing thoracic kyphosis may do this.

Authors investigating vertebral bone failure under compressive forces have shown that recovery of cancellous bone height is possible following removal of forces17.

The research was conducted in lab conditions with short-term compressive forces of very high loads to vertebral cancellous bone, with a resulting 94% recovery of bone height following removal of the loads. The authors suggest this recovery mechanism inherent with cancellous bone may be the key in allowing a damaged vertebrae/articular joints to regain original shape (and height!) with little loss of function. There hasn’t been conclusive research on long- term osteoporotic fractures with respect to potential recovery of vertebral height through a similar mechanism.

However, it would stand to reason that unloading activities such as active extension, postural correction and/or avoiding/adapting ADLs which are flexion-based, can reduce compressive loads which MAY prevent further fractures.

**3.2.4 *What Do We Know about Exercise After Vertebral Fractures?***

* The nature of “best exercises” still remains unclear
* Improvements in back extension strength, psychological symptoms, QOL have been noted
* These exercises may improve balance
* Improvements in pain is not a strong finding
* A significant improvement in vertebral morphometry has not been demonstrated

(Gold19, Malmros33, Papaioannou41 Webber53, Hongo23)

***Adverse Events HAVE been reported during these programs...***

* Fractured costal cartilage during prone exercise
* Fractured rib while rolling from supine to prone
* Metatarsal fracture when 2lb weight fell on foot
* Hip fracture after 6MO physical examination
* Soft tissue pain (neck, back)
* Back pain, unspecified – 2/3 returned to exercise
* Pain during exercise, fall concerns (14/74)

(Gold19, Hongo 22, Papaioannou41)

**Take-home message:**

*No exercise is without risk, but in general, the research indicates:*

*DO: extension*

*(with care & appropriate positioning)*

*DO* ***NOT*** *DO: flexion*

**3.3 Osteoporosis Exercise Guidelines**

Giangregorio LM et a., *Osteoporosis International (2014) 25:821-35*

**Overarching Guidelines:**

1. **Adults with OP:**

* Engage in a multicomponent exercise programme: includes resistance training in combination with balance retraining
* Do not engage in aerobic training to the exclusion of resistance/balance retraining

1. **Adults with OP & Vertebral Fractures:**

* As above
* Consultation with a Physical Therapist is recommended

1. **Activities of Daily Living Movement Guidelines:**

* Recommend that patient modify activities that apply *rapid, repetitive, weighted or end-range* flexion (forward bending) or twisting torque to the spine.

**3.3.1 *Guidelines for Clients with Osteoporosis and no Fractures***

National exercise guidelines are generally appropriate however, consider additional recommendations:

* Perform weight-bearing aerobic activity most often;
* Progressive resistance training designed to increase muscle strength i.e., 8-12 repetitions at an intensity rating of 5-8 on a 0-10 scale
* Balance training, accumulating 2 hours per week or 20 min per day;
* Daily exercise to ↑ muscular endurance in spinal extensors;
* Spine sparing approach to activities of daily living

**3.3.2 *Guidelines for Clients with Osteoporosis and Fractures***

* National exercise guidelines are not appropriate, so do this instead:
* 150 min/week moderate intensity aerobic activity, performed in bouts ≥10 min
* Vigorous aerobic activity may not be appropriate;
* Progressive resistance training designed to increase muscle strength, emphasis on form/alignment instead of intensity;
* Balance training strongly for all, accumulating 2 hours/week or 20 min/day;
* Daily exercises to ↑ muscular endurance in spinal extensors;
* Perform exercises in positions where spine is least loaded when possible: loads in supine<standing<seated;
* PT/OT guidance on appropriate exercise, alignment, transitions, use of assistive aids, positioning for pain control.
* Spine sparing approach to activities of daily living

**3.3.3 *Examples of How to Apply Exercise Guidelines***

|  |  |
| --- | --- |
| **Exercise Component & Frequency** | **Examples/Comments** |
| Strength Training  ≥ 2x/week | * Exercises for legs, arms, chest, shoulders, back * Use body weight against gravity, bands, weights\* * 8-12 repetitions maximum per exercise |
| Balance Training  ~ 20mins daily | * Standing still: one-leg stand, semi-tandem * stance, shift weight between heels and toes while standing * Dynamic movements: Tai Chi, tandem walking, dancing * Progress from standing still to dynamic |
| Aerobic physical activity  ≥ 5x/week  (30min/day) | * Do bouts of 10 min or more * Accumulate ≥ 30 min per day * Moderate- or vigorous-intensity (5-8 on 0-10 scale)\* |
| Posture/ Back Extensor Training  5-10mins daily | * Lie face up on firm surface, knees bent, feet flat. Use pillow only if head doesn’t reach floor. Do this 5-10 min/day. * Progressions   1) lying with gentle head press, without changing chin position, perform 3-5 seconds “holds”;  2) Core activation in standing (see intro to theraband: Videos: www.osteoporosis.ca/after-the- fracture/videos/ |
| Spine Sparing Strategies during daily activities | Learn modifications such as a “hip hinge” and “step to turn” so that you can safely perform activities that typically flex (bending forward) or twist spine |

**3.4 Research Summary: Hip Fractures & Exercise**

**3.4.1 *Post Hip Fracture Exercise***

A recent Cochrane review 21 of mobilization strategies post osteoporotic hip-fracture suggested:

* There is insufficient evidence overall to establish the effectiveness of the reviewed mobilization strategies used in rehabilitation after hip fracture surgery (including physiotherapy, treadmill, resistance training & electrical stimulation)
* Limited number of trials, limited power
* Little information about persistence

**Two positive RCT studies (Binder 3, Hauer 22):**

Concluded that improved mobility occurred with intensive, supervised ongoing exercise/therapy, specifically with significant differences between the exercise and control groups in the following measurements:

* Improved walking velocity
* Less need of walking aid
* Improved measures on the Physical Performance Test
* Improved Stair climbing
* Increased leg extensor strength, decreased fear of falling, improved balance

*Interestingly, no change in BMD was found2*

*What were the characteristics of these two positive trials?*

* Exercise was prescribed for 3x/wk for 3 months or 6 months
* Patients were supervised in an outpatient centre, using machines
* Progressive resistive training at 70-90% or 65% max
* Included functional training – walking, stepping, balance activities

**More recent work on post hip fracture rehabilitation has revealed:**

* Higher intensity, weight-bearing exercise are not better than lower intensity seated or lying exercises for mobility and balance 40
* Increased muscle strength and power with 2x/wk. supervised resistance training for 12 wks.43
* Arm ergometry + inpatient rehabilitation improved aerobic fitness, mobility and balance38
  + 1. ***Conflicting Reviews on Walking Benefits***

Cochrane Review: Exercise for preventing and treating osteoporosis in postmenopausal women4,5

* 3 studies utilizing walking programs
* comparison to control groups
* walking program: high intensity, 3x/wk, 30-45 minutes
* analyzed results showed walking to have a positive effect on the BMD of spine

1.31[95%CI (-0.03 to2.65)] and the hip 0.92 [95%CI(0.21 to1.64)]

*Author’s conclusion: Walking resulted in statistically significant improvements of BMD in lumbar spine and hip. The authors suggest that this program may be easiest, simplest and best program for implementation long-term.*

Meta-analysis of walking for preservation of bone mineral density in postmenopausal women34

* Meta-analysis carried out in line with Cochrane Collaboration guidelines
* 8 walking studies reviewed – 5 RCT studies and 3 non-randomized trials
* All utilized control groups
* Walking program amongst 8 studies varied (self-paced, brisk pace, pace based on heart rate, treadmill walking & outdoor walking)
  + 8 showed relative change in lumbar spine BMD of 0.39%
  + 5 studies examined femoral neck BMD – a relative change of 0.35%

*Author’s conclusions: walking as a singular exercise intervention is not sufficient to*

*preserve BMD at the spine or hip in post-menopausal women. The effects on BMD may be clinically too small to impact reduction of fractures.*

**Points to Ponder:**

Is improving BMD the only reason you would consider prescribing walking for your client? If you review research of the effect of prescription medications on BMD, the reports often demonstrate small changes in BMD but large increases in fracture risk reduction percentage. What does this suggest about focusing on BMD changes as the ultimate indicator of an intervention’s success?

**3.4 Other Research to Consider**

**The Potential of HIGH IMPACT Programs:**

The mechanostat theory16 dictates that bone adaptation is a response system likened to a thermostat in which a set point, or minimum effective strain (MES), is determined by

internal & external factors and therefore respond to loads above or below these MES points with either bone formation or resorption. Simply put, load the bone above its natural MES, and it will adapt the bone to support the new demand; conversely, unloading the bone (below its MES) and the BMD will decline to meet its new metabolic environment.

Animal studies have provided information regarding mechanical loading for optimal bone formation:

* Strain from loading must be of high magnitude.
* A high rate of strain provides a greater osteogenic stimulus than same peak strain achieved gradually.
* Bone adaptation is driven by unusual strain distributions and may stimulate an osteogenic response at a lower MES
* Cycles of loading are unimportant beyond a certain threshold30, 39,44

Human research of high-impact loading reveals:

* RCTs investigating brief, high-impact exercise in premenopausal women have shown significant improvements of hip and/or spine BMD1,2,28,52,54
* Similar programs applied to postmenopausal women do not show any significant trends to improving BMD2

**Bottom Line**

Theoretically, brief, unique, high impact exercise should induce bone formation. Research supporting this theory exists in

premenopausal women, however physiologic factors (i.e., hormonal, co-morbidities, aging) may prevent similar adaptations in older adults, and other factors (pain, restrictions with co-morbidities, fear etc.,) may prevent the safe or successful

implementation of high impact programs in older adults.



**Other POSITIVE EFFECTS of Exercise in OP:**

* Exercise reduces the risk of falls and fractures in osteopenic women already at risk24
* A 10-week comprehensive exercise & balance program reduced back pain, improved quality of life and balance33 in post-menopausal women with vertebral fractures
* A 12-week home-based trunk strengthening program enhanced quality of life in postmenopausal osteoporotic & osteopenic women11
* A low-intensity back strengthening exercise program effectively improved quality of life in osteoporotic patients23
* A recent Cochrane review 18 determined that multiple component group exercise, Tai Chi in a group, and individually prescribed multiple component home exercise all reduce the rates of falls and risk of falling.
* If the treatment goal is to prevent falls, a recent systematic review45 indicates that the inclusion of balance retraining in an exercise program is important. Furthermore, the criterion for a minimal effective exercise dose would equate to a twice weekly program over 25 weeks. Lastly, the study revealed that exercise programs which did not include walking were more effective in prevention of falls. Therefore, walking

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