

Osteoporosis: Pathology, Assessment & Management (non-live)

Goals and Objectives

Course Description

"Osteoporosis: Pathology, Assessment & Management (non-live)" is an online recorded video of a previously presented live CE webinar for occupational therapists and occupational therapy assistants that presents contemporary information about osteoporosis. This course includes discussion of pathogenesis, etiology, diagnostic tests, pharmacological management, and therapeutic considerations for patients with this condition.

Course Rationale

The purpose of this course is to provide participants with contemporary information about the osteoporosis. Rehabilitation professionals can use this information when implementing their treatment programs to address the specific needs of individuals effected by this condition.

Course Goals and Objectives / Learning Outcomes

Upon completion of this course, participants will be able to:

1. Compare normal bone development with skeletal fragility and bone loss.
2. Distinguish primary, secondary, juvenile, and organ transplant osteoporosis.
3. Describe pathogenesis of secondary osteoporosis and underlying disease mechanisms.
4. Identify common fractures associated with osteoporosis.
5. Distinguish diagnostic tests utilized for bone density measurement.
6. Identify clinical risk assessment tools to assess osteoporosis and fracture risk.
7. Detail screening indications, diagnostic classifications, and treatment thresholds.
8. Identify common adverse reactions from medications prescribed to manage osteoporosis.
9. Describe lifestyle and dietary modifications implemented to manage disease progression.
10. Identify fracture prevention strategies including use of fall risk assessment and benefits of exercise.

Course Provider – Innovative Educational Services

Provider Contact Information – information@cheapceus.com

Course Instructor - Jodi Gootkin, PT, MEd, CEAS

Conflict of Interest – No financial or non-financial conflict of interest exists for the presenter or provider of this course.

Target Audience – Occupational Therapists, Occupational Therapy Assistants

Course Educational Level – This course is applicable for introductory learners.

Course Prerequisites – None

Method of Instruction – Recorded on-demand video

Location - Cheapceus.com

Date – Available continuously on-demand

Course Completion Requirements / Criteria for Issuance of CE Credits – Viewing of the 3-hour recorded video in its entirety, and scoring 70% correct or greater on the course post-test

Continuing Education Credits – Three (3) contact hours / .3 AOTA CEUs

Course Fee - \$34.95

Registration Information – This activity is offered on-demand and does not require registration in advance by the learner. Learners may participate anytime in this activity by going to: cheapceus.com

Special Needs Requests – Email: information@cheapceus.com or phone: 954-663-4101

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Refund Policy - Unrestricted 100% refund upon request. The request for a refund by the learner shall be honored in full without penalty or other consideration of any kind. The request for a refund may be made by the learner at any time without limitations before, during, or after course participation.



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Osteoporosis: Pathology, Assessment & Management

Live Interactive Webinar Presented By
Jodi Gootkin, PT, MED, CEAS
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Course Overview

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Goals and Objectives

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▶ Application of concepts presented in this webinar is at the discretion of the individual participant in accordance with federal, state, and professional regulations.

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Course Outline and Schedule

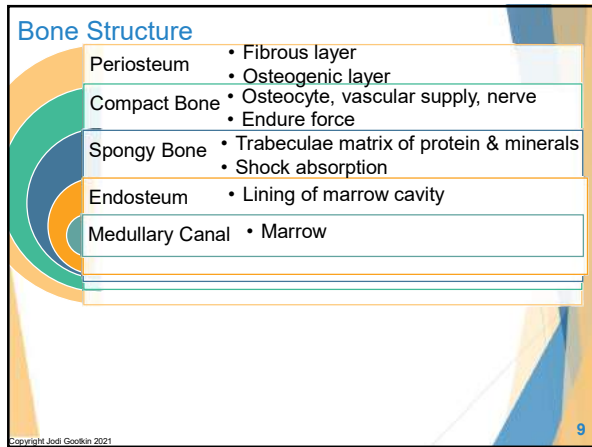



Topic	Time
Healthy Bone Development	0:00-0:10
Types of Osteoporosis	0:11-0:15
Risk Factors	0:16-0:20
Primary Pathogenesis	0:21-0:30
Secondary Underlying Disease Pathogenesis	0:31-0:40
Secondary Medication Associated	0:41-0:45
Juvenile and Organ Transplant	0:46-0:50
Interactive Discussion of Clinical Applications	0:51-0:60
Consequences of Osteoporosis	1:00-1:05
Fracture Related Morbidity and Mortality	1:06-1:10
Vertebral and Hip Fracture	1:11-1:20
Osteoporosis Screening	1:21-1:25
Diagnostic Tests and Classifications	1:26-1:40
Clinical Risk Assessment Tools	1:41-1:50
Interactive Discussion of Clinical Applications	1:51-2:00
Pharmacologic Management	2:01-2:05
Medications and Adverse Effects	2:06-2:15
Supplements and Diet Recommendations	2:16-2:25
Fall Risk Assessment and Management	2:26-2:35
Exercise Considerations and Outcomes	2:36-2:50
Interactive Discussion of Clinical Applications	2:51-3:00

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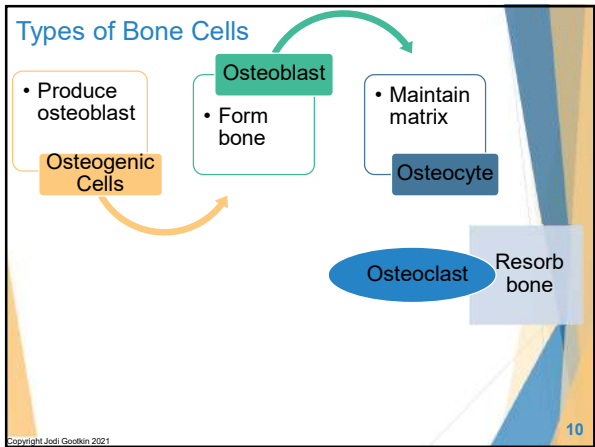
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Facts

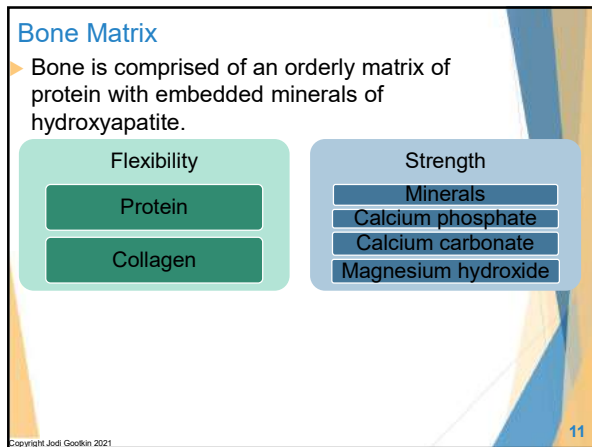
- ▶ By 2020, approximately 12.3 million individuals in the US over age 50 will have osteoporosis.
- ▶ 21% - 31% of individuals who sustain a hip fracture die within 1 year.
- ▶ 71% of osteoporotic fractures occur in women, but men have a higher fracture-related mortality rate.
- ▶ Current research on screening benefits and effectiveness of management strategies for men is insufficient.

Curry, S. J., Krist, A. H., Owens, D. K., Barry, M. J., Coughney, A. B., Davidson, K. W., ... & Landefeld, C. S. (2018). Screening for osteoporosis to prevent fractures: US Preventive Services Task Force recommendation statement. *Jama*, 319(24), 2521-2531.

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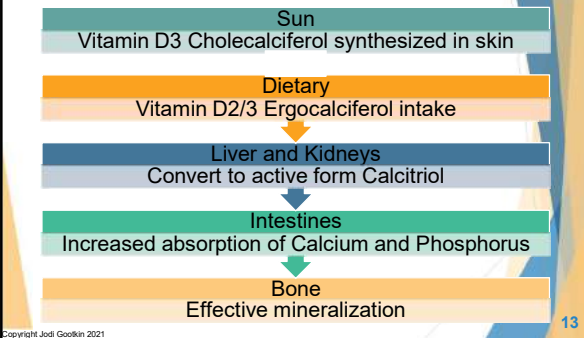
Normal Bone Remodeling

- ▶ A balanced process to maintain bone where osteoclasts resorb bone which is replaced with new bone by osteoblasts.
- ▶ When bone is subject to impact, bone cells are signaled to replace the damaged bone.
- ▶ The process to slow osteoclast activity occurs through programmed cell death.
- ▶ The body relies on Vitamin D and Calcium to develop and maintain mineralization of bone.

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Role of Vitamin D



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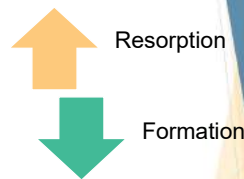
Metabolic Bone Disease (MBD)

- ▶ Classification of conditions presenting with diminished bone strength caused by abnormalities of mineral homeostasis.
 - ▶ Osteoporosis
 - ▶ Osteomalacia
 - ▶ Paget's disease
 - ▶ Osteogenesis imperfecta

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Osteoporosis

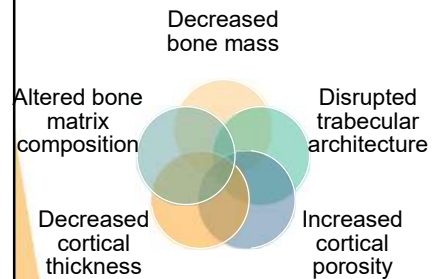
- ▶ A disorder of the skeletal system characterized by decreased bone mass and quality leading to bone fragility and increased risk of fractures.



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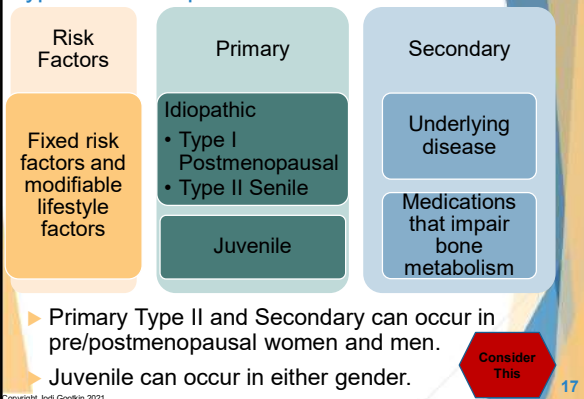
Abnormal Bone Remodeling

- ▶ High bone turnover occurs when resorption is greater than bone formation contributing to decreased bone strength.



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Types of Osteoporosis



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Risk Factors

- ▶ Fixed risk factors
 - ▶ Female Gender
 - ▶ Age
 - ▶ Dark complexion
- ▶ Modifiable lifestyle risk factors
 - ▶ Low body weight
 - ▶ Excessive caffeine consumption
 - ▶ Smoking and Alcohol abuse
 - ▶ Low Calcium, Phosphorus and Vitamin D diet
 - ▶ Sedentary and/or indoor lifestyle

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Smoking

- Nicotine and cadmium found in cigarettes can have a direct toxic effect on bone cells.
- Additional risk factors associated with individuals who smoke may contribute.

Decreased calcium absorption
Smoking
Decreased vascular supply
Slower osteoblast production
Diminished estrogen levels

Li, H., Wallin, M., Barnegard, L., Sallsten, G., Lundh, T., Ohlsson, C., ... & Andersson, E. M. (2020). Smoking-induced risk of osteoporosis is partly mediated by cadmium from tobacco smoke: The MDCS Sweden Study. *Journal of Bone and Mineral Research*. UCI Health <https://www.ucihealth.org/blog/2018/11/smoking-bone-health> - text=Smoking%20decreases%20the%20body%20absorption%20of%20calcium%20in%20women%20and%20men.

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Primary Type I (Postmenopausal) Pathogenesis

- After menopause, the protective effects of estrogen on bone are lost.

Increased bone resorption due to less inhibition of osteoclasts
Decreased bone formation due to decreased osteoblast production with shorter life span
Trabecular bone damage

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Primary Type II (Senile) Pathogenesis

- Occurs in both men and women.
- Bone density declines continuously with aging as bone formation lags behind resorption.

Age-related calcium deficiency
Lower remodeling rate
Decreased bone formation
Trabecular and cortical damage

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Female Prevalence

Rapid loss postmenopause
Slow loss with aging
Longer life span
Osteoporosis more common in women

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Juvenile Osteoporosis

- Idiopathic osteoporosis occurring during critical bone development years influences bone mass into adulthood.
- Vertebral compression fractures in the absence of local disease or high-energy trauma may be indicative of osteoporosis.

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International Society for Clinical Densitometry. (2019). 2019 ISCD Official Positions - Pediatric.

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Secondary Osteoporosis Etiology: Underlying Disease

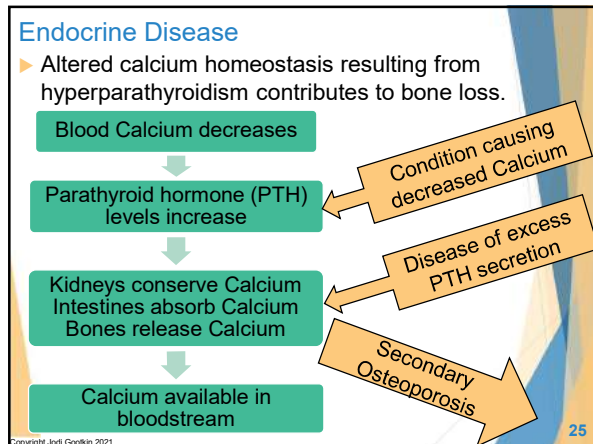
- Endocrine disease
 - Hyperthyroidism, hypogonadism, hyperparathyroidism, diabetes mellitus
- Gastrointestinal, Hepatic and Nutritional Disorders
 - Celiac disease, Crohn's disease, inflammatory bowel disease, gastric bypass surgery, anorexia nervosa, bulimia, cystic fibrosis, liver disease
- Renal Disorders
 - Chronic kidney disease
- Autoimmune disorders
 - Rheumatoid arthritis, systemic lupus erythematosus

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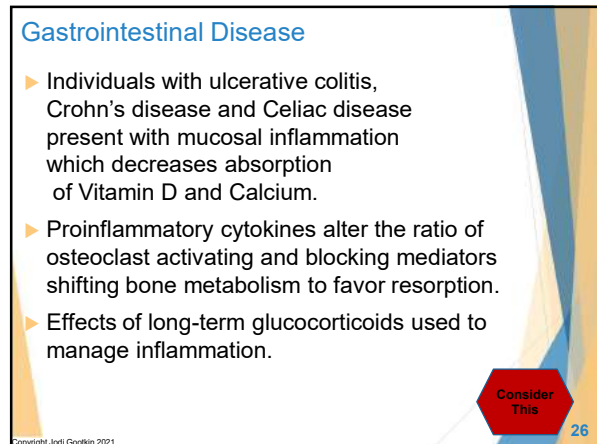
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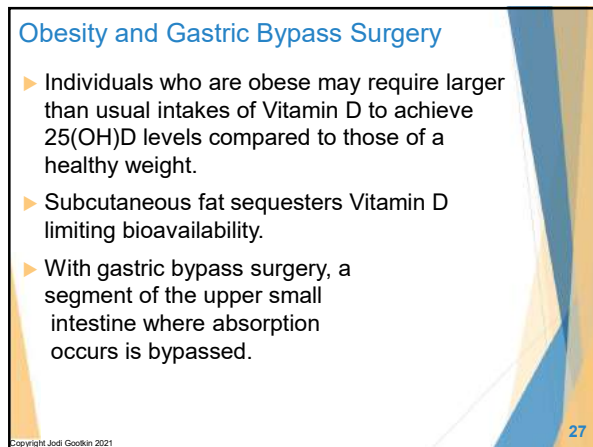
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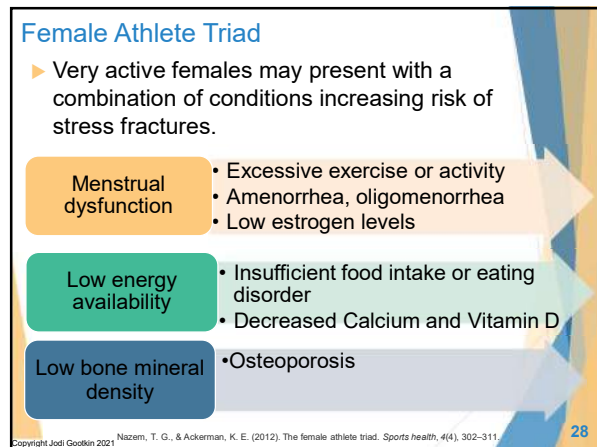
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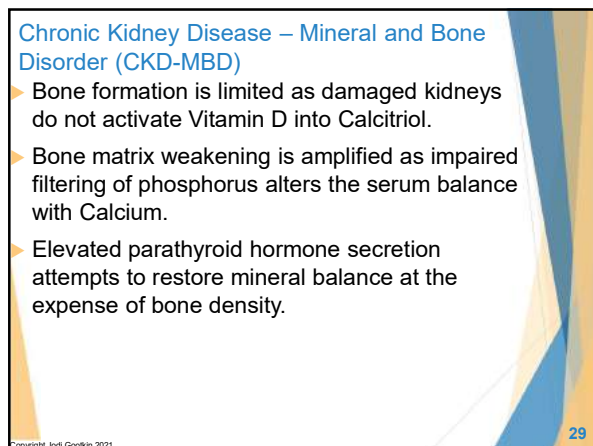
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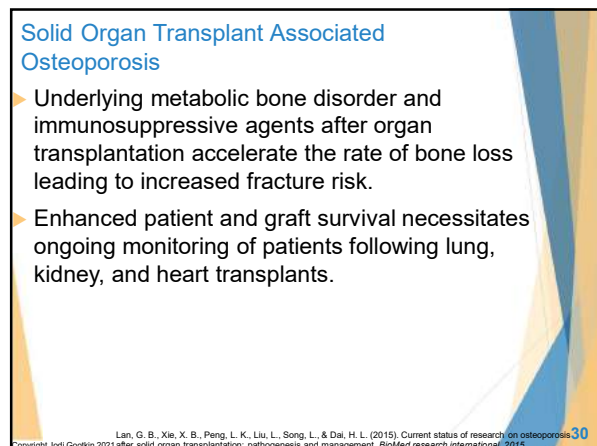
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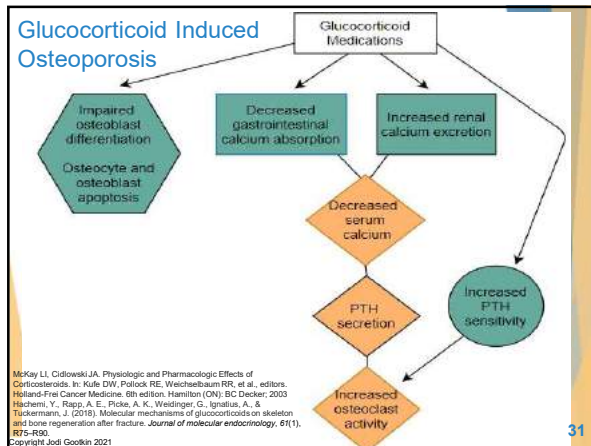


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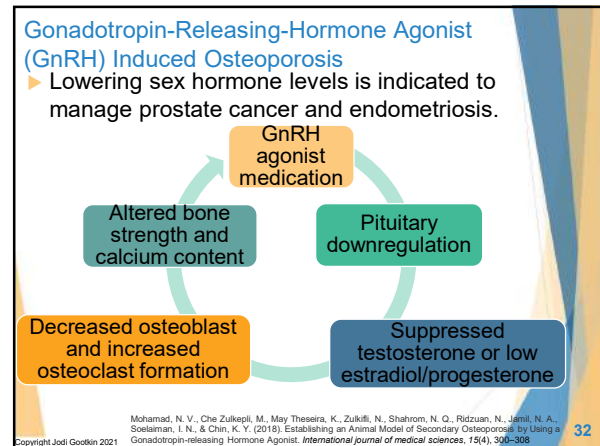


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Genetic Susceptibility

- Research is exploring osteoporosis as a complex polygenic disease with genetic and epigenetic mechanisms contributing to susceptibility and development.
 - Postmenopausal – PDLIM4 gene
 - Juvenile - LRP5 gene

Deng, H., Zhou, W., Wang, P., Zuo, E., Ying, X., Chai, S., ... & Liu, H. (2020). Comprehensive Analysis of the Genetic and Epigenetic Mechanisms of Osteoporosis and Bone Mineral Density. *Frontiers in Cell and Developmental Biology*, 8, 194. <https://doi.org/10.3389/fcell.2020.00194> <https://pubmed.ncbi.nlm.nih.gov/condition/juvenile-primary-osteoporosis/#genes> Copyright Jodi Gootkin 2021

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Consequences of Osteoporosis: Fractures

- Osteoporotic fracture – fractures associated with low bone mineral density.
- Fragility fracture - Fracture from forces that would not ordinarily result in injury or without identifiable trauma.
 - Low-energy from standing height or less

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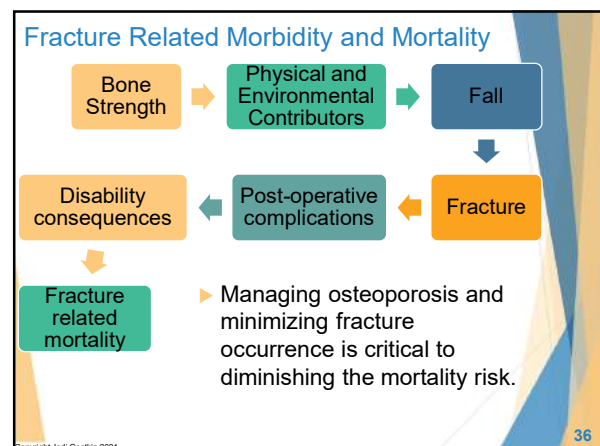
Fragility Fractures

- Fractures are more common in cancellous bones due to the higher turnover rate.
- Type I – postmenopause individuals most often sustain wrist/forearm and spine/vertebrae (cancellous bone)
- Type II – Senile individuals most often sustain hip/femur, pelvis, proximal humerus and spine/vertebrae (cortical and cancellous)

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Fracture Healing

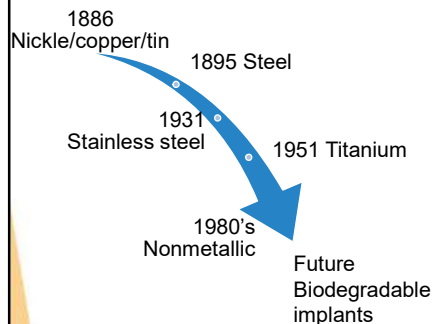
- ▶ Deterioration of bony architecture presents challenges for fracture healing.
 - ▶ Implant anchoring
 - ▶ Hardware ingrowth
 - ▶ Bony union
- ▶ Failure may be attributed to decreases in the quality of new bone formed at the fracture site.
 - ▶ Callus area
 - ▶ Mineral density
 - ▶ Peak failure load
 - ▶ Bending stiffness

Copyright Jodi Gootkin 2021 Feron, J. (2014). Fracture consolidation and osteoporosis. *Medicographia*, 36, 156-162.

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Internal Fixation Hardware



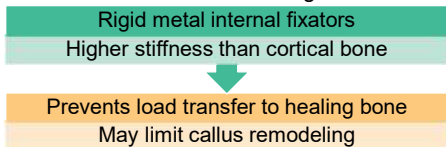
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Fracture Management Considerations

- ▶ Decreased cellular responsiveness, prolonged reaction and healing phases combined with rigid metal implants create an unfavorable environment for bone remodeling.



Tian, L., Tang, N., Ngai, T., Wu, C., Ruan, Y., Huang, L., & Qin, L. (2019). Hybrid fracture fixation systems developed for orthopaedic applications: A general review. *Journal of orthopaedic translation*, 16, 1-13.

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Hydroxyapatite-Coated Screws

- ▶ Fragile bone can lead to loosening of screws and loss of correction with repetitive loading.
- ▶ Screws coated with hydroxyapatite (HA) can stimulate bone ingrowth at the bone-implant interface producing greater osseointegration.

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Fracture Fixation Future Advances

- ▶ Stabilization permitting controlled interfragmentary micromotion can enhance cortical healing of deteriorated bone structure.
- ▶ Research is exploring how Magnesium in hybrid fixation hardware can biodegrade over time providing less fixation stability as healing occurs.
- ▶ Magnesium ions are demonstrating beneficial osteogenic effects.

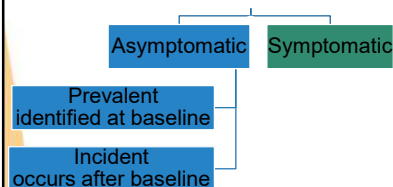
Wang, J. L., Xu, J. K., Hopkins, C., Chow, D. H. K., & Qin, L. (2020). Biodegradable Magnesium-Based Implants in Orthopedics—A General Review and Perspectives. *Advanced Science*, 7(8), 1902043.

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Vertebral Compression Fracture (VCF)

- ▶ May be clinically silent only associated with postural changes, limited activity, or development of restrictive lung disease.
- ▶ Diagnosed by at least a 20% or 4mm decrease in bone height.



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Iliocostal Friction Syndrome (ICFS)

- ▶ Vertebral compression fractures narrow the space between the lowest anterior rib and the top of the iliac crest.
- ▶ Patient presents with unexplained flank and/or back pain.

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VCF Genant Classification

Grade	Description
Grade 0	normal
Grade 1	mild fracture, <25% loss of height
Grade 2	25% to 40% loss of height
Grade 3	>40% loss of height

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Vertebral Fracture Rehabilitation

- ▶ Spinal extension exercises are favored.
- ▶ Education on bone-safe body mechanics.
- ▶ Research suggests that bracing associated postural alignment and gait mechanics improvements require continued strengthening to be maintained.

Garg, B., Dixit, V., Batra, S., Malhotra, R., & Sharan, A. (2017). Non-surgical management of acute osteoporotic vertebral compression fracture: A review. *Journal of clinical orthopaedics and trauma*, 8(2), 131–138.
Jacobus, E., Senden, R., McCrum, C., van Rhijn, L. W., Meijer, K., & Willems, P. C. (2019). Effect of a semirigid thoracolumbar orthosis on gait and sagittal alignment in patients with an osteoporotic vertebral compression fracture. *Clinical interventions in aging*, 14, 671–680.

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Vertebroplasty

- ▶ Injection of bone cement into the crushed vertebral body through posterior cannulas to stabilize loose bone fragments.

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Kyphoplasty

- ▶ Expansion of the compressed vertebral cavity to restore lost height allowing improved sagittal spinal alignment.

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Spinal Instrumented Fusion

- ▶ Osteoporotic patients presenting with spinal stenosis and spondylolisthesis may require pedicle screw fixation to stabilize the spine.
- ▶ HA coated pedicle screws demonstrate greater pull-out resistance and stronger anchoring that contributes to improved ability to withstand repetitive loading over time.

Che, M., Mordaira, H., Inami, S., Takeuchi, D., Nohara, Y., & Taneichi, H. (2018). Pedicle screws with a thin hydroxyapatite coating for improving fixation at the bone-implant interface in the osteoporotic spine: experimental study in a porcine model. *Journal of Neurosurgery: Spine*, 28(6), 679-687.

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Hip Fracture

- ▶ Mechanism of injury, presence of osteoporosis and fall risk should be considered for patients presenting with hip fractures.

Fracture location	Internal Fixation
Femoral neck nondisplaced	Cannulated screw
Femoral neck displaced	Closed reduction and percutaneous pinning Sliding hip screw Hemi/total arthroplasty
Intertrochanteric	Sliding hip screw
Subtrochanteric	Intramedullary nail

Cannada, L. K. & Hill, B. W. (2014). Osteoporotic Hip and Spine Fractures: A Current Review. *Geriatric orthopaedic surgery & rehabilitation*, 5(4), 207-212.

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Osteoporosis Screening

- Bone Mineral Density (BMD) Measurement
 - Bone densitometry to assess bone integrity

And / Or

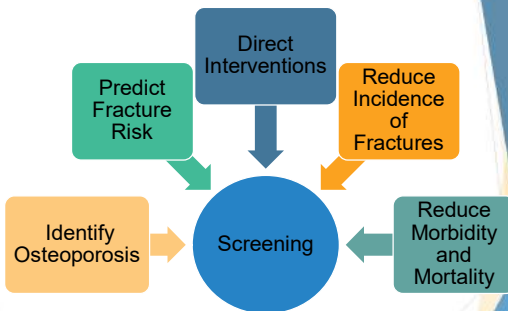
- Clinical Risk Assessments
 - Tools to identify individuals at risk of osteoporosis development or osteoporotic fracture occurrence.

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Benefits of Early Detection



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Bone Mineral Density Measurement Screening Indications

- ▶ Women 65 years and older
- ▶ Men 70 and older
- ▶ Women younger than 65 years with risk factors including postmenopause
- ▶ Men younger than 70 with risk factors
- ▶ Adulthood hip or vertebral fracture in the absence of major trauma

<https://www.cdc.gov/genomics/disease/osteoporosis.htm>
<https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/osteoporosis-screening1>
<https://link.springer.com/article/10.1007/s00198-014-2794-2>

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Screening Intervals

- ▶ National Osteoporosis Foundation (NOF) recommends bone mineral density (BMD) measurement 1-2 years after initiating medical management and ever 2 years thereafter.
- ▶ Screening for early detection does not appear to have negative impacts on anxiety or quality of life.

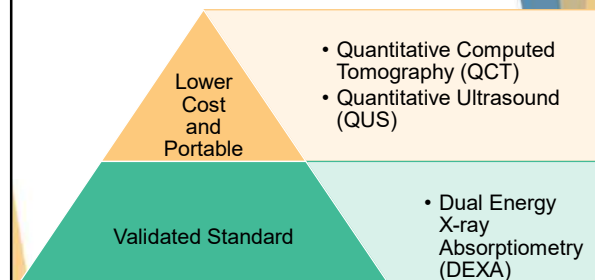
Shepstone, L., Lenaghan, E., Cooper, C., Clarke, S., Fong-Soe-Khoo, R., Fordham, R., ... & Holland, R. (2018). Screening in the community to reduce fractures in older women (SCOOP): a randomised controlled trial. *The Lancet*, 391(10122), 741-747.

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Bone Mineral Density (BMD) Measurement



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Dual Energy X-ray Absorptiometry (DEXA)

- ▶ A type of low-level x-ray utilized to measure bone mass based on energy absorption by Calcium in the bone matrix.
- ▶ DEXA testing is the standard for osteoporosis diagnosis and used to determine treatment thresholds for drug therapies.

Central

- Hip
- Lumbar Spine

Peripheral

- Radius
- Calcaneus

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Diagnostic Criteria

- ▶ Bone Mineral Density (BMD) values from DEXA are utilized for diagnosis and to establish treatment guidelines.

Bone Mineral Density (BMD)

- Measured in g/cm^2
- Expressed as standard deviation (SD) above or below mean BMD of reference population

T-score

- Comparison to young adult reference population of the same sex

Z-score

- Comparison to age, sex, and ethnicity matched reference population

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Z-scores

- ▶ Z-scores are correlated with other diagnostic testing and clinical assessments to diagnose osteoporosis in premenopausal women, men younger than 50 years old, and children.

Definition	Z-score
Within the expected range for age	above -2.0
Below the expected range for age	-2.0 or lower

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World Health Organization (WHO) Diagnostic Classification

	DEXA BMD Measurement Definition	T-Score
Normal	Within 1 SD of mean bone density for young adult women	≥ -1
Low mass (osteopenia)	1–2.5 SD below mean for young-adult women	Between -1 and -2.5
Osteoporosis	≥ 2.5 SD below normal mean for young-adult women	≤ -2.5
Severe or "established" osteoporosis	≥ 2.5 SD below normal mean for young-adult women in a patient who has already experienced ≥ 1 fractures	≤ -2.5

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World Health Organization. (2004, May). WHO scientific group on the assessment of osteoporosis at primary health care level. In Summary meeting report (Vol. 2015). Copyright Jodi Gootkin 2021

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Quantitative Ultrasound (QUS)

- ▶ Evaluates bone quality at peripheral sites while avoiding radiation exposure, allowing portability, and increasing affordability of screening.

Measures speed of sound (SOS) through bone and broadband ultrasound attenuation (BUA)

Formula calculates equivalent T-score

Komar, C., Ahmed, M., Chen, A., Richwine, H., Zia, N., Nizar, A., & Bauer, L. (2019). Advancing methods of assessing bone quality to expand screening for osteoporosis. J. Am. Osteopath. Assoc., 119, 142-154. Copyright Jodi Gootkin 2021

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Quantitative Computed Tomography (QCT)

- ▶ Scanning provides a true volumetric measurement of cancellous bone density.
- ▶ Performed of the spine (axial QCT) or peripherally of an extremity (pQCT).

Trabecular Spine	WHO Equivalent
Greater than 120 mg/cm^3	Normal
80 mg/cm^3 to 120 mg/cm^3	Osteopenia
Less than 80 mg/cm^3	Osteoporosis

American College of Radiology. (2018) ACR-SPR-SSR Practice Parameter for the performance of musculoskeletal QCT. Copyright Jodi Gootkin 2021

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Dental Radiographs

- ▶ Emerging research identifies a correlation between hip and mandibular bone density.
- ▶ Dental Panoramic Radiographs (DPR) have the potential to serve as an early detector of osteoporosis.

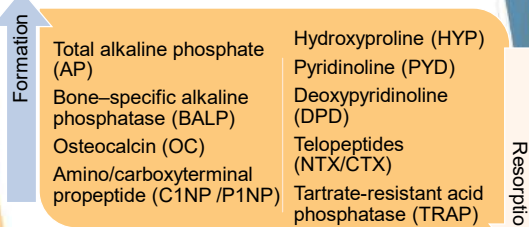
Yeung, A. W. K., & Mozos, I. (2020). The Innovative and Sustainable Use of Dental Panoramic Radiographs for the Detection of Osteoporosis. *International Journal of Environmental Research and Public Health*, 17(7), 2449. Copyright Jodi Gootkin 2021

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Biochemical Markers

- ▶ Examination of blood and urine levels of bone turnover markers provides insight into the rate of bone metabolism to monitor disease progression and medication effectiveness.



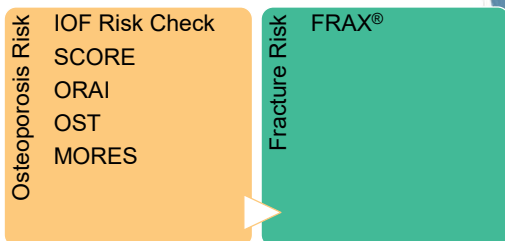
Kuo, T., Chen, C. Bone biomarker for the clinical assessment of osteoporosis: recent developments and future perspectives. *Biomark Res* 5, 18 (2017). Copyright Jodi Gootkin 2021

62

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Clinical Risk Assessment Tools

- ▶ All tools appear to perform similarly in their ability to identify individuals at risk for development of osteoporosis.



Viswanathan, M., Reddy, S., Berkman, N., Cullen, K., Middleton, J. C., Nicholson, W. K., & Kahwati, L. C. (2018). Screening to prevent osteoporotic fractures: updated evidence report and systematic review for the US Preventive Services Task Force. *Jama*, 319(24), 2532-2551. Copyright Jodi Gootkin 2021

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International Osteoporosis Foundation (IOF) Risk Check

- ▶ Online questionnaire considering age, personal and family fracture history, BMI, height loss, medical conditions, alcohol consumption and smoking,
- ▶ Provides information and indicates if risk factors are present with recommendation to consult physician.

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Simple Calculated Osteoporosis Risk Estimation (SCORE)

- ▶ Considers risk factors of age, weight, estrogen, race, rheumatoid arthritis, and fracture history to produce an osteoporosis risk score.

Low risk: scores of 6 and below

- ▶ Moderate risk: scores between 7 and 15
- ▶ High risk: scores of 16 and above

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Osteoporosis Risk Assessment Instrument (ORAI)

- ▶ Calculates scores based on age, weight, and current estrogen use.
- ▶ Bone densitometry indicated if total score is greater than or equal to 9.

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Osteoporosis Self-Assessment Tool (OST)

- ▶ Based only on two factors of age and weight.
- ▶ Low risk: greater than 2
- ▶ Moderate risk: 1 to -3
- ▶ High risk: greater than -4
- ▶ Bone densitometry indicated for scores less than 2

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Male Osteoporosis Risk Estimation Score (MORES)

- ▶ Uses age, weight and COPD history to predict osteoporosis risk in men.
- ▶ Scores greater than or equal to 6 are considered positive for increased risk.

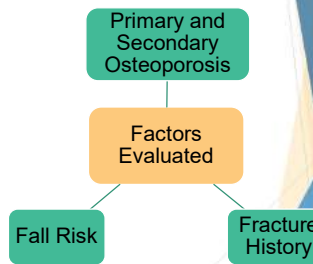
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Fracture Risk Assessment

- ▶ Information gathered from physical examination, diagnostic tests and patient history contribute to risk assessment for fragility fracture.



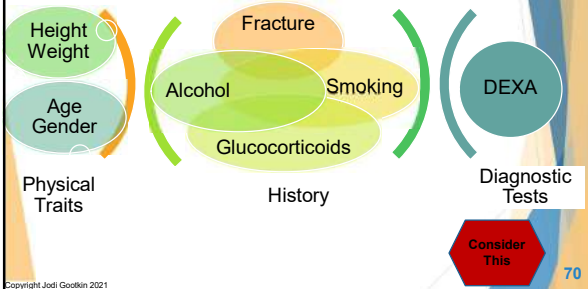
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FRAX® Fracture Risk Assessment Tool

- ▶ Evaluates fracture risk based on clinical risk factors and bone mineral density to determine 10-year probability of fracture.

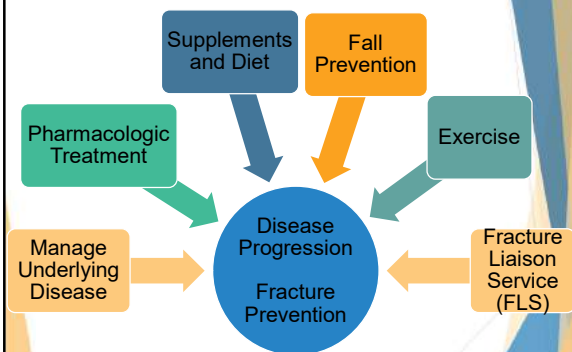


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Multi-Modal Osteoporosis Management



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Pharmacologic Treatment Thresholds

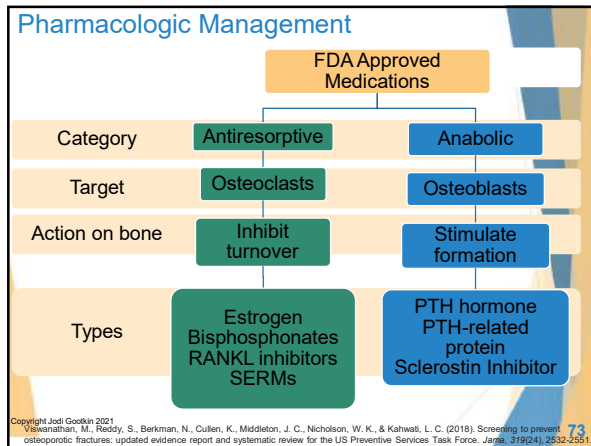
- ▶ Thresholds for intervention with medications are based on BMD testing.
- ▶ The National Osteoporosis Foundation (NOF) recommends pharmacologic treatment:
 - ▶ Clinical or asymptomatic hip or vertebral fractures
 - ▶ T-scores ≤ -2.5
 - ▶ Postmenopausal women and men age 50 or older with T-score -1.0 to -2.5 AND 10 year fracture probability $\geq 3\%$ or FRAX® $\geq 20\%$

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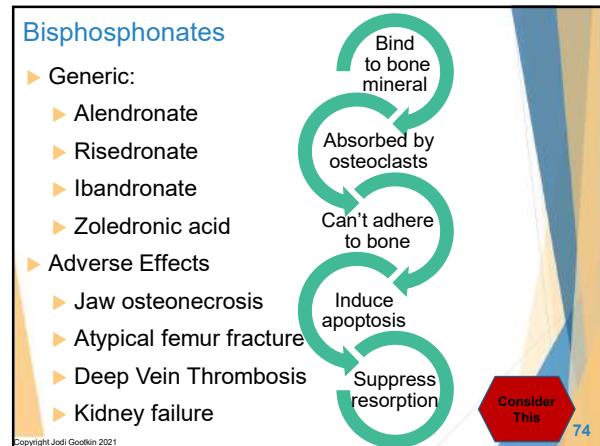
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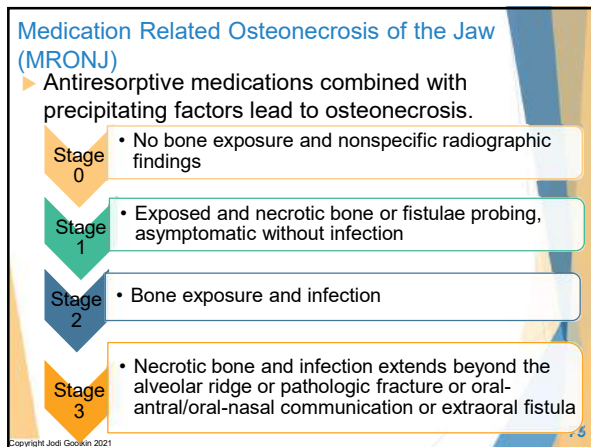
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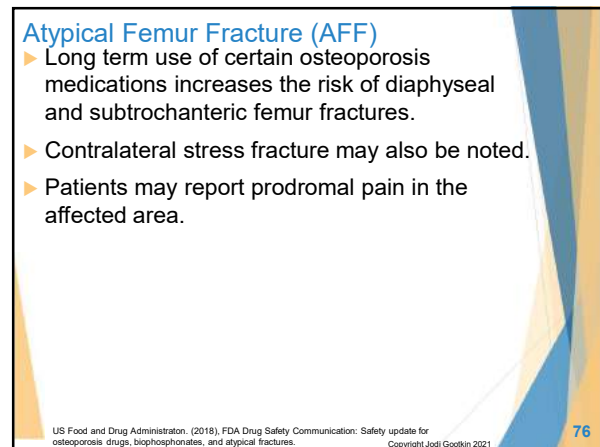
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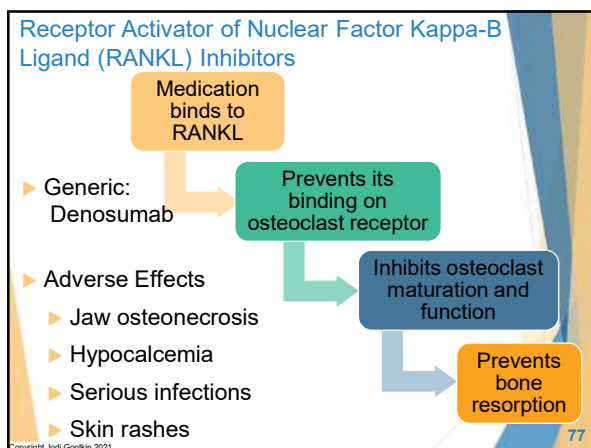
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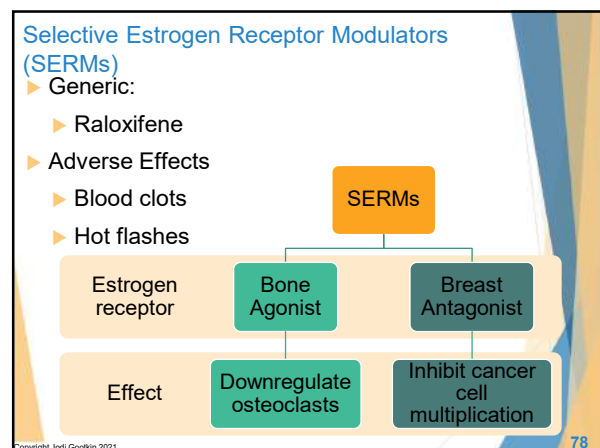
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Parathyroid Hormone (PTH) and Parathyroid Hormone-Related Protein (PTHrp)

- ▶ Generic:
 - ▶ Teriparatide
 - ▶ Abaloparatide
- ▶ Adverse Effects
 - ▶ FDA Blackbox Warning: Osteosarcoma
 - ▶ Not recommended for use beyond 2 years

PTH → Increased osteoblast number and function → Encourage calcium and phosphate deposition → Increased trabecular and cortical bone formation

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Sclerostin Inhibitor

- ▶ Generic: Romosozumab
- ▶ Adverse Effects
 - ▶ FDA Blackbox Warning: Myocardial infarction, stroke, and cardiovascular death
 - ▶ Treatment limited to 12 months
 - ▶ Atypical femur fracture
 - ▶ Jaw osteonecrosis
 - ▶ Hypocalcemia

Osteoblast activity ↑
Blocks protein that normally "turns off" osteoblasts
↓
Osteoclast activity ↓

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Drug Therapy Fracture Outcomes in Women

- ▶ In postmenopausal women, medications are effective at managing osteoporosis and preventing fractures.

Medication	Reduced	No Change
Bisphosphonates	Vertebral and nonvertebral	Hip
SERMs	Vertebral	Nonvertebral
RANKLs	Vertebral, nonvertebral, hip	
PTH	Vertebral	Nonvertebral

United States Preventive Services Task Force. Final Recommendation Statement Osteoporosis to Prevent Hip Fractures: Screening. Recommendations Summary. Copyright, Jodi Gootkin 2021 81

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Drug Therapy Fracture Outcomes in Men

- ▶ Evidence on successful pharmacological management in men is limited.

Medication	Reduced	No Change
Bisphosphonates	Vertebral	Nonvertebral
Parathyroid Hormone		Nonvertebral

United States Preventive Services Task Force. Final Recommendation Statement Osteoporosis to Prevent Hip Fractures: Screening. Recommendations Summary. Copyright, Jodi Gootkin 2021 82

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Calcium Intake Recommendations

- 1-3 years: 700 mg/day
- 4-8 years: 1000 mg/day
- 9-18 years: 1300 mg/day
- 19-50 years women: 1000 mg/day
- 19-70 years men: 1000 mg/day
- Men 70+ years: 1200 mg/day
- 51+ women postmenopausal women: 1200 mg/day

Cosman, F., de Beur, S. J., LeBoff, M. S., Lewicki, E. M., Tanner, B., Randall, S., & Lindsay, R. (2014). Clinician's guide to prevention and treatment of osteoporosis. Osteoporosis international, 25(10), 2359-2381. International Osteoporosis Foundation Osteoporosis Prevention. https://www.iofbonehealth.org/osteoporosis-musculoskeletal-disorders/osteoporosis/prevention/Calcium Copyright, Jodi Gootkin 2021 83

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Calcium Sources

- ▶ The most readily available dietary sources of Calcium are milk and dairy products, some green vegetables and fruits, canned fish, nuts and fortified foods.

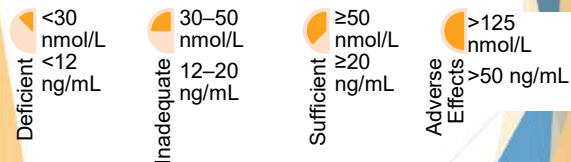
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Vitamin D Bioavailability

- ▶ 25-hydroxyVitamin D is the circulating form of Vitamin D that reflects the level of cutaneous synthesis and nutritional intake.
- ▶ Sufficient serum 25(OH)D concentrations are required for bone remodeling.

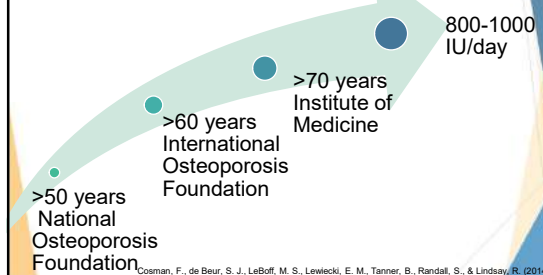


Copyright Jodi Gootkin 2021 <https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/> 85

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Vitamin D Intake Recommendations

- ▶ Individuals with primarily indoor lifestyles require higher dietary intake to achieve sufficient levels.

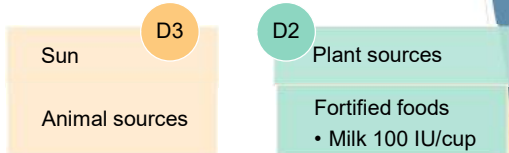


Copyright Jodi Gootkin 2021 Cosman, F., de Beur, S. J., LeBoff, M. S., Lewiecki, E. M., Tanner, B., Randall, S., & Lindsay, R. (2014). Clinical's guide to prevention and treatment of osteoporosis. *Osteoporosis International*, 25(10), 2359-2380. <https://www.iofbonehealth.org/osteoporosis-musculoskeletal-disorders/osteoporosis/prevention/vitamin-d> 86

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Vitamin D Sources

- ▶ Nutritional doses of Vitamin D2 and D3 appear to be equivalent but at high doses Vitamin D2 is less potent.



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Vitamin D for Fracture Prevention

- ▶ USPSTF recommendation:
 - ▶ Inconclusive evidence of the benefits for men and premenopausal women.
 - ▶ For postmenopausal women, moderate evidence 400 IU or less has no benefit and insufficient evidence for dosages greater than 400 IU.

United States Preventive Services Task Force. (April 2018) Final recommendation statement Vitamin D, Calcium, or combined supplementation for the primary prevention of fractures in community-dwelling adults: Preventive medication.

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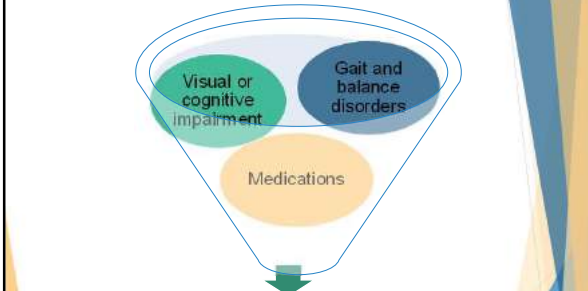
Potential Harm of Supplements

- ▶ Patients taking combined Vitamin D and Calcium should be monitored for renal calculi.

United States Preventive Services Task Force. (April 2018) Final recommendation statement Vitamin D, Calcium, or combined supplementation for the primary prevention of fractures in community-dwelling adults: Preventive medication. Copyright Jodi Gootkin 2021 89

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Fall Risk Assessment



- ▶ The multiple variables that contribute to increased risk of falls must be considered to develop comprehensive rehabilitation programs.

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Postural Hypotension Assessment

1. Have the patient lie supine for 5 minutes
2. Measure blood pressure and pulse rate
3. Have the patient stand
4. Immediately measure blood pressure and pulse rate.
5. Stand for 3 minutes and measure vital signs

Positive for postural hypotension if:

- ▶ Systolic drops ≥ 20 mm Hg and/or diastolic blood pressure that drops ≥ 10 mm Hg
- ▶ Patient reports vertigo or lightheadedness

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Fall Risk Assessment Tools

- ▶ Timed Up and Go Test (TUG)
 - ▶ Score ≥ 12 seconds signifies high risk
 - ▶ Note characteristics such as “en bloc turning”
- ▶ 30-Second Chair Stand Test
 - ▶ Score below average for age and gender.
- ▶ The 4-Stage Balance Test
 - ▶ Narrow base, instep to big toe, tandem, single leg
 - ▶ Inability to hold the tandem stance for 10 seconds.

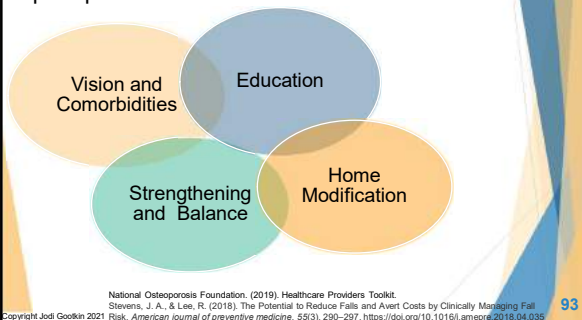
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Fall Prevention Program Components

- ▶ Fall risk self-assessments (Check Your Risk for Falling) can aid in educating patients and prompt discussion and action.



National Osteoporosis Foundation. (2019). Healthcare Providers Toolkit. Stevens, J. A., & Lee, R. (2018). The Potential to Reduce Falls and Avert Costs by Clinically Managing Fall Risk. *American journal of preventive medicine*, 55(3), 290-297. <https://doi.org/10.1016/j.amepre.2018.03.033>

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Visual Impairment Adaptations

- ▶ Color perception and contrast sensitivity deterioration limits ability to distinguish colors.
 - ▶ Blue, purple and green
 - ▶ Navy blue, brown, black
- ▶ Depth perception impairment causes difficulty distinguishing surfaces that are not high-contrast colors or contain contrast borders.

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Hip Protectors

- ▶ Padded shorts or underwear worn to help prevent fractures by distributing the force of a fall on the hip to the surrounding soft tissues.

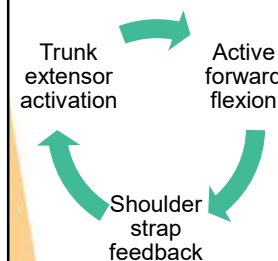
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Activating Spinal Orthosis

- ▶ The orthosis incorporates a steel rail from C7 to the sacrum with straps around the shoulders and fastening around the pelvis.



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Bone-Safe Body Mechanics

- ▶ Avoid slouching, forward bending from trunk, twisting and combined motions with force.
- ▶ Ensure proper posture, good base of support and do not pull on rail to negotiate stairs.
- ▶ Sleep side lying in bed with pillow between knees.
- ▶ Modifications or alternatives to high-impact activities and those that place excessive force or stress across joints.

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Exercise

- ▶ NOF recommends 30 minutes of weight-bearing exercise on most days of the week and 2 or 3 days of muscle strengthening, and balance, posture and functional exercise daily.
- ▶ Fracture risk should be considered.

Low

No osteoporosis with normal BMD and no fall/fracture risk factors

Maximize bone mass and strength

Moderate

Low bone mass and/or clinical or functional risk factors for fracture

Preserve or improve bone mass and strength

High

Osteoporosis, previous fracture and/or multiple risk factors for fracture.

Preserve or improve bone mass and strength

National Osteoporosis Foundation. (2019). Healthcare Providers Toolkit.
Beck BR, et al. (2016) Exercise and Sports Science Australia (ESSA) position statement on exercise prescription for the prevention and management of osteoporosis. J Sci Med Sport

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Exercise Prescription Considerations

- ▶ To be osteogenic exercise should be:
 - ▶ Dynamic intermittent vs. static loads
 - ▶ Magnitude for progressive overload
 - ▶ Applied in diverse loading patterns
 - ▶ Applied with few loading cycles of adequate intensity
- ▶ Prioritize mode of exercise based on impairments.
 - ▶ Wheelchair level: strength, balance, weight bearing

Consider individual comorbidities, recent fractures and activity tolerance.

Daly, R. M., Dalla Via, J., Duckham, R. L., Fraser, S. F., & Helge, E. W. (2019). Exercise for the prevention of osteoporosis in postmenopausal women: an evidence-based guide to the optimal prescription. *Brazilian journal of physical therapy*, 23(2), 170-180.

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Aerobic Training

- ▶ Low or non-impact aerobic activities have little or no effect on stimulating bone.
- ▶ Some protection may be provided when performed in combination with low load activities or at higher intensity levels.
- ▶ Risk benefit analysis related to falls must be considered.

Daly, R. M., Dalla Via, J., Duckham, R. L., Fraser, S. F., & Helge, E. W. (2019). Exercise for the prevention of osteoporosis in postmenopausal women: an evidence-based guide to the optimal prescription. *Brazilian journal of physical therapy*, 23(2), 170-180.

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Weight Bearing Exercise

- ▶ Caution must be taken to prevent fracture.
- ▶ Intersperse impact loading between balance and resistance training activities.

Vertical GRF relative to body weight

Activity	Vertical GRF relative to body weight
Lunge	1.1
Marching	1.5
Lateral Step-ups 15 cm	2.1
Forward step-up 30 cm	2.7
Lateral step-up 30cm	3.1
Single leg hop	3.4
Side to side jump	5.9

Daly, R. M., Dalla Via, J., Duckham, R. L., Fraser, S. F., & Helge, E. W. (2019). Exercise for the prevention of osteoporosis in postmenopausal women: an evidence-based guide to the optimal prescription. *Brazilian journal of physical therapy*, 23(2), 170-180.

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Progressive Resistance Training (PRT)

- ▶ Exercise should be site-specific targeting hip and spine with direct gravitational loading or indirect muscle pull on bone.
- ▶ Trunk strengthening favoring extension exercises
 - ▶ Avoid deep forward spine flexion
- ▶ Rate of progression should be 50%, 60%, 70%, and 80% of 1RM to ensure correct technique
- ▶ Power resistance training may assist in offsetting Type II muscle fiber atrophy.

Beck BR, et al. (2016) Exercise and Sports Science Australia (ESSA) position statement on exercise prescription for the prevention and management of osteoporosis. J Sci Med Sport

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Balance and Mobility Training

- ▶ Balance and mobility training programs do not appear to provide sufficient bone strain to stimulate adaptive skeletal benefit but can enhance neuromuscular condition to diminish fall risk.
- ▶ Alter base of support, surface, visual input, speed, concurrent arm motion.
- ▶ Including dual task training can improve functional performance in both single and dual task conditions.

Daly, R. M., Dalla Via, J., Duckham, R. L., Fraser, S. F., & Helge, E. W. (2019). Exercise for the prevention of osteoporosis in postmenopausal women: an evidence-based guide to the optimal prescription. *Brazilian Journal of Physical Therapy*, 23(2), 170-180.

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Otago Home Exercise Program

- ▶ Initial supervised therapist instruction followed by home-based patient participation with therapist monitoring.
- ▶ Program of AROM, lower extremity strengthening, balance exercises, and walking plan over 52 weeks.

Sherrington C, Whitney JC, Lord SR, et al. Effective exercise for the prevention of falls: a systematic review and meta-analysis. 2008. In: Database of Abstracts of Reviews of Effects
Copyright, Jodi Gootkin 2021 CDC (2011). Tools to implement the Otago Exercise Program: A program to reduce falls. First Edition

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Tai Ji Quan: Moving for Better Balance (TJQMBB)

- ▶ A community based and implemented program to help improve postural stability, control of body positioning, gait initiation, locomotion, movement symmetry and coordination, range of motion and lower extremity strength.
- ▶ Instructor led sessions 2-3 times per week for 24 weeks.
- ▶ A series of 8 forms emphasizing weight-shifting and direction of core.

Administration for Community Living. (2012). Tai Chi: Moving for Better Balance.

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Whole Body Vibration (WBV)

- ▶ Mechanical vibration signals delivered through a platform are amplified into bone tissue.
- ▶ The vibration appears to activate mechanoreceptors to increase anabolic activity.
- ▶ Other theories suggest that improved muscle and bone circulation provide nutrients needed to build bone tissue.
- ▶ Improved strength and coordination can reduce fall risk.

Agency for Healthcare Research and Quality. (2011). Whole-Body Vibration Therapy for Osteoporosis. Effective Health Care
Dionello, C. et al. (2016). Effects of whole body vibration exercises on bone mineral density of women with postmenopausal osteoporosis without medications: novel findings and literature review. *Journal of musculoskeletal & neuronal interactions*, 16(3), 193-203.
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Exercise Outcomes

Population	Intervention	Outcome
Males 65-90 years	Resistance, WBV, Qi Gong, Orthosis	Resistance/Activating Orthosis improved strength and mobility WBV improved mobility Qi Gong no change
Females over 60 years	Activating orthosis, Resistance/ Balance	Both decreased pain and increased strength. No change spinal curve

Genest, F. M. N., Lindström, S., Scherer, S., Schneider, M., & Seefried, L. (2020). Efficacy and safety of simple exercise interventions for men with osteoporosis—a prospective randomized controlled trial.
Alin, C. K., Uzunel, E., Kronhed, A. C. G., Alinaghizadeh, H., & Salminen, H. (2019). Effect of treatment on back pain and back extensor strength with a spinal orthosis in older women with osteoporosis: a randomized controlled trial. *Archives of osteoporosis*, 14(1), 5.

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Fracture Liaison Services (FLS)

- ▶ Participation in a fracture prevention program after a fragility fracture aids in identifying treatment gaps to target medical management.
- ▶ American Orthopedic Association Own the Bone®
- ▶ International Osteoporosis Foundation Capture the Fracture®

<https://www.nof.org/patients/communication-with-your-doctor/fracture-liaison-service-fls/>

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Conclusion

- ▶ Prevention, detection, and treatment of osteoporosis can decrease fracture risk, complications and mortality as well as improve quality of life.

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1. What characteristic is common in secondary osteoporosis?

- A. Effects of aging contribute to its development
- B. Associated with estrogen deficiency
- C. Related to underlying disease or specific medication use
- D. Does not affect premenopausal women or men

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2. Which fracture in a pediatric patient may prompt additional assessment for the presence of juvenile osteoporosis?

- A. Calcaneal burst
- B. Vertebral compression
- C. Tibial growth plate
- D. Colle's fracture

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3. Why are Individuals with gastrointestinal disease at a greater risk of developing osteoporosis?

- A. Altered osteoclast mediator ratios promoting bone resorption
- B. Effects of long-term corticosteroid use to manage inflammation
- C. Malabsorption of Vitamin D and Calcium
- D. All of the above

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4. Which of the following does NOT describe osteoporosis related fractures?

- A. Result from high-energy trauma
- B. Occur following a fall from standing height or less
- C. Referred to as fragility fractures
- D. Most common in the hip, vertebrae, forearm, and proximal humerus

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5. According to current recommendations, which individual should be screened for osteoporosis?

- A. 63-year-old active female who plays pickle ball 3 days a week
- B. 52-year-old female with history of early onset menopause and smoking
- C. 68-year-old male who is a community ambulator and works part-time
- D. 55-year-old obese female with vertebral fracture sustained in a motor vehicle accident

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6. "Comparison to age, sex, and ethnicity matched reference population" describes which DEXA scan value?

- A. Bone Mineral Density (BMD)
- B. Standard Deviation (SD)
- C. T-Score
- D. Z-Score

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7. According to the World Health Organization, what T-score value on DEXA would be classified as osteoporosis?

- A. ≥ -1
- B. between -1 and -2.5
- C. ≤ -2.5
- D. ≤ -2.5 with fragility fracture

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8. Which tool evaluates fracture risk based on clinical risk factors and bone mineral density to determine 10-year probability of fracture?

- A. ORAI
- B. FRAX[®]
- C. MORES
- D. SCORE

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9. Individuals prescribed _____ to manage bone loss, should be closely monitored for osteonecrosis of the jaw.

- A. Bisphosphonates
- B. Estrogen based therapies
- C. Parathyroid hormone
- D. Vitamin D supplements

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10. What is the recommended daily Calcium intake for women postmenopause and men over 70 years old?

- A. 700 mg/day
- B. 1000 mg/day
- C. 1200 mg/day
- D. 1300 mg/day

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References

- Academy of Geriatric Physical Therapy and American Bone Health. (2010). Do it right! And Prevent Fractures!. <https://geriatricspt.org/special-interest-groups/bone-health/AGPT-Fracture-Brochure.pdf> Accessed May 11, 2020.
- Administration for Community Living. (2012). Tai Chi: Moving for Better Balance. https://acl.gov/sites/default/files/programs/2017-03/TaiChi_InterventionSummary.pdf Accessed June 22, 2020.
- Afrin, N., Sund, R., Honkanen, R. et al. (2020). A fall in the previous 12 months predicts fracture in the subsequent 5 years in postmenopausal women. *Osteoporos Int* 31, 839–847
- Ahmadzadeh, Arman & Emam, Mohammadmehdi & Rajaei, Alireza & Moslemizadeh, Mohammad & Jalessi, Maryam. (2014). Comparison of three different osteoporosis risk assessment tools: ORAI (osteoporosis risk assessment instrument), SCORE (simple calculated osteoporosis risk estimation) and OST (osteoporosis self-assessment tool). *Medical journal of the Islamic Republic of Iran*. 28. 94.
- Ale, A. O. (2019). Thyroid Disorders and Osteoporosis. In *Topics in Osteoporosis*. IntechOpen.
- Alin, C. K., Uzunel, E., Kronhed, A. C. G., Alinaghizadeh, H., & Salminen, H. (2019). Effect of treatment on back pain and back extensor strength with a spinal orthosis in older women with osteoporosis: a randomized controlled trial. *Archives of osteoporosis*, 14(1), 5.
- Alshehre, S. M., Duffy, S., Jones, G., Ledger, W. L., & Metwally, M. (2020). A prospective, single-centre, single-arm, open label study of the long term use of a gonadotropin releasing hormone agonist (Triptorelin SR, 11.25 mg) in combination with Tibolone add-back therapy in the management of chronic cyclical pelvic pain. *Reproductive Biology and Endocrinology*, 18, 1-10.
- American College of Radiology. (2018) ACR-SPR-SSR Practice Parameter for the performance of musculoskeletal QCT. <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/QCT.pdf> Accessed June 19, 2020
- Amigues, I. (2019). Osteoporosis. American College of Rheumatology. <https://www.rheumatology.org/I-Am-A/Patient-Caregiver/Diseases-Conditions/Osteoporosis> Accessed April 8, 2020.
- Banefelt, J., Åkesson, K. E., Spångéus, A., Ljunggren, O., Karlsson, L., Ström, O., Ortsäter, G., Libanati, C., & Toth, E. (2019). Risk of imminent fracture following a previous fracture in a Swedish database study. *Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA*, 30(3), 601–609
- Beck BR, et al. (2016) Exercise and Sports Science Australia (ESSA) position statement on exercise prescription for the prevention and management of osteoporosis. *J Sci Med Sport*
- Beck, B. R., & Winters-Stone, K. M. (2020). Exercise in the prevention of osteoporosis-related fractures. In *Osteoporosis* (pp. 211-238). Humana, Cham.
- Beck, B. R., Daly, R. M., Singh, M. A. F., & Taaffe, D. R. (2017). Exercise and Sports Science Australia (ESSA) position statement on exercise prescription for the prevention and management of osteoporosis. *Journal of science and medicine in sport*, 20(5), 438-445.

Benedetti, M. G., Furlini, G., Zati, A., & Letizia Mauro, G. (2018). The Effectiveness of Physical Exercise on Bone Density in Osteoporotic Patients. *BioMed Research International*, 1–10.

Berk, E., Koca, T. T., Güzelsoy, S. S., Nacitarhan, V., & Demirel, A. (2019). Evaluation of the relationship between osteoporosis, balance, fall risk, and audiological parameters. *Clinical rheumatology*, 38(11), 3261-3268.

Bethel, M. (2019). Osteoporosis. *Medscape*. <https://emedicine.medscape.com/article/330598-overview#a2> Accessed January 31, 2020

Bijelic, R., Milicevic, S., & Balaban, J. (2017). Risk Factors for Osteoporosis in Postmenopausal Women. *Medical archives (Sarajevo, Bosnia and Herzegovina)*, 71(1), 25–28.

Bodmer, N.S., Häuselmann, H.J., Frey, D. et al.(2019). Expert consensus on relevant risk predictors for the occurrence of osteoporotic fractures in specific clinical subgroups – Delphi survey. *BMC Rheumatol* 3, 50

Brown, McKenzie, "The Effect of Exercise on Postmenopausal Women with Osteoporosis" (2019). *Nursing Capstones*. 65. <https://commons.und.edu/nurs-capstones/65>

Brubaker, M. L., & Sinaki, M. (2016). Successful management of iliocostal impingement syndrome: a case series. *Prosthetics and Orthotics International*, 40(3), 384-387.

Bubbear J. S. (2016). Atypical Femur Fractures in Patients Treated with Bisphosphonates: Identification, Management, and Prevention. *Rambam Maimonides medical journal*, 7(4), e0032.

Bultink, I. E. (2018). Bone disease in connective tissue disease/systemic lupus erythematosus. *Calcified tissue international*, 102(5), 575-591.

Cadarette SM, Mclsaac WJ, Hawker GA, et al. The validity of decision rules for selecting women with primary osteoporosis for bone mineral density testing. *Osteoporos Int*. 2004;15(5):361-366.

Cannada, L. K., & Hill, B. W. (2014). Osteoporotic Hip and Spine Fractures: A Current Review. *Geriatric orthopaedic surgery & rehabilitation*, 5(4), 207–212.

Center for Metabolic Bone Diseases, University of Sheffield, UK. (2008). FRAX® Fracture Risk Assessment Tool. <https://www.sheffield.ac.uk/FRAX/> Accessed January 29, 2020.

Centers for Disease Control and Prevention. (2019). Does osteoporosis run in your family? <https://www.cdc.gov/genomics/disease/osteoporosis.htm> Accessed January 31, 2020

Centers for Disease Control, National center for Injury Prevention and Control Division of Unintentional Injury Prevention. (2018). Tools to implement the Otago Exercise Program: A program to reduce falls. First Ed. <https://www.med.unc.edu/aging/cqec/files/2018/09/ImplementationGuideforPT.pdf> Accessed June 25, 2020

Christine M. McDonough, Carrie H. Colla, et. al. (2020). Falling Down on the Job: Evaluation and Treatment of Fall Risk Among Older Adults With Upper Extremity Fragility Fractures, *Physical Therapy*, Volume 97, Issue 3, March 2017, Pages 280–289

Cosman, F., de Beur, S. J., LeBoff, M. S., Lewiecki, E. M., Tanner, B., Randall, S., & Lindsay, R. (2014). Clinician's guide to prevention and treatment of osteoporosis. *Osteoporosis international*, 25(10), 2359-2381.

Crosby, Alicia, "Nonpharmacologic Interventions and Lifestyle Modifications Resulting in Prevention and Reduction of Osteoporosis" (2019). Nursing Capstones. 74. <https://commons.und.edu/nurs-capstones/74>

Curry, S. J., Krist, A. H., Owens, D. K., Barry, M. J., Caughey, A. B., Davidson, K. W., ... & Landefeld, C. S. (2018). Screening for osteoporosis to prevent fractures: US Preventive Services Task Force recommendation statement. *JAMA*, 319(24), 2521-2531.

Daly, R. M., Dalla Via, J., Duckham, R. L., Fraser, S. F., & Helge, E. W. (2019). Exercise for the prevention of osteoporosis in postmenopausal women: an evidence-based guide to the optimal prescription. *Brazilian journal of physical therapy*, 23(2), 170–180.

Dionello, C. F., Sá-Caputo, D., Pereira, H. V., Sousa-Gonçalves, C. R., Maiworm, A. I., Morel, D. S., Moreira-Marconi, E., Paineiras-Domingos, L. L., Bembem, D., & Bernardo-Filho, M. (2016). Effects of whole body vibration exercises on bone mineral density of women with postmenopausal osteoporosis without medications: novel findings and literature review. *Journal of musculoskeletal & neuronal interactions*, 16(3), 193–203.

Dong, H., Zhou, W., Wang, P., Zuo, E., Ying, X., Chai, S., ... & Liu, H. (2020). Comprehensive Analysis of the Genetic and Epigenetic Mechanisms of Osteoporosis and Bone Mineral Density. *Frontiers in Cell and Developmental Biology*, 8, 194.

Donnally III CJ, DiPompeo CM, Varacallo M. Vertebral Compression Fractures. [Updated 2020 Mar 25]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-.

Drake, M. T., & Khosla, S. (2019). Sex steroids and the pathogenesis of osteoporosis. *Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism*, 412.

El Demellawy, D., Davila, J., Shaw, A., & Nasr, Y. (2018). Brief Review on Metabolic Bone Disease. *Academic forensic pathology*, 8(3), 611–640.

El-Hajj Fuleihan G. (2020). Building Bridges to Address the Osteoporosis Crisis. *The Journal of clinical endocrinology and metabolism*, 105(4), 1292–1293. <https://doi.org/10.1210/clinem/dqz307>

Féron, J. (2014). Fracture consolidation and osteoporosis. *Medicographia*, 36, 156-162.

Garg, B., Dixit, V., Batra, S., Malhotra, R., & Sharan, A. (2017). Non-surgical management of acute osteoporotic vertebral compression fracture: A review. *Journal of clinical orthopaedics and trauma*, 8(2), 131–138.

Genest, F. M. N., Lindström, S., Scherer, S., Schneider, M., & Seefried, L. (2020). Efficacy and safety of simple exercise interventions for men with osteoporosis—a prospective randomized controlled trial.

Geusens P, Hochberg MC, van der Voort DJ, Pols H, van der Klift M, Siris E, Melton ME, Turpin J, Byrnes C, Ross P. Performance of risk indices for identifying low bone density in postmenopausal women. *Mayo Clin Proc*. 2002; 77(7):629-37.

Grossman, D. C., Curry, S. J., Owens, D. K., Barry, M. J., Caughey, A. B., Davidson, K. W., ... & Kubik, M. (2018). Interventions to prevent falls in community-dwelling older adults: US Preventive Services Task Force recommendation statement. *Jama*, 319(16), 1696-1704.

Gullberg, J., Lindh, C., Axtelius, B., Horner, K., Devlin, H., & Povlsen, L. (2020). Osteoporosis risk assessment in primary dental care—The attitudes of Swedish dentists, patients and medical specialists. *Gerodontology*.

Hachemi, Y., Rapp, A. E., Picke, A. K., Weidinger, G., Ignatius, A., & Tuckermann, J. (2018). Molecular mechanisms of glucocorticoids on skeleton and bone regeneration after fracture. *Journal of molecular endocrinology*, 61(1), R75–R90.

Hanley, D. A., Adachi, J. D., Bell, A., & Brown, V. (2012). Denosumab: mechanism of action and clinical outcomes. *International journal of clinical practice*, 66(12), 1139–1146.

Harding, A. T., & Beck, B. R. (2017). Exercise, osteoporosis and bone geometry. *Sports*, 5(2)29.

Holdsworth, G., Roberts, S. J., & Ke, H. Z. (2019). Novel actions of sclerostin on bone. *Journal of molecular endocrinology*, 62(2), R167-R185.

Huldén, E., Castedal, M., Karlsson, M. K., Kalaitzakis, E., & Swärd, P. (2020). Osteoporosis in cirrhotics before and after liver transplantation: relation with malnutrition and inflammatory status. *Scandinavian Journal of Gastroenterology*, 55(3), 354-361.

Hyuma Makizako, Hiroyuki Shimada, Takehiko Doi, Kota Tsutsumimoto, Sho Nakakubo, Ryo Hotta, Takao Suzuki, (2017). Predictive Cutoff Values of the Five-Times Sit-to-Stand Test and the Timed “Up & Go” Test for Disability Incidence in Older People Dwelling in the Community, *Physical Therapy*, Volume 97, Issue 4, April 2017, Pages 417–424.

Ing-Mari Dohrn, Agneta Ståhle, Kirsti Skavberg Roaldsen, (2016) “You Have to Keep Moving, Be Active”: Perceptions and Experiences of Habitual Physical Activity in Older Women With Osteoporosis, *Physical Therapy*, Volume 96, Issue 3, 1 March 2016, Pages 361–370

International Osteoporosis Foundation. Osteoporosis Prevention: Calcium. <https://www.iofbonehealth.org/osteoporosis-musculoskeletal-disorders/osteoporosis/prevention/calcium> Accessed February 2, 2020

International Osteoporosis Foundation. Osteoporosis Prevention: Vitamin D. <https://www.iofbonehealth.org/osteoporosis-musculoskeletal-disorders/osteoporosis/prevention/vitamin-d> Accessed February 3, 2020

International Society for Clinical Densitometry. (2019). 2019 ISCD Official Positions – Pediatric. <https://www.iscd.org/official-positions/2019-iscd-official-positions-pediatric/> Accessed March 12, 2020.

Ireland, A., & Rittweger, J. (2017). Exercise for osteoporosis: how to navigate between overeagerness and defeatism. *Journal of musculoskeletal & neuronal interactions*, 17(3), 155.

Jacobs, E., Senden, R., McCrum, C., van Rhijn, L. W., Meijer, K., & Willems, P. C. (2019). Effect of a semirigid thoracolumbar orthosis on gait and sagittal alignment in patients with an osteoporotic vertebral compression fracture. *Clinical interventions in aging*, 14, 671–680.

Jenna C Gibbs, Caitlin McArthur, John D Wark, et. Al. , (2020). The Effects of Home Exercise in Older Women With Vertebral Fractures: A Pilot Randomized Controlled Trial, *Physical Therapy*, Volume 100, Issue 4, April 2020, Pages 662–676

Kahwati LC, Weber RP, Pan H, et al. Vitamin D, Calcium, or Combined Supplementation for the Primary Prevention of Fractures in Community-Dwelling Adults: An Evidence Review for the U.S. Preventive Services Task Force [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2018 Apr. (Evidence Synthesis, No. 160.) Available from: <https://www.ncbi.nlm.nih.gov/books/NBK525398/>

Kaminen, V., Latha, A. P., & Ramathulasi, K. (2016). Association between serum 25-hydroxyvitamin D levels and bone mineral density in normal postmenopausal women. *Journal of mid-life health*, 7(4), 163–168. <https://doi.org/10.4103/0976-7800.195694>

Osteoporosis: Pathology, Assessment & Management
Copyright Jodi Gootkin 2021

- Keith G. Avin, Timothy A. Hanke, Neva Kirk-Sanchez, Christine M. McDonough, Tiffany E. Shubert, Jason Hardage, Greg Hartley. (2015). Management of Falls in Community-Dwelling Older Adults: Clinical Guidance Statement From the Academy of Geriatric Physical Therapy of the American Physical Therapy Association, *Physical Therapy*, Volume 95, Issue 6, 1 June 2015, Pages 815–834.
- Kendler, D. L., Bauer, D. C., Davison, K. S., Dian, L., Hanley, D. A., Harris, S. T., ... & Lewiecki, E. M. (2016). Vertebral fractures: clinical importance and management. *The American journal of medicine*, 129(2), 221-e1.
- Komar, C., Ahmed, M., Chen, A., Richwine, H., Zia, N., Nazar, A., & Bauer, L. (2019). Advancing methods of assessing bone quality to expand screening for osteoporosis. *J. Am. Osteopath. Assoc*, 119, 147-154.
- Kozuma, W., Kon, K., Kawakami, S., Bobothike, A., Iijima, H., Shiota, M., & Kasugai, S. (2019). Osteoconductive potential of a hydroxyapatite fiber material with magnesium: In vitro and in vivo studies. *Dental materials journal*, 38(5), 771-778.
- Krela-Kaźmierczak I, Szymczak A, Łykowska-Szuber L, Eder P, Linke K. (2016). Osteoporosis in Gastrointestinal Diseases. *Adv Clin Exp Med.*;25:185-90.
- Kuo, T., Chen, C. Bone biomarker for the clinical assessment of osteoporosis: recent developments and future perspectives. *Biomark Res* 5, 18 (2017).
- Lan, G. B., Xie, X. B., Peng, L. K., Liu, L., Song, L., & Dai, H. L. (2015). Current status of research on osteoporosis after solid organ transplantation: pathogenesis and management. *BioMed research international*, 2015.
- Lee, J. S., Adhikari, S., Liu, L., Jeong, H. G., Kim, H., & Yoon, S. J. (2019). Osteoporosis detection in panoramic radiographs using a deep convolutional neural network-based computer-assisted diagnosis system: a preliminary study. *Dentomaxillofacial Radiology*, 48(1), 20170344.
- Li, H., Wallin, M., Barregard, L., Sallsten, G., Lundh, T., Ohlsson, C., ... & Andersson, E. M. (2020). Smoking-induced risk of osteoporosis is partly mediated by cadmium from tobacco smoke: The MrOS Sweden Study. *Journal of Bone and Mineral Research*.
- Lou, S., Lv, H., Yin, P., Li, Z., Tang, P., & Wang, Y. (2019). Combination therapy with parathyroid hormone analogs and antiresorptive agents for osteoporosis: a systematic review and meta-analysis of randomized controlled trials. *Osteoporosis International*, 30(1), 59-70.
- Lydick E, Cook K, Turpin J, Melton M, Stine R, Byrnes C. Development and validation of a simple questionnaire to facilitate identification of women likely to have low bone density. *J Manag Care*. 1998; 4(1):37-48.
- Mangano, K. M., Noel, S. E., Sahni, S., & Tucker, K. L. (2019). Higher Dairy Intakes Are Associated with Higher Bone Mineral Density among Adults with Sufficient Vitamin D Status: Results from the Boston Puerto Rican Osteoporosis Study. *The Journal of nutrition*, 149(1), 139–148
- McClung M. R. (2017). Sclerostin antibodies in osteoporosis: latest evidence and therapeutic potential. *Therapeutic advances in musculoskeletal disease*, 9(10), 263–270.
- McKay LI, Cidlowski JA. Physiologic and Pharmacologic Effects of Corticosteroids. In: Kufe DW, Pollock RE, Weichselbaum RR, et al., editors. *Holland-Frei Cancer Medicine*. 6th edition. Hamilton (ON): BC Decker; 2003

Mirza, F., & Canalis, E. (2015). Management of endocrine disease: Secondary osteoporosis: pathophysiology and management. *European journal of endocrinology*, 173(3), R131–R151. <https://doi.org/10.1530/EJE-15-0118>

Mohamad, N. V., Che Zulkepli, M., May Theseira, K., Zulkifli, N., Shahrom, N. Q., Ridzuan, N., Jamil, N. A., Soelaiman, I. N., & Chin, K. Y. (2018). Establishing an Animal Model of Secondary Osteoporosis by Using a Gonadotropin-releasing Hormone Agonist. *International journal of medical sciences*, 15(4), 300–308.

Mostafa, H. K. (2019). Structure and Function of Periosteum with Special Reference to its Clinical Application. *Egyptian Journal of Histology*, 42(1), 1-9.

Murshed, M. (2018). Mechanism of bone mineralization. *Cold Spring Harbor Perspectives in Medicine*, a031229.

National Institutes of Health Osteoporosis and Related Bone Diseases. (2018). Juvenile Osteoporosis. NIH Pub. No. 18-7886 <https://www.bones.nih.gov/health-info/bone/bone-health/juvenile/juvenile-osteoporosis> Accessed April 12, 2020.

National Institutes of Health, Office of Dietary Supplements. (2020). Vitamin D: Fact Sheet for Health Professionals. (2020). Retrieved June 23, 2020, from <https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/>

National Institutes of Health, Office of Dietary Supplements. (2020). Calcium Fact Sheet for Health Professionals. Retrieved June 23, 2020 <https://ods.od.nih.gov/factsheets/Calcium-HealthProfessional/>

National Osteoporosis Foundation. (2019). Healthcare Providers Toolkit. <https://www.bonesource.org/healthcare-professionals-toolkit> Accessed June 22, 2020

National Osteoporosis Foundation. Fracture Liaison Service “FLS”. <https://www.nof.org/patients/communication-with-your-doctor/fracture-liaison-service-fls/> Accessed May 11, 2020.

National Osteoporosis Foundation. What is Osteoporosis and What Causes It? <https://www.nof.org/patients/what-is-osteoporosis/> Accessed April 20, 2020.

Nazem, T. G., & Ackerman, K. E. (2012). The female athlete triad. *Sports health*, 4(4), 302–311.

Nicolatou-Galitis, O., Schiødt, M., Mendes, R. A., Ripamonti, C., Hope, S., Drudge-Coates, L., ... & Van den Wyngaert, T. (2019). Medication-related osteonecrosis of the jaw: definition and best practice for prevention, diagnosis, and treatment. *Oral surgery, oral medicine, oral pathology and oral radiology*, 127(2), 117-135.

Niederle, M.B., Foeger-Samwald, U., Riss, P. et al. (2019). Effectiveness of anti-osteoporotic treatment after successful parathyroidectomy for primary hyperparathyroidism: a randomized, double-blind, placebo-controlled trial. *Langenbecks Arch Surg* 404, 681–691

Nugroho, N., Faris, M., & Setiawan, A. (2020). Idiopathic Juvenile Osteoporosis with Progressive Kyphoscoliosis: A Case Report. *JURNAL WIDYA MEDIKA*, 6(1), 55-64.

Oh, H. J., Ryu, K. H., Park, B. J., & Yoon, B. H. (2018). Osteoporosis and Osteoporotic Fractures in Gastrointestinal Disease. *Journal of bone metabolism*, 25(4), 213–217.

- Ohe, M., Moridaira, H., Inami, S., Takeuchi, D., Nohara, Y., & Taneichi, H. (2018). Pedicle screws with a thin hydroxyapatite coating for improving fixation at the bone-implant interface in the osteoporotic spine: experimental study in a porcine model, *Journal of Neurosurgery: Spine SPI*, 28(6), 679-687.
- Pagnotti, G. M., Styner, M., Uzer, G., Patel, V. S., Wright, L. E., Ness, K. K., ... & Rubin, C. T. (2019). Combating osteoporosis and obesity with exercise: leveraging cell mechanosensitivity. *Nature Reviews Endocrinology*, 15(6), 339-355.
- Park, S. B., & Chung, C. K. (2011). Strategies of spinal fusion on osteoporotic spine. *Journal of Korean Neurosurgical Society*, 49(6), 317-322.
- Pearson, R. G., Masud, T., Blackshaw, E., Naylor, A., Hinchcliffe, M., Jeffery, K., ... & Illum, L. (2019). Nasal administration and plasma pharmacokinetics of parathyroid hormone peptide PTH 1-34 for the treatment of osteoporosis. *Pharmaceutics*, 11(6), 265.
- Portier, A., Villoutreix, C., Beaussier, H., Grine, A., Glippa, S., Vilfaillot, A., ... & Rajzbaum, G. (2019). Implementation of a fracture liaison service an effective initiative to improve healthcare after osteoporotic hip or wrist fracture. *Journal of Osteoporosis and Bone Research*.
- Qaseem, A., Forciea, M. A., McLean, R. M., & Denberg, T. D. (2017). Treatment of low bone density or osteoporosis to prevent fractures in men and women: a clinical practice guideline update from the American College of Physicians. *Annals of internal medicine*, 166(11), 818-839.
- Ramos, L., Rodrigues, F., Shirahige, L., et. Al. (2019). A single whole body vibration session influences quadriceps muscle strength, functional mobility and balance of elderly with osteopenia and/or osteoporosis? Pragmatic clinical trial. *Journal of diabetes and metabolic disorders*, 18(1), 73-80.
- Rinat, B., Rubin, G., Orbach, H., et. Al. (2016). Can orthopedic surgeons help create a better head start for osteoporosis treatment after hip fracture?. *Medicine*, 95(27), e4141.
- Rubin, K. H., Abrahamsen, B., Friis-Holmberg, et. al. (2013). Comparison of different screening tools (FRAX®, OST, ORAI, OSIRIS, SCORE and age alone) to identify women with increased risk of fracture. A population-based prospective study. *Bone*, 56(1), 16-22.
- Ruiz-Gaspà, S., Guañabens, N., et. al. (2020). Bile acids and bilirubin effects on osteoblastic gene profile. Implications in the pathogenesis of osteoporosis in liver diseases. *Gene*, 725, 144167.
- Russow, G., Jahn, D., Appelt, J., Märdian, S., Tsitsilonis, S., & Keller, J. (2018). Anabolic Therapies in Osteoporosis and Bone Regeneration. *International journal of molecular sciences*, 20(1), 83.
- Shepherd AJ, Cass AR, Carlson CA, Ray L. Development and internal validation of the male osteoporosis risk estimation score. *Ann Fam Med*. 2007;5(6):540-546.
- Shepstone, L., Lenaghan, E., Cooper, C., Clarke, S., Fong-Soe-Khioe, R., Fordham, R., ... & Holland, R. (2018). Screening in the community to reduce fractures in older women (SCOOP): a randomised controlled trial. *The Lancet*, 391(10122), 741-747.
- Sherrington C, Whitney JC, Lord SR, et al. Effective exercise for the prevention of falls: a systematic review and meta-analysis. 2008. In: Database of Abstracts of Reviews of Effects (DARE): Quality-assessed Reviews [Internet]. York (UK): Centre for Reviews and Dissemination
- Sidhaye, A., Goldswieg, B., Kaminski, B., Blackman, S. M., & Kelly, A. (2019). Endocrine complications after solid-organ transplant in cystic fibrosis. *Journal of Cystic Fibrosis*, 18, S111-S119.

Siu, A., Allore, H., Brown, D., Charles, S. T., & Lohman, M. (2019). National Institutes of Health Pathways to Prevention Workshop: research gaps for long-term drug therapies for osteoporotic fracture prevention. *Annals of internal medicine*, 171(1), 51-57.

Stevens, J. A., & Lee, R. (2018). The Potential to Reduce Falls and Avert Costs by Clinically Managing Fall Risk. *American journal of preventive medicine*, 55(3), 290–297.

Subramaniam, S., Ima-Nirwana, S., & Chin, K. Y. (2018). Performance of Osteoporosis Self-Assessment Tool (OST) in Predicting Osteoporosis-A Review. *International journal of environmental research and public health*, 15(7), 1445.

Tang, C. H. (2020). Osteoporosis: From Molecular Mechanisms to Therapies. *International Journal of Molecular Sciences*. 21, 714.

The International Society for clinical Densitometry. (2019). 2019 Official ISCD positions- Adult. <https://www.iscd.org/official-positions/2019-iscd-official-positions-adult/> Accessed January 31, 2020

Tian, L., Tang, N., Ngai, T., Wu, C., Ruan, Y., Huang, L., & Qin, L. (2019). Hybrid fracture fixation systems developed for orthopaedic applications: A general review. *Journal of orthopaedic translation*, 16, 1-13.

United States Preventive Services Task Force. (April 2018) Final recommendation statement vitamin d, calcium, or combined supplementation for the primary prevention of fractures in community-dwelling adults: Preventive medication.

<https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/vitamin-d-calcium-or-combined-supplementation-for-the-primary-prevention-of-fractures-in-adults-preventive-medication> Accessed February 2, 2020

United States Preventive Services Task Force. (June 2018) Final Recommendation Statement Osteoporosis to Prevent Hip Fractures: Screening. Recommendations Summary.

<https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/osteoporosis-screening1> Accessed January 30, 2020

US Department of Health and Human Services. Agency for Healthcare Research and Quality. (2011). Whole-Body Vibration Therapy for Osteoporosis. Effective Health Care Program Technical Brief Number 10. https://effectivehealthcare.ahrq.gov/sites/default/files/pdf/osteoporosis-vibration-therapy_technical-brief.pdf Accessed June 22, 2020.

US Food and Drug Administration. Forteo teriparatide (rDNA origin) injection Warning. (2008). https://www.accessdata.fda.gov/drugsatfda_docs/label/2008/021318s015lbl.pdf Accessed May 14, 2020.

US Food and Drug Administration. (2018), FDA Drug Safety Communication: Safety update for osteoporosis drugs, bisphosphonates, and atypical fractures. <https://www.fda.gov/drugs/drug-safety-and-availability/fda-drug-safety-communication-safety-update-osteoporosis-drugs-bisphosphonates-and-atypical> Accessed June 19, 2020

US Preventive Services Task Force. (June 2018) Final Recommendation Statement - Osteoporosis to Prevent Fractures: Screening.

<https://www.uspreventiveservicestaskforce.org/uspstf/document/RecommendationStatementFinal/osteoporosis-screening> Accessed May 1, 2020.

US Preventive Services Task Force. Screening for Osteoporosis to Prevent Fractures: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2018;319(24):2521–2531.

doi:10.1001/jama.2018.7498

Osteoporosis: Pathology, Assessment & Management

Copyright Jodi Gootkin 2021

van Oostwaard M. Osteoporosis and the Nature of Fragility Fracture: An Overview. 2018 Jun 16. In: Hertz K, Santy-Tomlinson J, editors. Fragility Fracture Nursing: Holistic Care and Management of the Orthogeriatric Patient [Internet]. Cham (CH): Springer; 2018.

Viswanathan M, Reddy S, Berkman N, et al. Screening to Prevent Osteoporotic Fractures: An Evidence Review for the U.S. Preventive Services Task Force [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2018 Jun. (Evidence Synthesis, No. 162.) Available from: <https://www.ncbi.nlm.nih.gov/books/NBK532075/>

Viswanathan, M., Reddy, S., Berkman, N., Cullen, K., Middleton, J. C., Nicholson, W. K., & Kahwati, L. C. (2018). Screening to prevent osteoporotic fractures: updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*, 319(24), 2532-2551.

Wallace, T. C., Bauer, D. C., Gagel, R. F., Greenspan, S. L., Lappe, J. M., LeBoff, M. S., ... & Singer, A. J. (2016). The National Osteoporosis Foundation's methods and processes for developing position statements. *Archives of osteoporosis*, 11(1), 22.

Walton, K., Grogan, T. R., Eshaghzadeh, E., Hadaya, D., Elashoff, D. A., Aghaloo, T. L., & Tetradis, S. (2019). Medication related osteonecrosis of the jaw in osteoporotic vs oncologic patients—quantifying radiographic appearance and relationship to clinical findings. *Dentomaxillofacial Radiology*, 48(1), 20180128.

Wang, J. L., Xu, J. K., Hopkins, C., Chow, D. H. K., & Qin, L. (2020). Biodegradable Magnesium-Based Implants in Orthopedics—A General Review and Perspectives. *Advanced Science*, 7(8), 1902443.

Warriner, A. H., Patkar, N. M., Curtis, J. R., Delzell, E., Gary, L., Kilgore, M., & Saag, K. (2011). Which fractures are most attributable to osteoporosis?. *Journal of clinical epidemiology*, 64(1), 46–53. <https://doi.org/10.1016/j.jclinepi.2010.07.007>

Weaver, C. M., Dawson-Hughes, B., Rizzoli, R., & Heaney, R. P. (2019). Nutritional Support for Osteoporosis. *Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism*, 534.

Weber-Rajek, M., Mieszkowski, J., Niespodziński, B., & Ciechanowska, K. (2015). Whole-body vibration exercise in postmenopausal osteoporosis. *Menopause review*, 14(1), 41–47.

Wilson, D. J. (2019). Osteoporosis and sport. *European journal of radiology*, 110, 169-174.

Wong-Pack, M., Naqvi, N., Ioannidis, G., Khalil, R., Papaioannou, A., Adachi, J., & Lau, A. N. (2020). Evaluation of the Fracture Liaison Service within the Canadian Healthcare Setting. *Journal of Osteoporosis*, 2020.

World Health Organization (2007) Assessment of osteoporosis at the primary health care level. Summary Report of a WHO Scientific Group. WHO, Geneva, www.who.int/chp/topics/rheumatic/en/index.html

World Health Organization. (2007). WHO scientific group on the assessment of osteoporosis at primary health care level. In Summary meeting report Brussels, Belgium May 2004. <http://www.who.int/chp/topics/Osteoporosis.pdf> Accessed January 30, 2020

Yang, D. H., & Yang, M. Y. (2019). The Role of Macrophage in the Pathogenesis of Osteoporosis. *International journal of molecular sciences*, 20(9), 2093.

Yao, S., Hong, C. C., Bandera, E. V., Zhu, Q., Liu, S., Cheng, T. Y. D., ... & McCann, S. E. (2017). Demographic, lifestyle, and genetic determinants of circulating concentrations of 25-hydroxyvitamin D and vitamin D-binding protein in African American and European American women. *The American journal of clinical nutrition*, 105(6), 1362-1371.

Yeung, A. W. K., & Mozos, I. (2020). The Innovative and Sustainable Use of Dental Panoramic Radiographs for the Detection of Osteoporosis. *International Journal of Environmental Research and Public Health*, 17(7), 2449.

Yu, M., Downey, C., & Torralba, K. D. (2019). The Fracture Liaison Service to close the osteoporosis care gap: a leadership educational model for undergraduate and postgraduate trainees. *Clinical Rheumatology*. 39:619–626.

Zhang, L., Chun, C., Yang, Y., Liu, B., Zhu, Y., Chen, R., & Rong, L. (2019). Vitamin D Deficiency/Insufficiency Is Associated with Risk of Osteoporotic Thoracolumbar Junction Vertebral Fractures. *Medical science monitor : international medical journal of experimental and clinical research*, 25, 8260–8268.

Osteoporosis: Pathology, Assessment & Management Resources

International Osteoporosis Foundation Risk Check Test

<https://www.iofbonehealth.org/iof-one-minute-osteoporosis-risk-test>

Simple Calculated Osteoporosis Risk Estimation (SCORE)

<https://www.mdapp.co/osteoporosis-risk-score-calculator-316/>

Osteoporosis Risk Assessment Instrument (ORAI)

<https://www.ncbi.nlm.nih.gov/books/NBK45516/table/ch10.t5/>

Osteoporosis Self-Assessment Tool (OST)

<https://www.ncbi.nlm.nih.gov/books/NBK45516/figure/ch10.f2/>

Male Osteoporosis Risk Estimation Score (MORES)

<https://fpnotebook.com/rheum/exam/OstprsrskEstmntnScrlnMn.htm>

FRAX® Fracture Risk Assessment Tool

<https://www.sheffield.ac.uk/FRAX/>

National Institute of Health, Public and Privately Funded Clinical Trial Search

<https://clinicaltrials.gov/>

International Osteoporosis Foundation Calcium Calculator

<https://www.iofbonehealth.org/calcium-calculator>

International Osteoporosis Foundation Calcium Content of Common Foods

<https://www.iofbonehealth.org/osteoporosis-musculoskeletal-disorders/osteoporosis/prevention/calcium/calcium-content-common-foods>

National Osteoporosis Foundation Healthcare Providers Toolkit

Balance/Fall Risk Assessments and Patient Education Materials (starting on page 55)

<https://www.bonesource.org/healthcare-professionals-toolkit>

The Otago Exercise Program Implementation Guide and Videos

<https://www.med.unc.edu/aging/cgec/exercise-program/>

<https://www.med.unc.edu/aging/cgec/files/2018/09/ImplementationGuideforPT.pdf>

Tai Ji Quan: Moving for Better Balance (TJQMBB)

<https://tjqmbb.org/>

American Orthopedic Association - Own the Bone® Program

https://www.ownthebone.org/OTB/About/What_Is_Own_the_Bone.aspx

International Osteoporosis Foundation - Capture the Fracture® Program

<https://www.capturethefracture.org/about>

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