Important Concepts about Maintaining Bone Health:

- **Dairy & bone**: Dairy **helps meet** calcium/protein needs and can support **BMD**; **fracture prevention** signal is **modest/heterogeneous**, strongest where other Ca/D sources are limited and in higher-risk elders. PMC+1

🦴1️⃣ Strength & weight-bearing exercise

Most impactful for preserving bone *density and structure.*

- **Mechanical loading** (resistance training, impact, jumping, brisk walking, stair climbing) directly stimulates **osteoblast activity** and improves **bone geometry and strength** — effects no nutrient can replace.
- Meta-analyses show that **resistance and impact training** can increase or preserve BMD at the hip and spine, especially in postmenopausal women.
- Exercise also reduces **falls** (via balance and muscle mass), the single largest modifiable fracture risk factor.

📚 *References:*

- Martyn-St James & Carroll, *Bone* 2006; Iwamoto et al., *Am J Med* 2004; ACSM Position Stand 2019.

🌞2️⃣ Vitamin D

Critical for calcium absorption and bone mineralization.

- Vitamin D regulates **intestinal calcium absorption**, serum calcium, and parathyroid hormone (PTH).
- Deficiency → secondary hyperparathyroidism → bone resorption and osteopenia.
- Supplementation (esp. in those deficient or elderly/institutionalized) **reduces fracture risk modestly**, mainly when combined with calcium.
- Above sufficiency (~75 nmol/L or 30 ng/mL), extra intake provides little additional benefit.

📚 *References:*

- Bischoff-Ferrari et al., *NEJM* 2005; Weaver et al., *Osteoporos Int* 2016.

🧀3️⃣ Calcium

Necessary, but not sufficient alone.

- Adequate calcium (≈ 700–1,200 mg/day) prevents secondary hyperparathyroidism and supports bone remodeling.
- Supplements or high calcium intake **alone** have **minimal fracture protection** in community dwellers; effects improve only when combined with vitamin D or low baseline calcium.
- Both dairy and high-bioavailability plant sources work, provided intake is consistent.

📚 *References:*

- Tang et al., *Lancet* 2007; Tai et al., *BMJ* 2015.

🥦4️⃣ Protein

Supportive, especially when calcium & D are adequate.

- Protein provides the **matrix (collagen)** on which bone mineralizes and preserves **muscle mass** (reducing falls).
- High protein *with sufficient calcium and alkalizing fruits/veg* is **beneficial**, not harmful.
- But protein deficiency accelerates bone loss.

📚 *References:*

- Bonjour et al., *Am J Clin Nutr* 2013; Dawson-Hughes et al., *J Nutr* 2015.

🩺 🔹 Summary ranking (most to least impactful):

1️⃣ **Strength / resistance & impact training**
2️⃣ **Vitamin D sufficiency**
3️⃣ **Adequate calcium intake**
4️⃣ **Adequate protein intake**