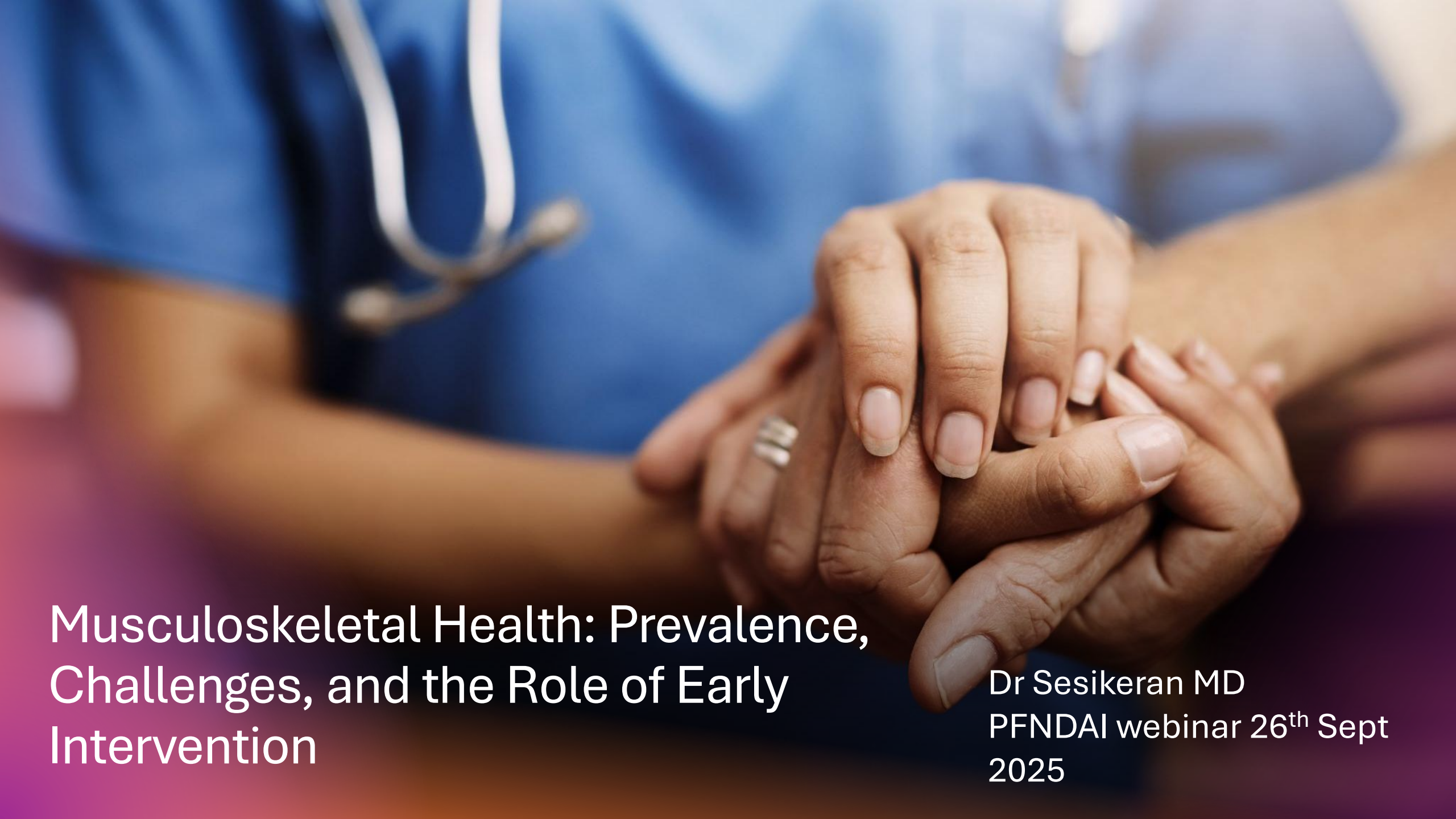
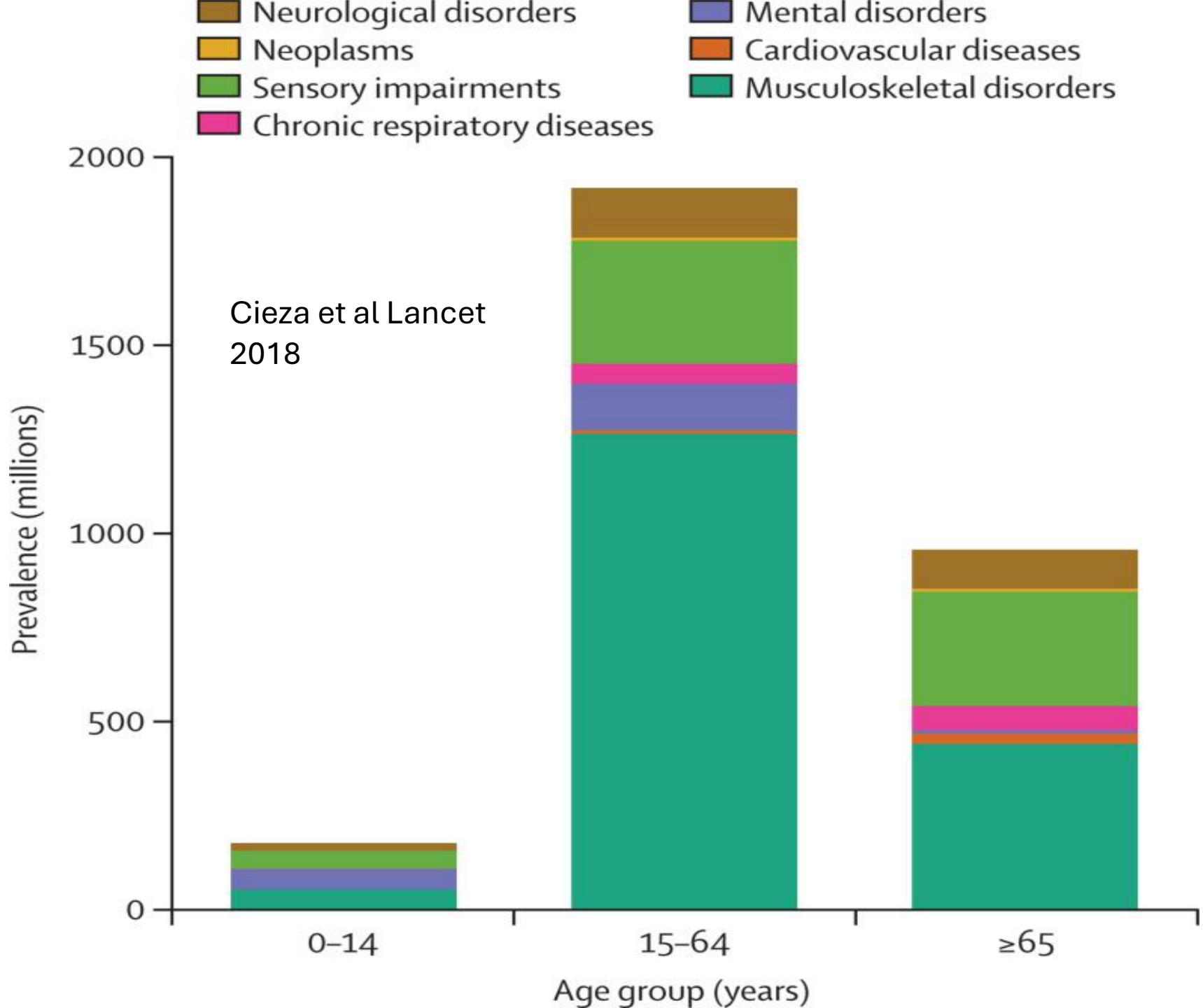


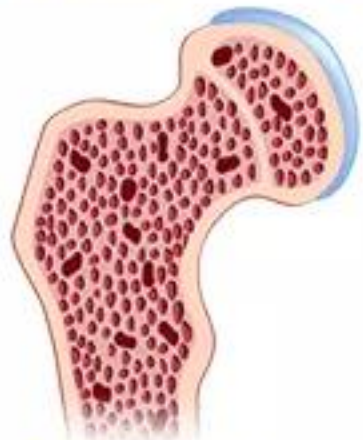
Musculoskeletal Health: Prevalence, Challenges, and the Role of Early Intervention

Dr Sesikeran MD

PFNDAI webinar 26th Sept 2025

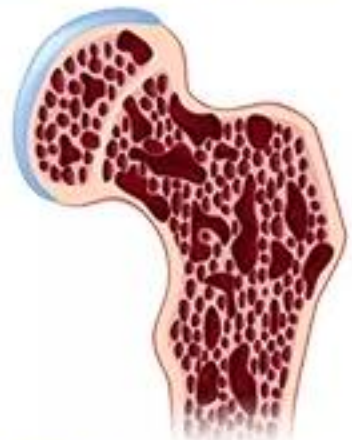

Neurological disorders
Mental disorders
Neoplasms
Cardiovascular diseases
Sensory impairments
Musculoskeletal disorders
Chronic respiratory diseases
Cieza et al Lancet 2018
2000
1500
1000
500
0
Prevalence (millions)
0–14
15–64
≥65
Age group (years)

Osteopenia and Osteoporosis: The Difference



Osteopenia

Bone density has begun to dwindle, but is not yet considered dangerous.



Osteoporosis

Bone density levels become critical and frequent fractures are likely.

Osteosarcopenia (Combined Osteoporosis and Sarcopenia)

Risk Factors-	Older age group	Women	Those who already had a fracture
Vitamin D deficiency,	Chronic inflammation,	Metabolic dysfunction,	Inactivity,
Corticosteroid use,	Genetic factors,	Adiposity,	Multimorbidity {Kirk, B et al ,*Aging Med*. **2019}**.

Global prevalence of osteoporosis

Approximately 30% of all postmenopausal women have osteoporosis in the USA and Europe.

At least 40% of these women and 15–30% of men will sustain one or more fragility fractures within their remaining lifetime.

1 in 3 women and over age 50 and 1 in 5 men over age 50 will experience osteoporotic fractures,

Kanis JA, et al (2000) .Osteoporos Int 11:669–674. https://doi.org/10.1007/s001980070064

Melton LJ, et al (1998) J Bone Miner Res 13:1915–1923.
https://doi.org/10.1359/jbmr.1998.13.12.1915

Prevalence of Osteoporosis in India

8 to 62% in Indian women of different age groups

Males older than 50 years-, ranging from 8.5 to 24.6%

Hip fractures every year >440,000, with a female to male ratio of about 3:1,

projected incidence of more than 600,000 in 2020 and over 1 million in 2050.

80–90 per cent of the elderly suffer from osteoporosis which increase the risk of fractures and long-term disability (ICRIER 2025) . Happens 10 – 20 yrs earlier than in the west

(Bhadada SK, et al The Indian Society for Bone and Mineral Research (ISBMR) position statement for the diagnosis and treatment of osteoporosis in adults. Arch Osteoporos 2021; 16(1):102.)

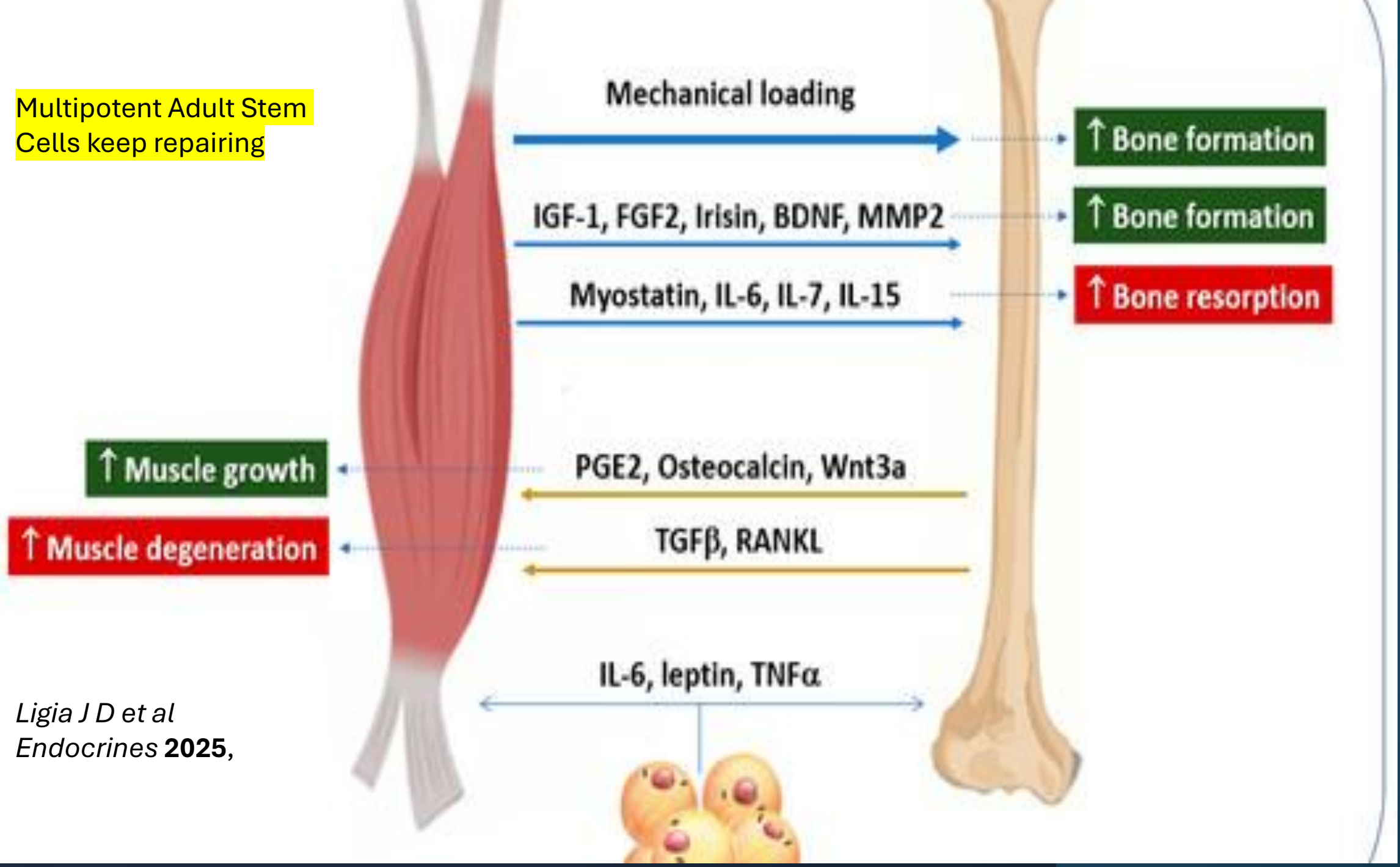
The Sequence

- Aging
- Chronic diseases
- Decreased muscle use and loading
- Loss of muscle mass- Sarcopenia
- Decrease movement of bones
- Loss of Bone density- Osteopenia or Osteoporosis
- Defective weight or load bearing
- Joint degeneration- Osteoarthritis
- Weakness- Pain- Decreased mobility- Worsening

Parameter	Osteopenia	Osteoporosis
Bone density	Lower than normal	Much below
# risk	Mild increase	High with minor trauma
T score in BMD	Between -1 and -2.5 SD	Lower than -2.5SD
Age	Any age more in older	Post menopausal women and older persons

T scores of BMD in healthy Indians is less than the western standards (ICMR (2019)

Multipotent Adult Stem Cells keep repairing



Ligia J D et al
Endocrines **2025**,

Muscle Contraction preserves Bone Muscle Unit throughout life

- During embryogenesis, muscle acts as a force generator in early development, exerting a mechanical load that is translated into signals that combine with the genetic program of organogenesis in adjacent tissues as development progresses and lasts throughout life [Huang, A.H.. *Dev. Biol.* **2017**,].
- Mechanical load is necessary during the formation of the bone–muscle unit, as it influences the development of the tendon, muscle, and their attachments [Felsenthal, N.; Zelzer, E.. *Development* **2017**].
- In the absence of muscle contraction, the number of myotubes decreases, resulting in smaller-than-normal muscles.

Muscle Contraction preserves Bone Muscle Unit throughout life

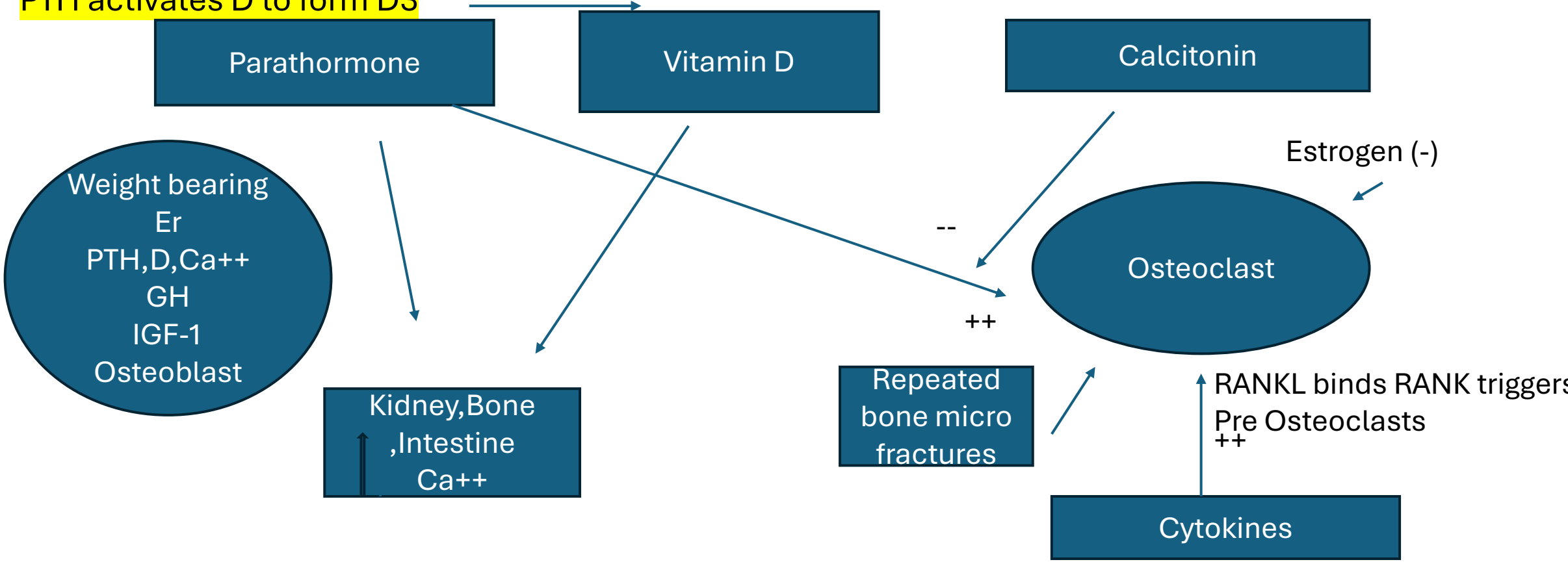
- Additionally, muscle contraction is essential for maintaining a pool of muscle progenitor cells.

- Muscle contraction is also needed to prevent neuromuscular joint degeneration .

Endocrines and bone health

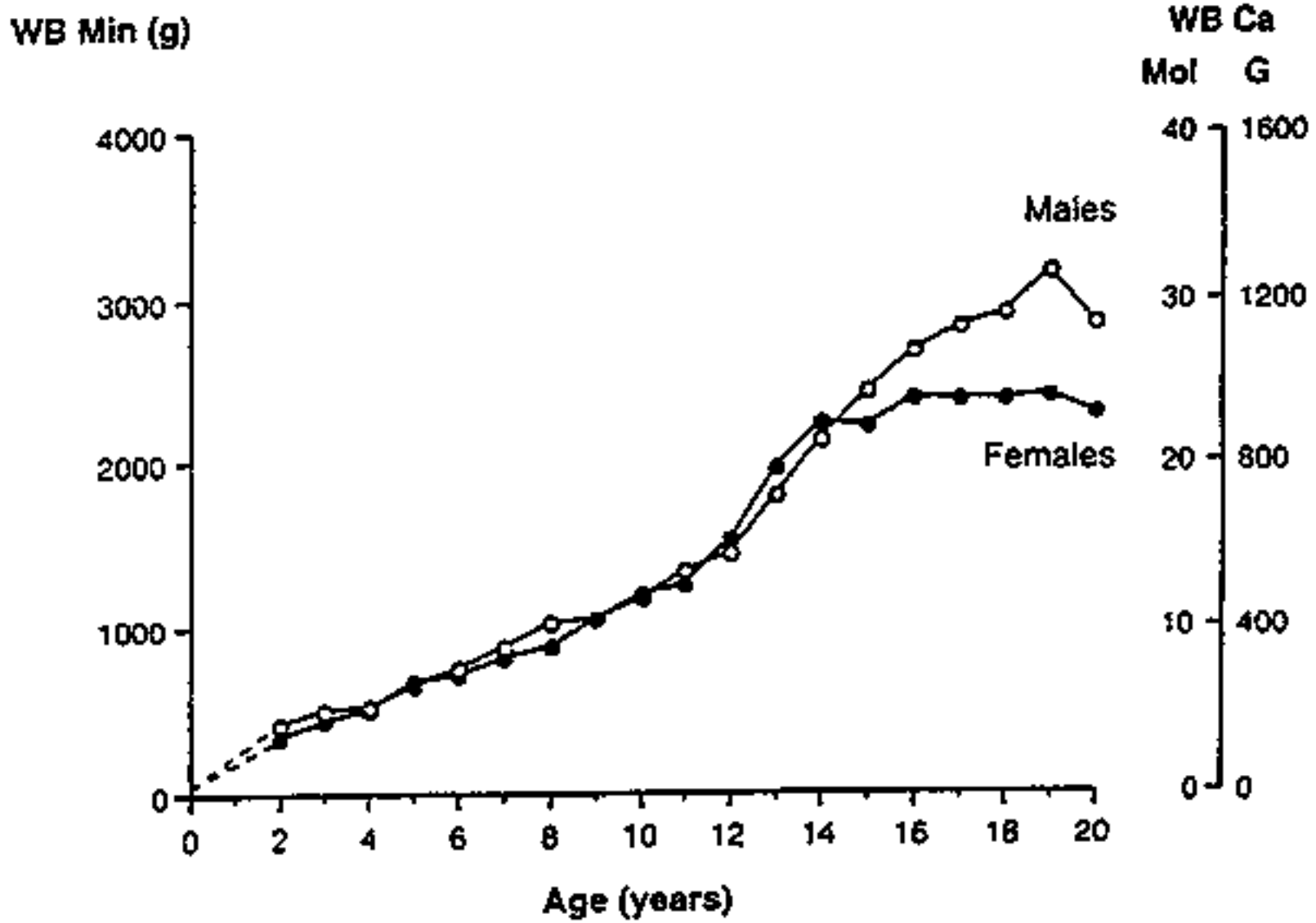
Erα and β- Apoptosis of osteoclasts

- PTH activates D to form D3



Vitamin D and calcium supplements cannot reverse osteoporosis but prevent further loss

FAO/WHO 1998



Whole body bone mineral

Whole body Calcium

Nutrition and metabolism in Chronic musculoskeletal Pain syndrome

- Overweight and obesity are two main aspects of nutritional status in patients with chronic musculoskeletal pain- Fibromyalgia and Osteoarthritis (Rossi, A et al . *Clin. Exp. Rheumatol* **2015**,)

- Prevalence of chronic musculoskeletal pain increases as body mass index (BMI) raises [Okifuji, A et al *J. Pain Res*. **2015**,].

Nutritional determinants in musculoskeletal disorders

Vitamin D

Dietary Calcium, Magnesium, and Protein

Pro- and anti-inflammatory metabolites from the diet has been studied in the prevention and management of rheumatoid arthritis . (Coras R, et al *Cells*. (2020)

An anti- inflammatory Mediterranean diet supplemented with omega-3 fatty acids (Nikiphorou E,et al *Autoimmun Rev.* (2023).

Nutritional determinants in musculoskeletal disorders

- Gut microbiome on musculoskeletal health with dysbiosis serving as a biomarker of bone metabolic activity (Seely KD et al *Int J Mol Sci*. (2021)

- Women with higher selenium consumption were also less likely to develop osteoporosis. (Zhang M, et al *Front. Nutr. 2023)*

Vitamin D

- 80 -90% synthesized in the body
- 10 – 20% from Diet
- Supplements help if plasma 25 OH is < 20ng but not at higher levels
- 490 million are deficient in India
- 50% of the population in most age groups (kalra et al 2023, Khadilkar et al 2022)

Vitamin D

- Vitamin D combined with calcium reduced the risk of falls compared with placebo or no treatment [Ling, Y.et al *Clin. Nutr.* **2021**,].
- No effect of vitamin D supplementation on fractures risk when participants enrolled were not vitamin D deficient.(LeBoff,et al *N. Engl. J. Med.* **2022**,)
- Whole foods approach, as it offers a broader range of nutrients, including protein, which is found in many foods rich in vitamin D and calcium (e.g., eggs, oily fish, dairy) [Geiker, N.R.W et al *Osteoporos. Int.* **2020**,].

Systematic reviews on Vit D supplementation and Osteo/Sarcopenia

Prokopidis et al. 2022- data from ten RCTs impact of vitamin D supplementation monotherapy on indices of sarcopenia, found a significant decrease in short physical performance battery

No effect on handgrip strength, time up and go, appendicular lean mass, general muscle strength, or general physical performance

Type of Vitamin D supplements used

- Plant-based vitamin D (D2, ergocalciferol) < animal-based vitamin D (D3, cholecalciferol), <calcifediol (25OHD or calcidiol),

- Evidence suggests that calcifediol is more effective in correcting vitamin D deficiency, achieving results in a shorter period compared with cholecalciferol (Holick, M.F. *Adv. Food Nutr. Res.* **2024)**, [Bouillon, R et al . *J. Steroid Biochem. Mol. Biol.* **2023**,].

Clinical trials on Vitamin D

- Maximum calcium absorption was observed when 25(OH) D was 32 ng/mL (Heaney et al., 2003; Holick et al., 2011).
- Continued vitamin D deficiency results in increased production of PTH ultimately leading to secondary hyperparathyroidism.
- 25 OH D levels < 20 ng is deficiency
- 25 OH D levels 21 to 29 ng is Insufficiency
- Vitamin D deficiency increases both the initiation and propagation of cracks by 22%–31%.

Clinical trials on Vitamin D …

- Vitamin D deficiency decreases bone mass and other alterations suggesting that the remaining mineralized bone was at increased risk for fracture.

- Vitamin D and calcium supplementation can increase or maintain bone mineral density (Dawson-Hughes et al., 1997) cross ref from Hollick Advances in Food and Nutrition Research, Volume 109
- 2024)

Clinical trials on Vitamin D. .....

Chapuy et al. (1992) -3270 elderly women were either given 800 IUs vitamin D3 and 1200 mg of calcium daily for 3 years or a placebo.

They reported the reduction of the risk of nonvertebral fractures by 32% and risk of hip fracture by 43% compared to the control group.

Clinical trials on Vitamin D. .....

Bischoff-Ferrari et al. (2005) 5 randomized controlled trials (n = 9294) for hip fracture and 7 randomized controlled trial for nonvertebral fracture risk (n = 9820) that used vitamin D3 supplementation.

They concluded that vitamin D supplementation (700-800 IUs/d) reduced relative risk of hip fracture by 26% and nonvertebral fractures by 23%. There was no significant benefit for persons taking 400 IUs daily.

- Higher dose vitamin D reduced nonvertebral fractures in community dwelling individuals by 29% and institutionalized older individual by 15%. They further reported this effect was independent of additional calcium supplementation (Bischoff Ferrari et al.,2009).

EAR/RDA ICMR NIN 2020

- Estimated Average Requirement (EAR)/RDA

Calcium

Adults 800 mg /day ; Lactation period 1000mg/ 1000 and 1200 mg

- Vitamin D –
- 400 iu /day / 600 iu

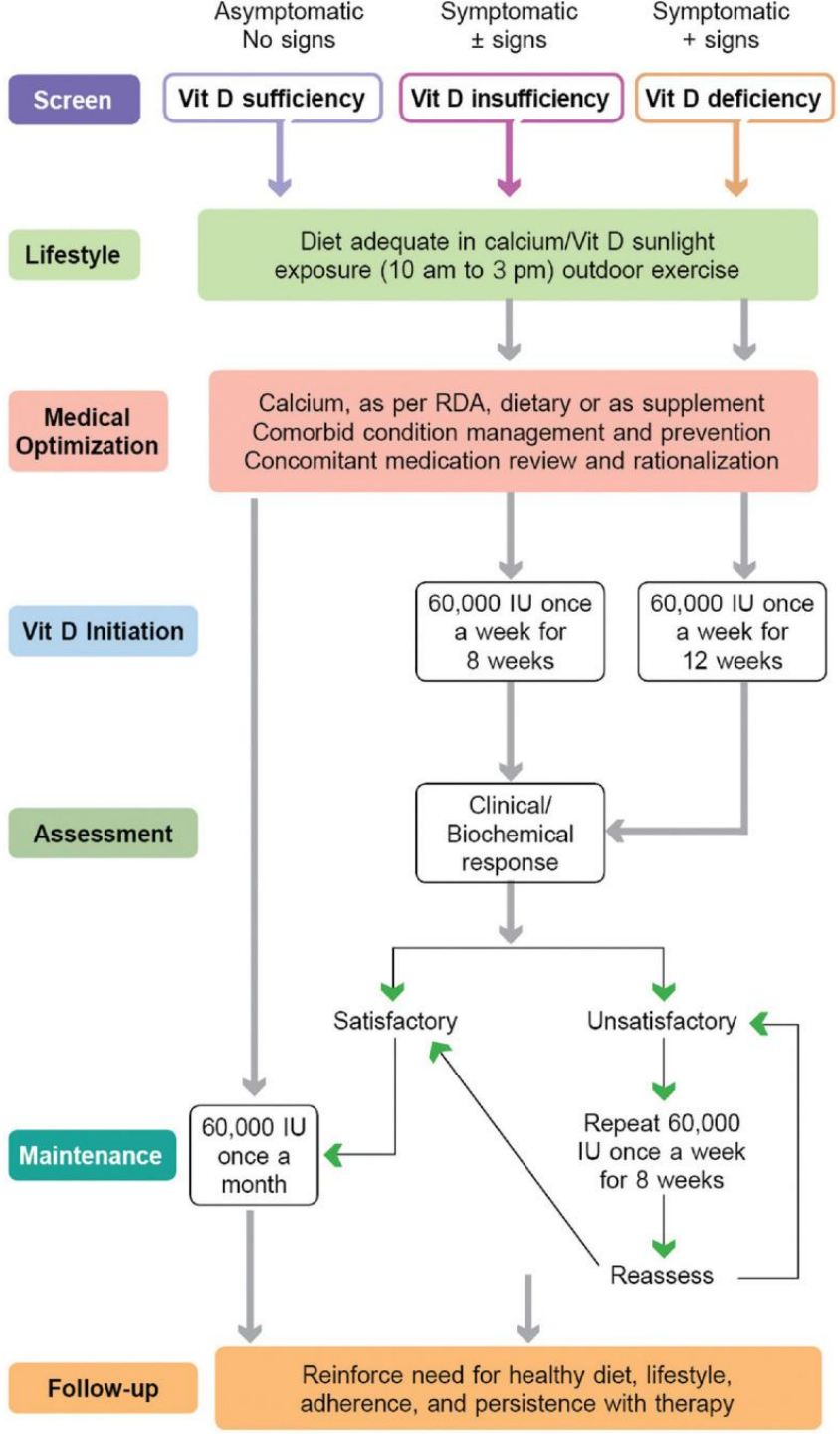
- A survey conducted in 2011–2012 in India reported a dietary calcium intake of only 429 mg/day [Harinarayan CV, et al (2007). Am J Clin Nutr Balk EM, et al (2017). Osteoporos Int

Endocrine Society Recommendations- 1

(Holick et al., 2011). For adults who are vitamin D deficient and have a normal weight an effective treatment strategy is to give them 50,000 IUs of vitamin D2 or vitamin D3 once a week for 8 weeks.

will substantially increase circulating concentrations of 25(OH)D into the range of 30 ng/mL (Malabanan, Veronikis, & Holick, 1998;

Pietras, Obayan, Cai, & Holick, 2009).



Kalra et al Indian J Endocrinol Metab 2025

Endocrine Society Recommendations - 2

To maintain vitamin D sufficiency 50,000 IUs of vitamin D2 or vitamin D3 once every 2 weeks is effective

(Holick et al., 2011; Pietras et al., 2009).

For toddlers and children 50,000IUs vitamin D2 or vitamin D3 once a week for 6 weeks corrects vitamin D

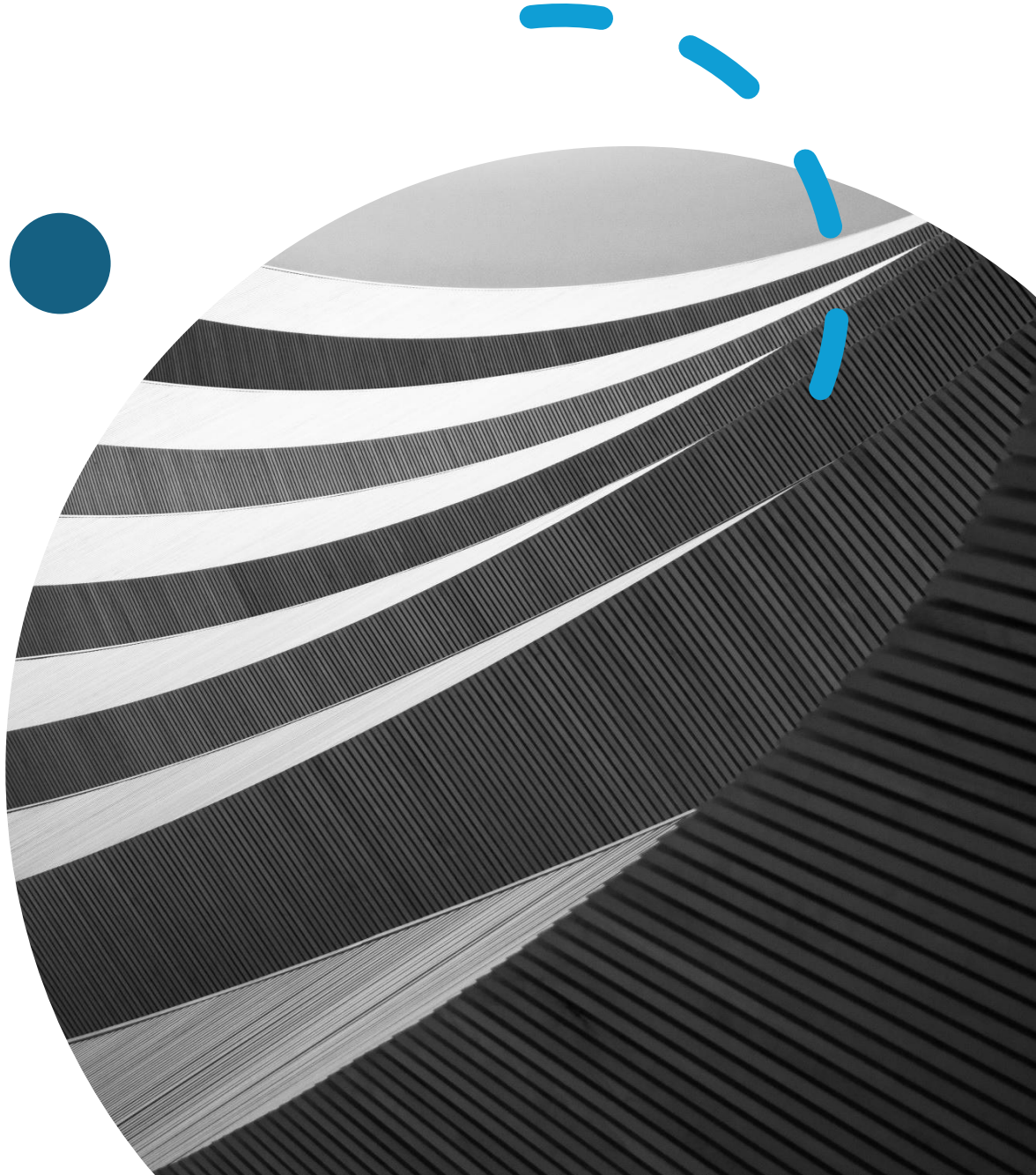
Endocrine Society Recommendations - 3

Alternatively, 2000 IUs of vitamin D2 or vitamin D3 is equally effective (Holick et al., 2011).

Obese adults require 2–3 times more vitaminD to satisfy their requirement (Ekwaru, Zwicker, Holick, Giovannucci, &

Veugelers, 2014; Holick et al., 2011).

. To maintain circulating concentrations of 25(OH)D above 30 ng/mL. RDA



Vitamin D is not an answer for all

- Vitamin D cannot treat osteoporosis
- It can mineralize the unmineralized osteoid
- It can prevent osteoporosis
- Life long requirement along with calcium
- Adolescence bone accretion and sustenance required

Food 100 G	Calcium mg
Pulses	102
GLV	280
Fish and sea foods	323
Milk (DGI recommends 300 g/day) Milk products	128 (384 mg) 755

EAT CALCIUM-RICH FOODS

- Children require higher level of calcium for growth and bone development.
-

Milk, curd, sesame seeds, ragi and GLVs like amaranth are good sources of calcium.

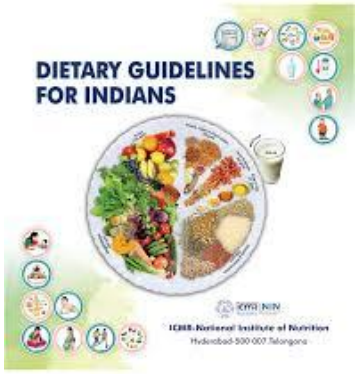
- Regular exercise

reduces calcium loss and strengthens bones.

- Exposure to sunlight (about 30 minutes preferably between 11.00 am to 2.00 pm) maintains vitamin D status which helps in calcium

absorption

.



Protein and osteosarcopenia (Ligia et al Endocrines 2025)

No conclusive data that protein supplementation may have a benefit in terms of increased BMD or reduced risk of fractures.

Protein supplementation has been variably associated with indices of muscle mass, strength and muscle performance when given alone.

Protein and osteosarcopenia (Ligia et al Endocrines 2025)

When combined with resistance exercise, it appears that whey protein may be associated with benefit.

Increasing protein intake above the recommended amount does not help improve muscle function, but malnutrition involving low protein-calorie intake is certainly an important risk factor for osteosarcopenia [**Chen et al 2024)**].

Dietary Patterns and Fracture risks- 1

- Swedish Mammography Cohort, during a median follow-up time of 25.5 years, hip fracture rate was 31% lower in the highest compared with the lowest quartile of participants adhering to the healthy dietary pattern.
- Women in the highest compared with the lowest quartile of the Western/convenience dietary pattern had a 50% higher hip fracture rate [Axelsson, et al *Osteoporos. Int.* **2022**,].
- Protein, calcium, and vitamin D, other minerals, vitamins, and bioactive antioxidant compounds, affect musculoskeletal health both independently and in combination.

Vegetarians and vegans

- Epidemiological studies have reported that vegetarians and vegans experience poorer musculoskeletal health, with consistent longitudinal evidence linking adherence to these diets to an increased risk of fractures. (Tong, T.Y.N et al . *BMC Med*. **2020**, Webster, J et al *BMC Med*. **2022**, Thorpe, et al *Am. J. Clin. Nutr*. **2021)**
- UK Women's Cohort and found a 33% increased risk of hip fracture in vegetarians as compared with regular or occasional meat or pescatarians eaters (Webster et al 2022).
- Strict vegetarians had a 17 to 33% higher risk of hip fracture compared with meat-eaters, (Ligia et al endocrines 2025)

A healthy balanced diet vegetarian or non vegetarian is beneficial

- A systematic review and meta-analysis of 31 studies found that a "Prudent/Healthy" diet was linked to a lower risk of low BMD in all age groups, while a "Western/Unhealthy" diet was associated with a higher risk of low BMD in older adults.
- The "Prudent/Healthy" diet pattern provided protection against fracture risk in men, whereas the "Western/Unhealthy" diet was associated with an increased incidence of fractures.
- Meta-analysis among 10 studies showing that the consumption of a vegetable-based diet was linked to a reduced risk of osteoporosis in postmenopausal women.

A healthy balanced diet vegetarian or non vegetarian is beneficial

- A predominantly plant-based diet and indicative of high diet quality, was linked to a lower risk of hip fractures.
- Nguyen et al. [109] in a further meta-analysis of 21 studies reported a protective link between a ‘healthy’ diet pattern and hip fracture even if there was contradictory evidence regarding the relationship between ‘healthy’ and ‘Western’ diets and BMD.
- (Denova-Gutierrez, **2018**, Zeng, **2019**, Panahande,. **2019**, Nguyen, **2021)**
- A meta-analysis of observational studies involving over thirteen thousand participants found a positive linear relationship between Mediterranean diet and higher total hip and trochanter BMD [Noori, M et al *Eur. J. Clin. Nutr.* **2022**,].

Iron deficiency and bone health

- Chronic iron deficiency is associated with an increased risk of disrupted bone homeostasis , and a higher likelihood of falls (Yang, J et al . *Int. J. Mol. Sci.* **2023**, Kim, Y et al *Int. J. Environ. Res. Public Health* **2022)**

Impact of ketogenic diets

- Garofalo, V. *Front. Endocrinol.* **2023**, found no significant changes in BMD or bone turnover markers following the ketogenic diet and concluded that there is a lack of sufficient well-designed human studies to definitively assess the impact of ketogenic diet on bone health.

Junk Food ?

- Western or pro-inflammatory dietary pattern, rich in excess meat, processed products, soft drinks, fried foods, sweets and refined grains, has been associated with a higher risk of osteoporosis (Movassagh, et al *Adv. Nutr.* **2017)**.

Exercise

- Combination of high-intensity progressive resistance and impact weight-bearing training was more effective in improving BMD at the lumbar spine compared with a home-based, low-intensity program in postmenopausal women (Watson, *J. Bone Miner. Res.* **2018)**
- The multicomponent training, for 27.2 weeks, 2.6 sessions per week, and 45 min per session, showed improvements in strength, flexibility, quality of life, BMD, balance, and functional fitness and reduced the risk of falls in older women with osteoporosis (Linhares, A Systematic Review and Meta-Analysis. *Int. J. Environ. Res. Public Health* **2022)**.

Role of Vitamin K2 in prevention and treatment of postmenopausal osteoporosis

- A systematic review and meta-analysis (Ming-Ling Ma et al , Front Public health 2022)
- VK2 Indirectly promoted bone mineralization and increased bone strength
- Mechanisms- Carboxylation of Osteocalcin which binds to hydroxyapatite to promote mineralization

Chondroitin Sulphate (CS) supplements in OA

(Rui Britto et al ; CUREUS, 2023)

- This review concludes that pharmacologic-grade CS supplements may have clinically significant benefits when properly standardized;
- However, high-quality evidence from properly designed clinical trials is still needed to draw definitive conclusions about clinical efficacy in osteoarthritis.

Specific Bioactive Collagen Peptides in Osteopenia and Osteoporosis: Long-Term Observation in Postmenopausal Women

(Denise Zdzieblik;J Bone Metab 2021)

- Long-term supplementation with specific bioactive collagen peptides appears to be effective in counteracting losses in BMD. Moreover, significant increases in BMD could contribute to improved bone stability.

Hyaluronic Acid oral supplements in OA

- Several RCTs -efficacy of oral hyaluronic acid (HA) supplements for treating mild-to-moderate osteoarthritis (OA).
- The overall consensus from recent reviews suggests that oral HA is a safe and effective therapy for reducing OA symptoms, especially for mild knee pain.

Mechanism of action of Oral Low Mol Weight HA

(Wang, Shyu-Jye et al ;Medicine 2021)

- **Absorption:** Ingested HA is not absorbed as a large, high-molecular-weight polymer.
- Instead, it is broken down by intestinal bacteria into smaller polysaccharide fragments in the digestive tract.
- **Signaling:** One proposed mechanism suggests these smaller fragments bind to receptors in the gut, which triggers a signaling cascade. This activation is believed to have anti-inflammatory effects that can ultimately reduce joint pain and inflammation.
- **Metabolism:** These polysaccharide fragments can be distributed to joint tissues and help improve symptoms.

Sarcopenia and exercise benefits

- Exercise interventions notably enhanced grip strength, knee extension strength, lower extremity muscle mass, walking speed, and functional mobility in this population.(Wang, H. *Int. J. Environ. Res. Public Health***2022**,)

Sarcopenia and exercise benefits

- Exercise had no effect on muscle mass
- Resistance training and multicomponent exercises significantly improved muscle strength
- Aerobic exercise did not .
- Inverse association between sarcopenia and each hourly increment in total, moderate, vigorous, and moderate–vigorous physical activity.
- Positively associated with bone mass and lower-limb muscle strength.
- (Rosique-Esteban et al . *Clin. Nutr.* **2019**,.

Exercise in frailty

- A meta-analysis by Yang et al.2024 of 28 RCTs involving frail older adults showed that a multicomponent exercise intervention can improve frailty status and promote enhancement of physical functional abilities.
- Another meta-analysis of 19 RCTs among community-dwelling frail older adults reported that multicomponent exercises significantly helped improve muscle strength, balance, and endurance, even if there was no conclusive evidence of the effects on enhancing quality of life or long-term health outcomes [**Wang et al 2024**].

1. Primary Source Document

Thank You

Ligia J. Dominguez,Nicola Veronese, Lee Smith
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Giuseppe Battaglia, Antonino Bianco
Mario Barbagallo
Endocrines **2025**, *6*(1), 10; https://doi.org/10.3390/endocrines6010010

Other sources of information
2. Dietary Guidelines for Indians ICMR 2024
3. Recommended Dietary Allowances ICMR 2020
4. Bhadada SK, Chadha M, Sriram U, Pal R, Paul TV, Khadgawat R, Joshi A, Bansal B, Kapoor N, Aggarwal A, Garg MK, Tandon N, Gupta S, Kotwal N, Mahadevan S, Mukhopadhyay S, Mukherjee S, Kukreja SC, Rao SD, and Mithal A. **The Indian Society for Bone and Mineral Research (ISBMR) position statement** for the diagnosis and treatment of osteoporosis in adults. Arch Osteoporos 2021; 16(1):102
5. Arpita Mukherfee et al ICRIER ; Road Map to address Vitmain D deficiency in India 2025
6. WHO; Musculoskeletal health 2022
7. Omer Elma et al J. Clin. Med. 2020, 9, 702;
8. Zhang M, Shan B, Lin S, Xu J and Zhang N (2023) Editorial: Nutrition and metabolism in musculoskeletal disorders. *Front. Nutr.* 10: