
بسم الله الرحمن الرحيم

Exercise and Osteoporosis

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Skeletal Muscle Is an Endocrine Organ

- Muscle as an Endocrine Organ: Focus on Muscle-Derived Interleukin-6, 2007

- Skeletal muscle: an endocrine organ, 2013

- Skeletal Muscle Is an Endocrine Organ. 2014

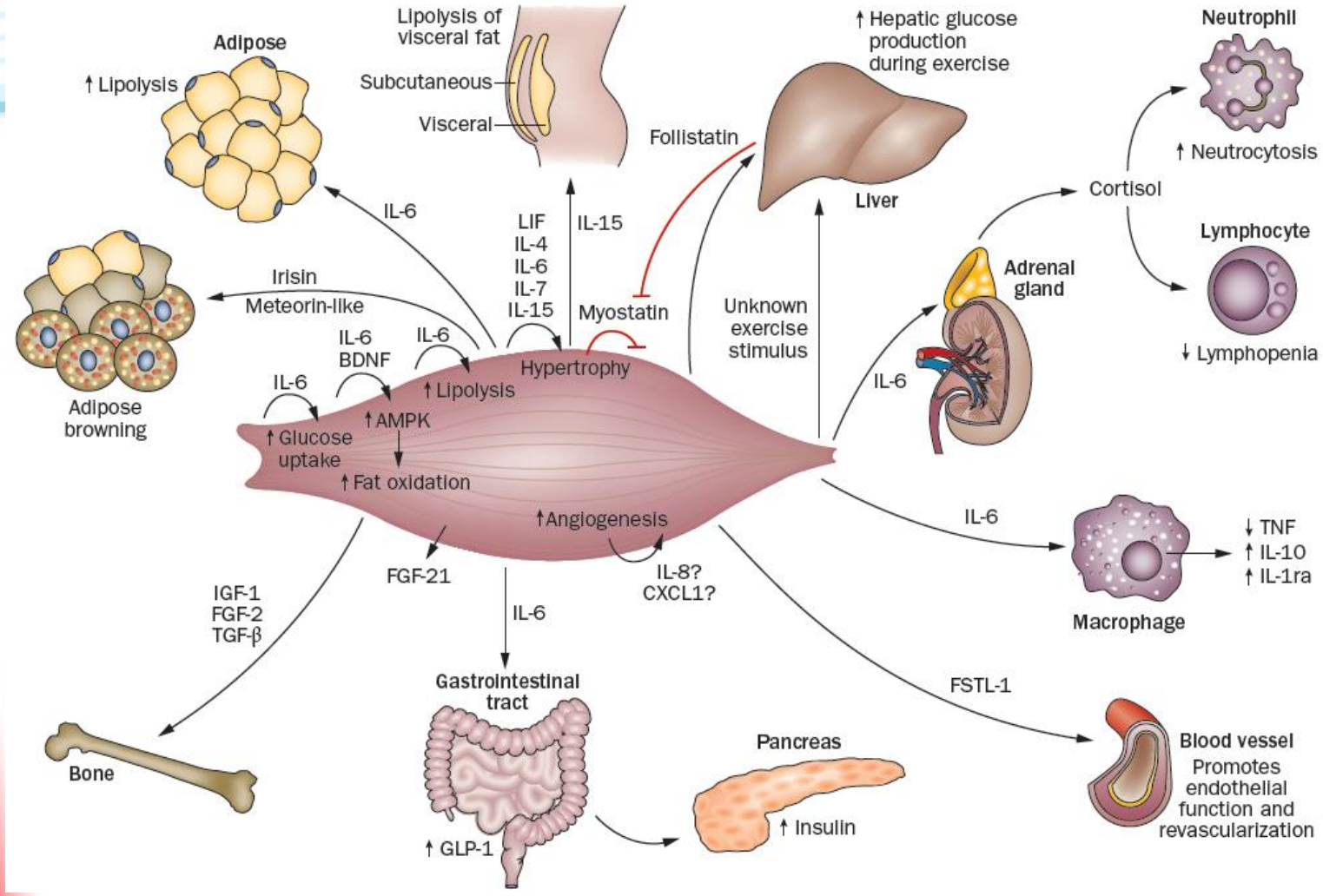
- Skeletal Muscle as an Endocrine Organ: The Role of Myokines in Exercise Adaptations, 2017

- Muscle tissue as an endocrine gland: Its role in health, 2022

- One of the most important of these advances is the discovery that skeletal muscle communicates with other organs by secreting proteins called **myokines**.

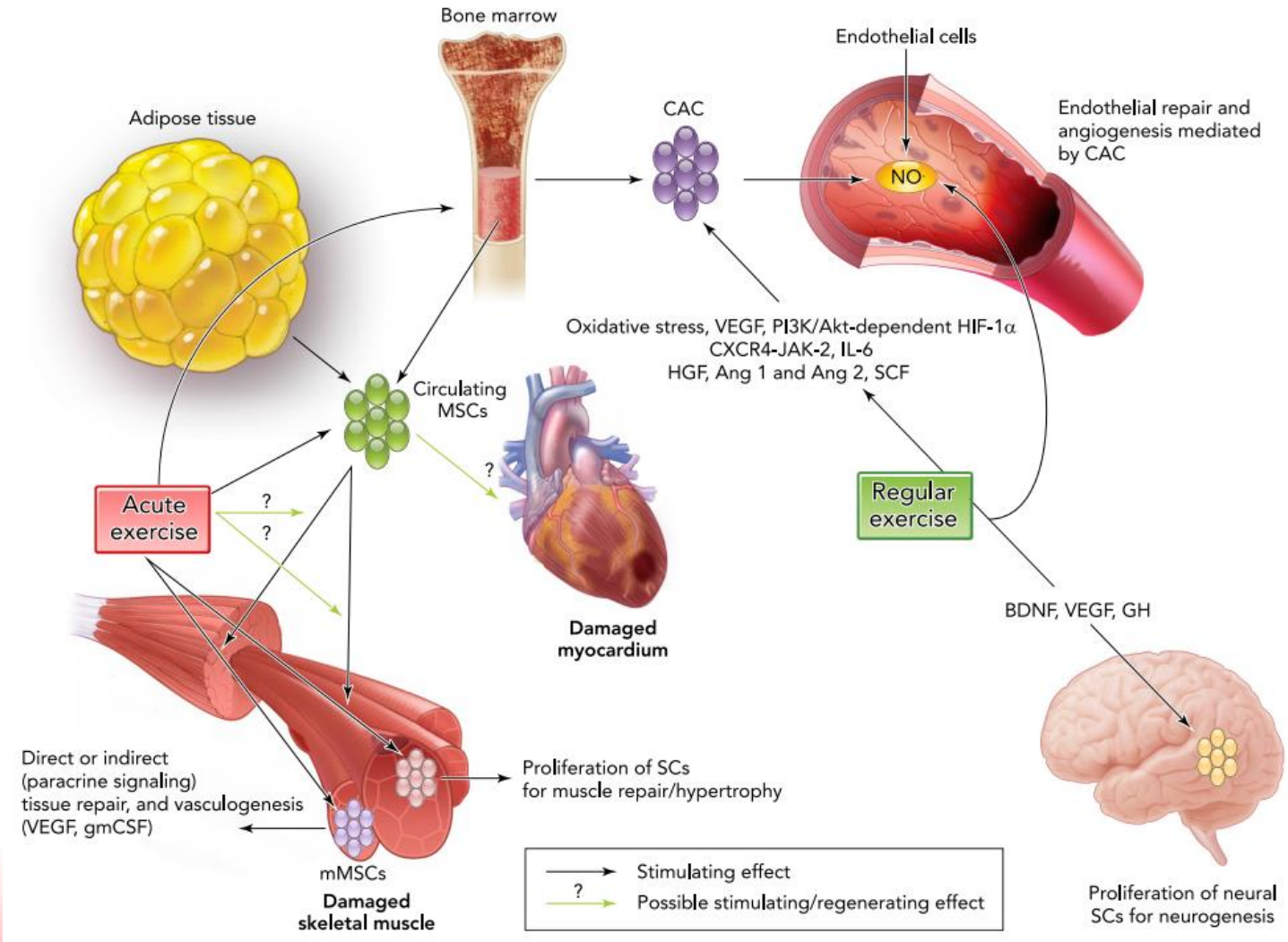
- Some myokines are thought to induce:
  - **Anti-inflammatory responses** with each bout of exercise
  - Mediate long-term exercise-induced **improvements in cardiovascular risk factors,** having an indirect anti-inflammatory effect.

Benatti FB, Pedersen BK. Exercise as an anti-inflammatory therapy for rheumatic diseases-myokine regulation. *Nature reviews. Rheumatology.* Feb 2015;11(2):86-97.



Adapted with permission obtained from Macmillan Publishers Ltd, *Nat. Rev. Endocrinol.* 8, 457–465 (2012).

Summary of the main types of stem cells associated with exercise, their main putative effects, and the molecular signals/pathways involved



REVIEWS

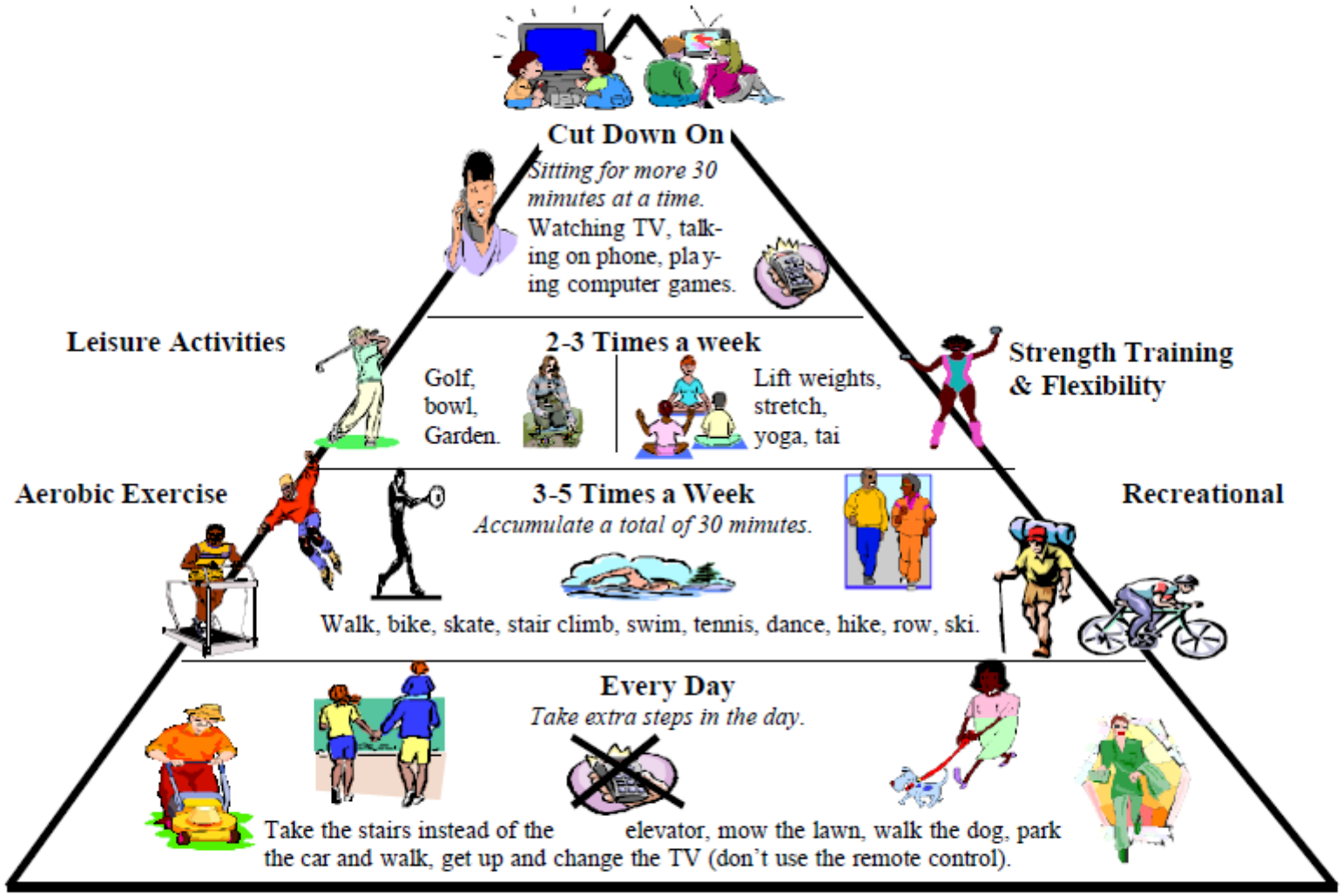
PHYSIC

Exercise is the Real Polypill

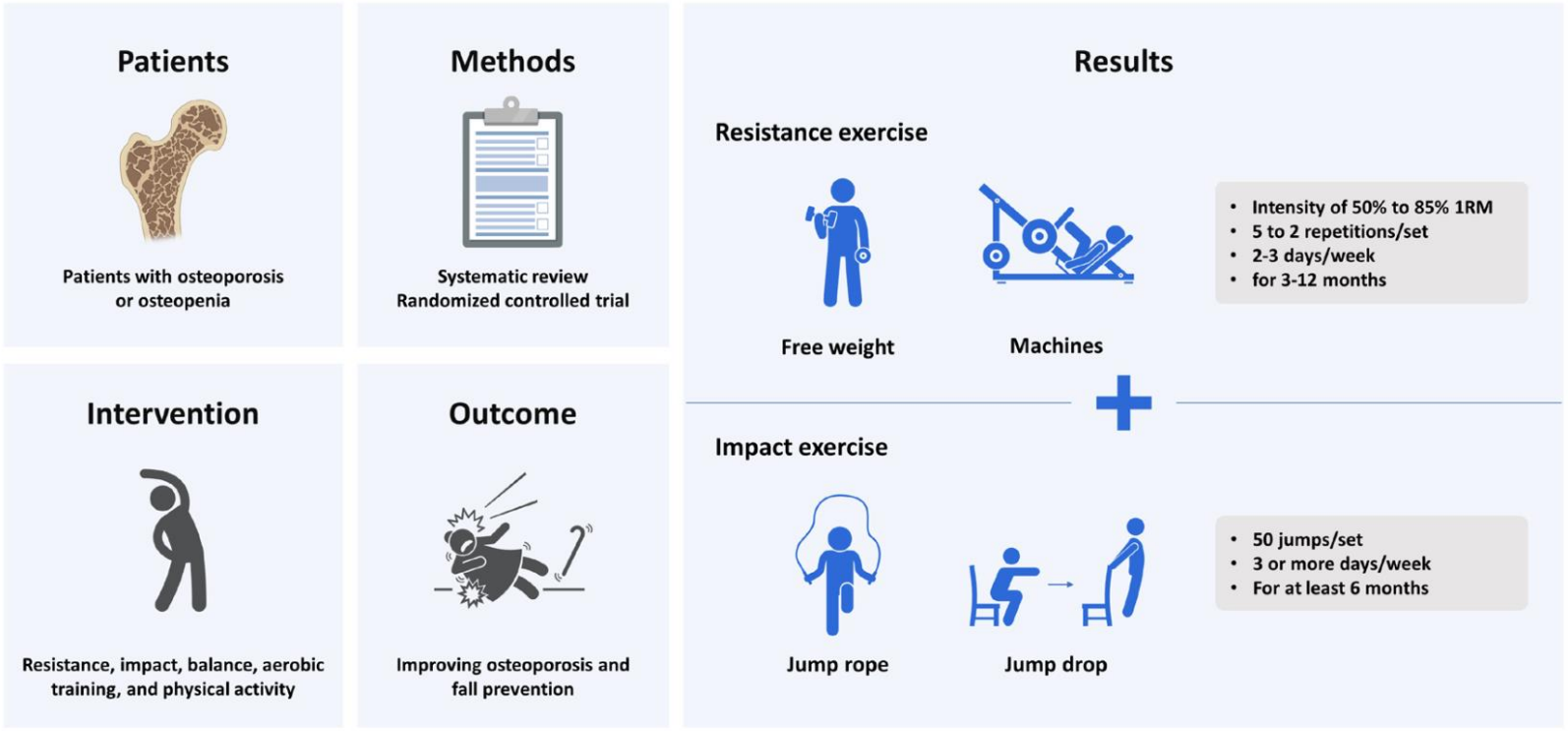
The concept of a "polypill" is receiving growing attention to prevent cardiovascular disease. Yet similar if not overall higher benefits are achievable with regular exercise, a drug-free intervention for which our genome has been haped over evolution. Compared with drugs, exercise is available at low cost and relatively free of adverse effects. We summarize epidemiological evidence on the preventive/therapeutic benefits of exercise and on the main biological mediators involved.

PHYSIOLOGY 28: 330–358, 2013;doi:10.1152/physiol.00019.2013

PHYSICAL ACTIVITY PYRAMID



Graphical Abstract



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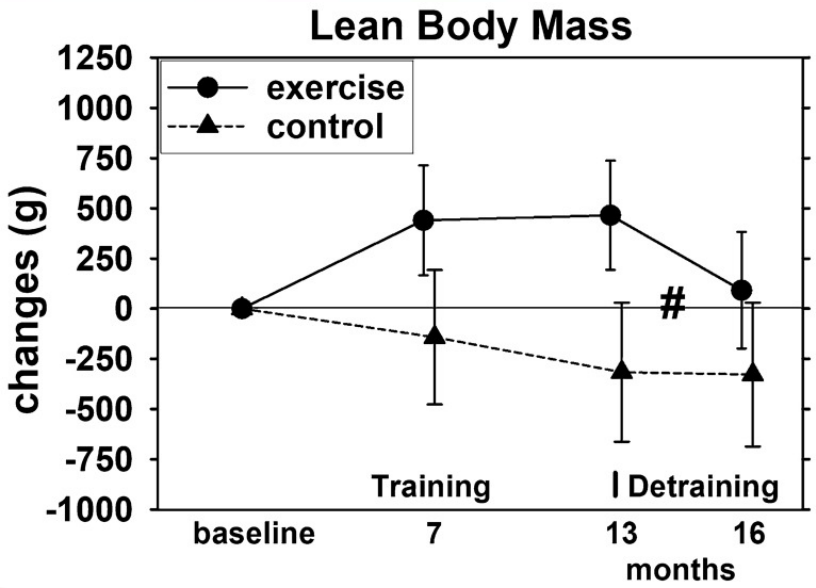
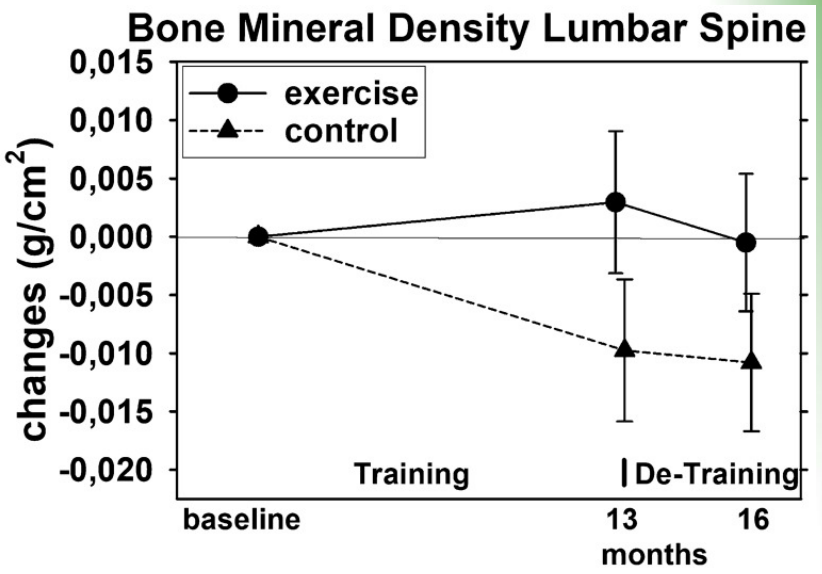
Position Statement: Exercise Guidelines for Osteoporosis Management and Fall Prevention in Osteoporosis Patients

Study	Type of intervention	Duration of intervention	Frequency weekly	Adherence	Duration of detraining
Englund et al., (25)	resistance training + aerobic + balance in 1 session	12 months	2x	N.A.	5 years
Iwamoto et al., (27)	resistance training (20 min) + step count	12 months	5x	N.A.	12 months
Kemmler et al., (26)	HIIT + high-effort resistance training	13 months	3x	79 ± 12% EG/78 ± 14% CG	3 months

▸ Front Sports Act Living. 2025 Sep 22;7:1655404. doi: 10.3389/fspor.2025.1655404

The effect of physical activity intervention and detraining on postmenopausal osteopenia and osteoporosis: a systematic review





Front Sports Act Living. 2025 Sep 22;7:1655404. doi: 10.3389/fspor.2025.1655404

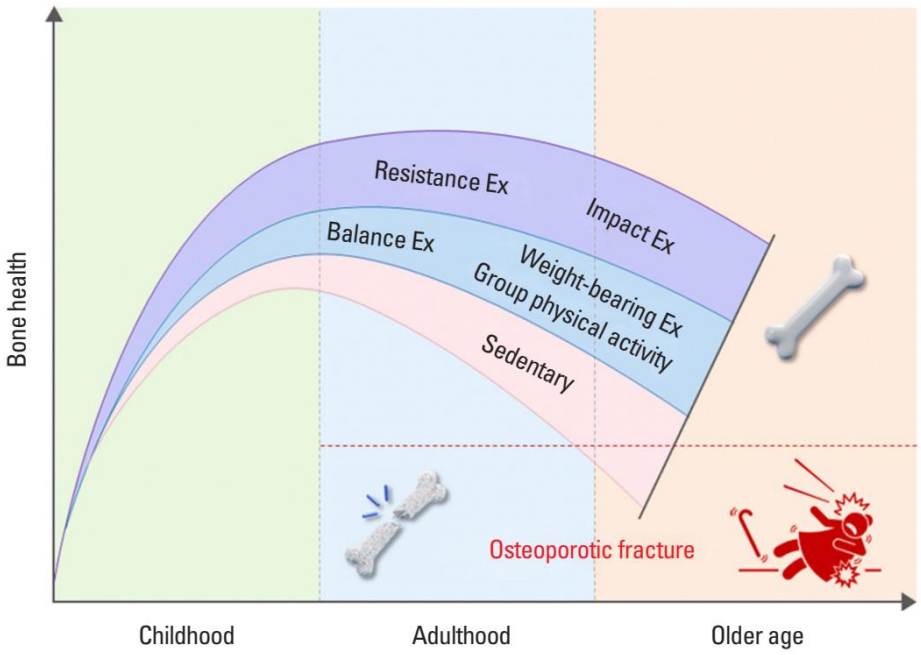
The effect of physical activity intervention and detraining on postmenopausal osteopenia and osteoporosis: a systematic review

- Tailored exercise interventions focusing on:
  - adherence,
  - intensity,
  - duration,
  - specific individual needs

  are recommended to sustain long-term bone health and physical function in older women.

Front Sports Act Living. 2025 Sep 22;7:1655404. doi: 10.3389/fspor.2025.1655404

The effect of physical activity intervention and detraining on postmenopausal osteopenia and osteoporosis: a systematic review



Exercise guidelines to improve osteoporosis and prevention of fall for individuals with osteoporosis or osteopenia

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- Exercise:
  - Slow age-associated bone loss
  - Delay the onset of osteoporosis
  - Reduce fracture risk.

- The benefits of exercise on bone health occur throughout the lifespan due:
  - increases in bone density, volume, and strength
  - improves balance in both young and older populations, which can reduce falls and subsequent osteoporotic fracture risk

- Exercise can generally be regarded as the **primary nonpharmacological treatment** for the prevention and management of osteoporosis.

- Exercise significantly **elevated** the levels of:
  - alkaline phosphatase(**ALP**)
  - N-terminal propeptide of type I procollagen(**P1NP**)
  - osteocalcin(**OC**)
- Exercise significantly **reduced** the levels of:
  - parathyroid hormone(**PTH**)
  - type I collagen cross-linked C-terminal peptide(**CTX**)

- Aerobic exercise: significantly reduced CTX levels,
- Both aerobic and resistance exercise significantly increased OC levels.

- Exercise interventions **lasting ≤6 months** and sessions of **≤60 min**
  - significantly reduced CTX levels,
  - significantly both increase OC levels

Endocrinology

TYPE Systematic Review
PUBLISHED 15 September 2025
DOI 10.3389/fendo.2025.1597046

Effects of exercise on bone metabolism in postmenopausal women: a systematic review and meta-analysis of randomized controlled trials

Exercise Prescription

- Currently, there is no consensus on the optimal Ex Rx for individuals with osteoporosis, and general recommendations are **similar to the Ex Rx for older adults**.

- In general, **aerobic exercise** is primarily for overall health benefits;
  - **weight-bearing** aerobic exercise (*e.g.*, walking) is preferred to weight-supported (*e.g.*, cycling),

- All Ex Rx should include some form of **higher-impact, higher-velocity,**
  - and/or higher intensity resistance training.

- **Supervised training** appears to be superior to unsupervised training with regard to most outcomes.

FITT RECOMMENDATIONS FOR INDIVIDUALS WITH OSTEOPOROSIS

	Aerobic	Resistance	Flexibility
Frequency	4–5 d · wk–1.	Start with 1–2 nonconsecutive d · wk– 1; may progress to 2–3 d · wk–1.	5–7 d · wk–1.
Intensity	Moderate intensity (40%–59% ˙V O2R or HRR). Use of the CR-10 scale with ratings of 3–4	Adjust resistance so that last 2 repetitions are challenging to perform. High-intensity and high-velocity training can be beneficial in those who can tolerate it.	Stretch to the point Of tightness or slight discomfort.
Time	Begin with 20 min; gradually progress to a minimum of 30 min (with a maximum of 45–60 min).	Begin with 1 set of 8–12 repetitions; increase to 2 sets after ~2 wk; no more than 8–10 exercises per session.	Hold static stretch for 10–30 s; 2–4 repetitions of each exercise.
Type	Walking, cycling, or other individually appropriate aerobic activity (weight bearing preferred). Impact loading exercises such as jumping or bench stepping can be used in those with low or moderate risk for fracture.	Standard equipment can be used with adequate instruction and safety considerations. Compound movement exercises are best.	Static stretching of all major joints.

Special Considerations

- The general recommendation is to prescribe moderate intensity weight-bearing exercise that **does not cause or exacerbate pain.**

- Exercises that involve **explosive movements** or **high-impact loading** should be avoided, especially in those at high risk for fracture.

- Specific exercises or portions of **group-led routines (*e.g.*, yoga, Pilates)** that **require excessive twisting, bending, or compression of the spine** should also be carefully assessed and avoided, particularly in those with very low spinal BMD values or prior history of vertebral fracture .

- **Falls** in those with osteoporosis increase the likelihood of a bone fracture.

- For older females and males at increased risk for falls, the Ex Rx should also include activities that **improve balance:**
  - exercises that strengthen the **quadriceps, hamstrings, and gluteal and trunk muscles** because these are the primary balance muscles.

- Tasks done with the **eyes closed** should also be considered for individuals with low or moderate (but not high) risk for fracture.

- In light of the rapid and profound effects of **immobilization and bed rest** on bone loss, and poor prognosis for recovery of BMD after remobilization, even the frailest older adults should **remain as physically active as health permits** because this will best preserve musculoskeletal integrity.

- Even **short bouts of standing or walking** are desirable during prolonged illnesses.

- **Goals and preferences** of the individual should also be considered to help with compliance.

Exercise Testing

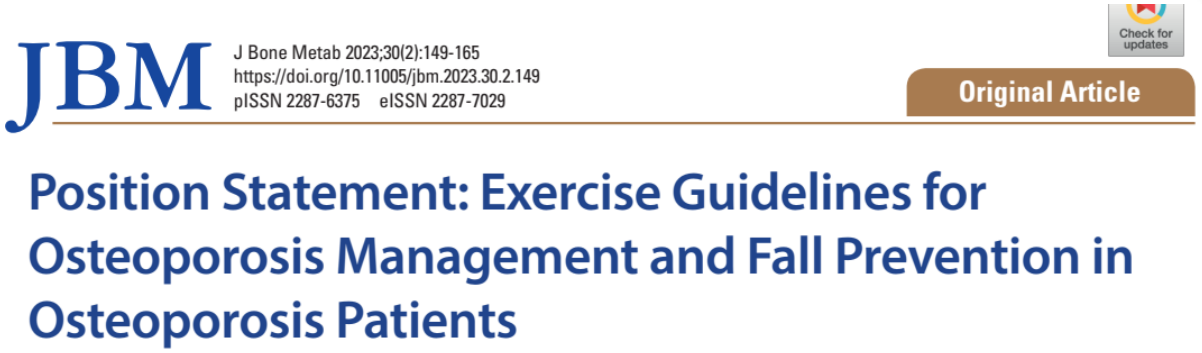
- Exercise Test:
  - Use of **cycle leg ergometry** as an alternative to treadmill exercise testing may be indicated in individuals with severe vertebral osteoporosis for whom walking is painful or risky.

- Vertebral compression fractures contributing to a loss of height and spinal deformation can compromise ventilatory capacity and result in a **forward shift in the center of gravity.** The latter may affect balance during treadmill walking.

- **Maximal muscle strength** testing may be contraindicated in individuals with severe osteoporosis due to the risks of skeletal injury.

Is resistance training an effective strategy for improving osteoporosis and fall prevention?

- Resistance training:
  - might be **protective** against further reductions in bone mass
  - plays a beneficial role in **reducing** osteoporosis-related **fracture risk** among those already diagnosed with osteoporosis or osteopenia.



What type of resistance training is effective for improving osteoporosis and fall prevention?

- **3 times a week** is recommended as a time efficient resistance training strategy to prevent age-related bone loss and falls.

- Resistance training frequency should be considered **in conjunction with training volume,** as training volume can determine the **recovery** required after vigorous training

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Are impact exercises effective for improving osteoporosis and fall prevention?

References	Year	Participants	Groups	Exercise details (FITT)	Main findings
Basat et al. [37]	2013	Women with osteopenia (N=42)	A: high-impact exercise/ B: strengthening exercise/ C: control	Total 6 months, 3 times/wk/ A: 30-40 min/ session, 1 set/10 repetition for 5 strengthening exercise/ B: 10 min/session, jump rope 10 jumps/day to 50 jumps/day	A: BMD at the lumbar spine and femoral neck (P=0.013) ↑[a], serum OC ↑[a], NTx ↓[b], HRQoL ↑[a]/ B: HRQoL ↑[a]
Kistler-Fischbacher et al. [44]	2021	Women with osteoporosis or osteopenia (N=115)	A: exercise+medicine/ B: low-intensity, pilates-based training+ medicine/ C: low-intensity, pilates-based training	Total 8 months, 2 times/wk, 40-min exercise: 5 sets of 5 repetitions, >80% to 85% 1RM, 3 free-weight resistance training exercises (dead-lift, back squat, overhead press), 1 high-impact exercise (jump drop), and two balance exercises	A: BMD (lumbar spine) ↑[a], functional performance ↑[a], fracture risk factor ↓[b]
Hettchen et al. [38]	2021	Women with osteopenia or osteoporosis (N=54)	A: high-impact weight-bearing, high-intensity, velocity resistance exercise/ B: low-intensity exercise	A: total 8 months, 3 times/wk/ B: total 8 months, 1 time/wk	A: BMD (lumbar spine) ↑[a], lean body mass ↑[a], hip/leg extension strength and power ↑[a]
Multanen et al. [43]	2017	Women with osteoporosis (N=80)	A: 1) aerobic and 2) step-aerobic jumping exercise programs/ B: control	Total 12 months, 3 times/wk, 55 min/session	A: femoral neck strength ↑[a]

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How can impact exercises be effectively applied to improve osteoporosis and fall prevention?

- Impact exercise, especially **jumping exercises** such as jump rope, jump drop, and jumping chin-ups with drop landing, were applied to women with osteopenia or osteoporosis with a duration varying from **6- to 12- months.**

- Most studies suggest that performing impact exercise at least **2 to 3 times a week** improves BMD.

Are balance exercises an effective strategy for improving osteoporosis and fall prevention?

- Improved postural balance following exercise training could **reduce the risk of fractures** by
  - Enhancing postural stability
  - Diminishing the risk of falls in older women with osteoporosis.

- Both balance training sole and combined exercise that includes balance training are associated with a significantly reduced frequency of falls in osteoporotic patients.

What is the effective way of applying balance exercises to improve osteoporosis and fall prevention?

References	Year	Participants	Groups	Exercise details (FITT)	Main findings
Madureira et al. [45]	2010	Osteoporosis (N=66)	A: intervention/ B: control	A: 48 weeks, 60 min/day for once a week, balance training/ B: instructions to prevent falls	Falls in A ↓, functional balance in A ↑, quality of life in A ↑
Mikó et al. [46]	2017	Osteoporosis (N=100)	A: intervention/ B: control	48 weeks, 30 min/day for 2 time a week, balance training	Number of falls in A ↓, Berg Balance Scale in A ↑, time up and go test in A ↑, balance tests using stabilometer in A ↑
Smulders et al. [47]	2010	Osteoporosis (N=96)	A: intervention/ B: control	5.5 weeks, 15-90 min/day for once a week, obstacle course, walking exercises, weight-bearing exercises, correction of gait abnormalities, and training in fall techniques	Fall rate in A 39% ↓, balance confidence in A 13.9% ↑, lower back BMD in A ↑, hip BMD in A ↑, activity level ↔, quality of life ↔
Liu-Ambrose et al. [48]	2004	Osteopenia (N=98)	A: resistance/ B: agility/ C: control	A: 25 weeks, 50 min/day for 2 time a week, 50–60% of 1RM with a work range of 2 sets of 10–15 repetitions and progressed to 75–85% of 1RM at a work range of 6–8 repetitions (2 sets) by week 4, resistance training / B: 24 weeks, 50 min/day for 2 time a week, agility training	Fall risk in A (57.3%) and B (47.5%) ↓, postural stability in A (30.6%) and B (29.2%) ↑

Are weight-bearing aerobic exercises effective for improving osteoporosis and fall prevention?

- A walking exercise could be the **most simple and self-manageable** way of preventing osteoporosis fractures, at least in terms of bone mass and BMD maintenance.

- However, since the effect of improving bone density may be limited only by walking exercise, it will be a **more effective strategy** for bone health if combined with impact exercise or resistance training.

How can weight-bearing aerobic exercises be effectively applied to improve osteoporosis and fall prevention?

- We recommend outdoor exercise at a moderate intensity of the rate of perceived exertion (RPE) 11 to 14 or 40% to 60% of the maximum heart rate for 30 min a day, at least 3 times a week.

- Specific markers of **bone formation** include:
  - bone specific alkaline phosphatase, irisin, and osteocalcin were **significantly increased**,

- While the marker of **bone resorption** such as:
  - N-terminal telopeptide of collagen type I and C-terminal telopeptide were **decreased.**

Are PA effective for improving osteoporosis and fall prevention?

- It is plausible that regular PA presents indirect evidence that bone density reduction due to aging or osteopenia can be alleviated and fracture can be prevented.

Modality	Frequency	Intensity	Time	Type	Evidence	Grade
Resistance training	≥2–3 days · week^{-1}: 5–12 repetition · set^{-1}	≥50% 1RM (intensity starts at 50% 1RM and progresses to 85% 1RM)	2–5 set · region^{-1}	Resistance exercise by combination of free weights and machines, including ≥3 major muscles	I	A
Impact exercise	≥2-3 days · week^{-1}	-	10-50 jumps/ session	Jump drop, jumping chin-ups with drop landings and jump rope, etc. ≥6 months	I	A
Balance training	≥1-3 days · week^{-1}	-	≥15 min/day	Dynamic and static balance	II	B
Weight-bearing aerobic exercise	≥3 days · week^{-1}	RPE 11–14, 40–60% HRR, 3–6 METs	≥20 min · day^{-1}	Weight-bearing aerobic exercise by walking, cycling, stepping, climbing, climbing the stair, etc.	II	B
Physical activity	≥2-5 days · week^{-1}	-	10–60 min · day^{-1}	Tai Chi, dynamic flamingo exercise, line dance, foot stamps, etc. ≥6 months	II	B

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Thank You