'An update on Nutrition, Exercise and Bone Health Outcomes'

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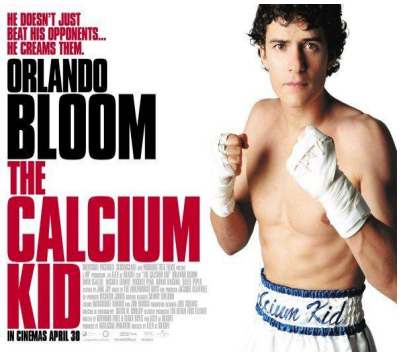
Presentation Outline

- Osteoporosis and bone health assessment
- Overview of exercise and bone health
- Recent developments in calcium and vitamin D
- Potential synergy between nutrition and exercise on bone growth

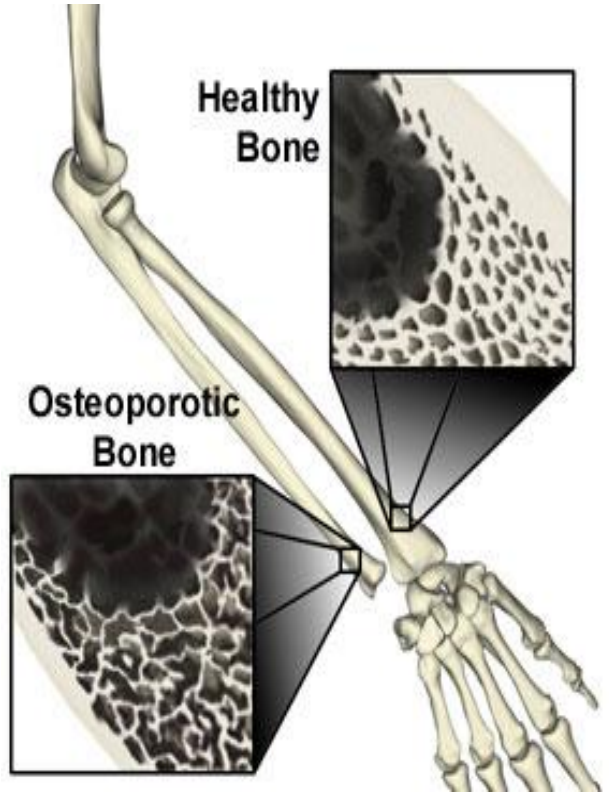


Osteoporosis... ***A major public health problem***

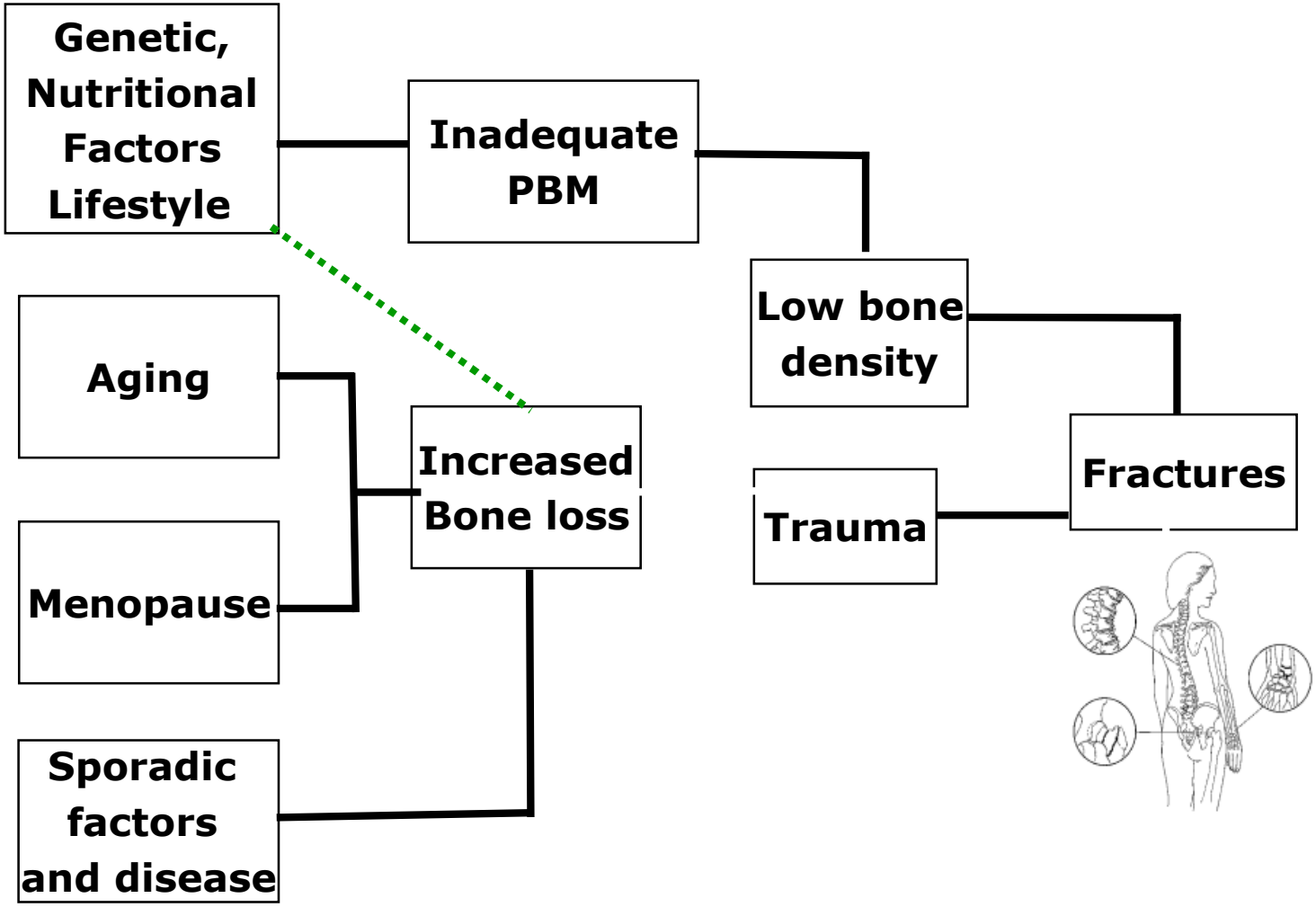
- A condition of fragility, with decreased bone mass and microarchitectural deterioration both contributing to the fragility.

- There is an osteoporotic fracture occurring in the EU every 30 seconds.

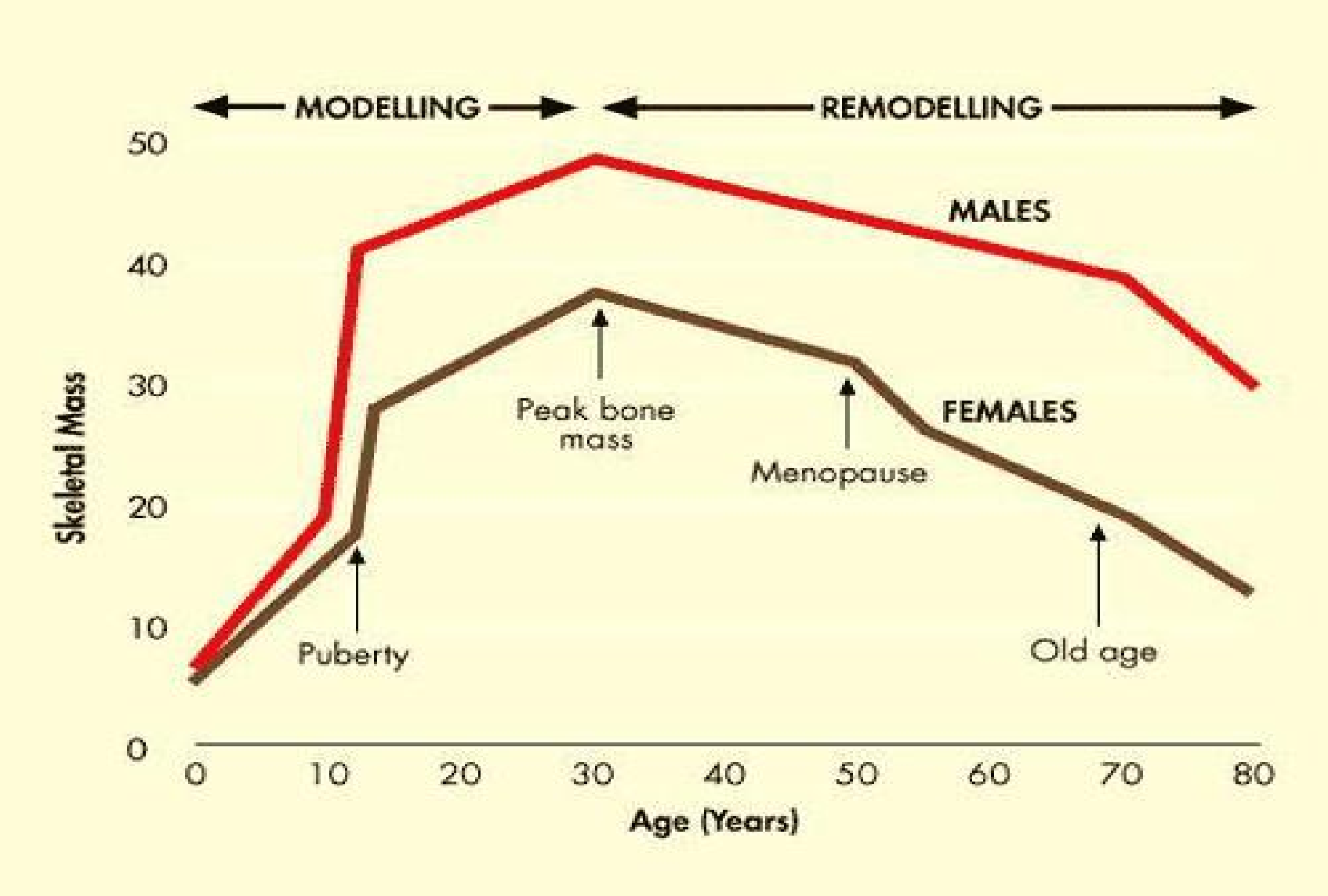
(International Osteoporosis Society)



Model of Pathogenesis of Osteoporosis [Riggs, 1988]



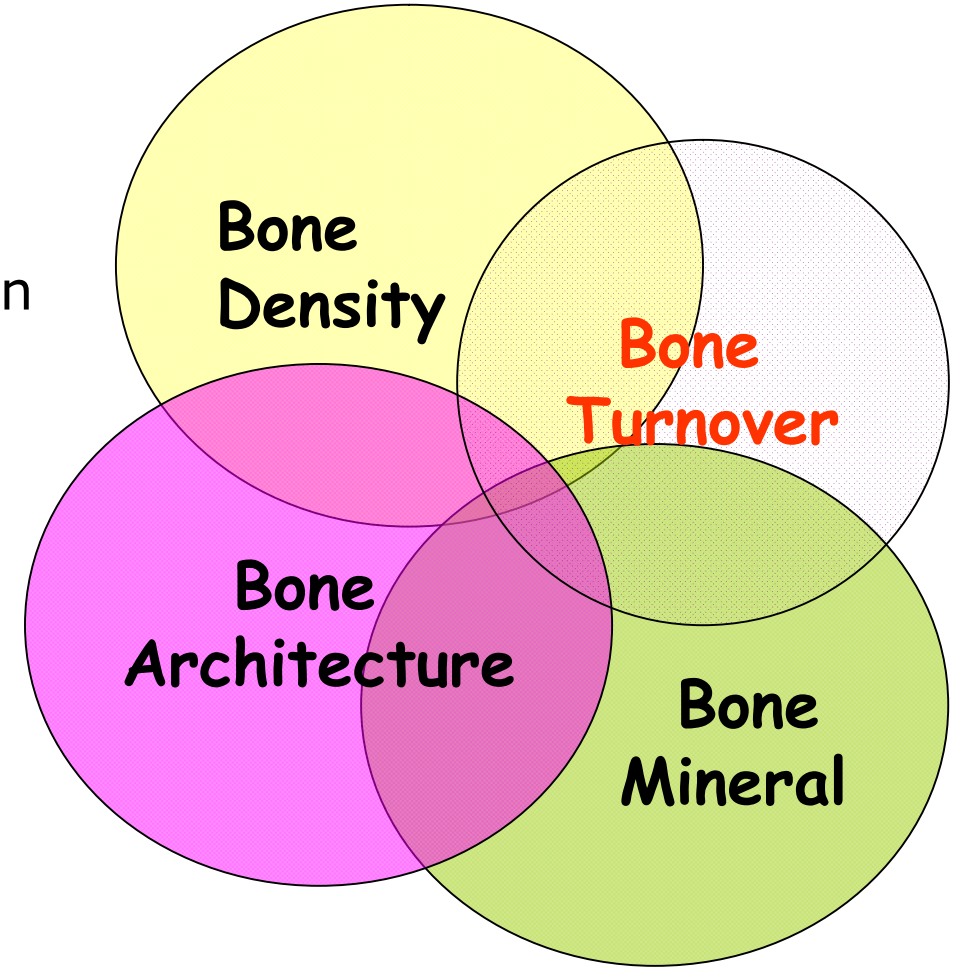
Life cycle of the skeleton



Bone Strength = Bone Density + Bone Quality

Bone Density: amount of matter per cm^3 of bone

Bone Quality: bone architecture
bone mineralisation
bone turnover



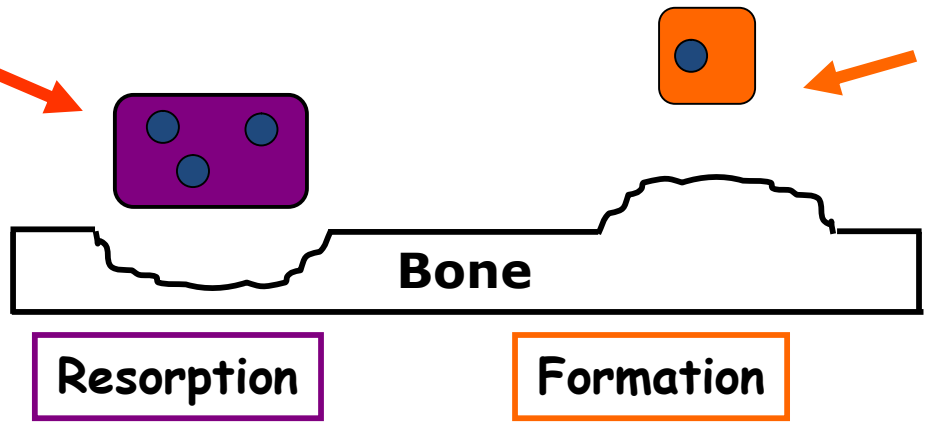
Influences

- genetics
- **physical activity**
- hormonal environment
- **nutrition**

Bachrach LK (2001) *Trends Endocrin Met,* 12,22-8.

Bone Turnover

Osteoclast
Large, multi-nucleated. Resorbs bone by dissolving minerals and degrading collagen.



Osteoblast
Forms bone by producing collagen and promoting mineralization

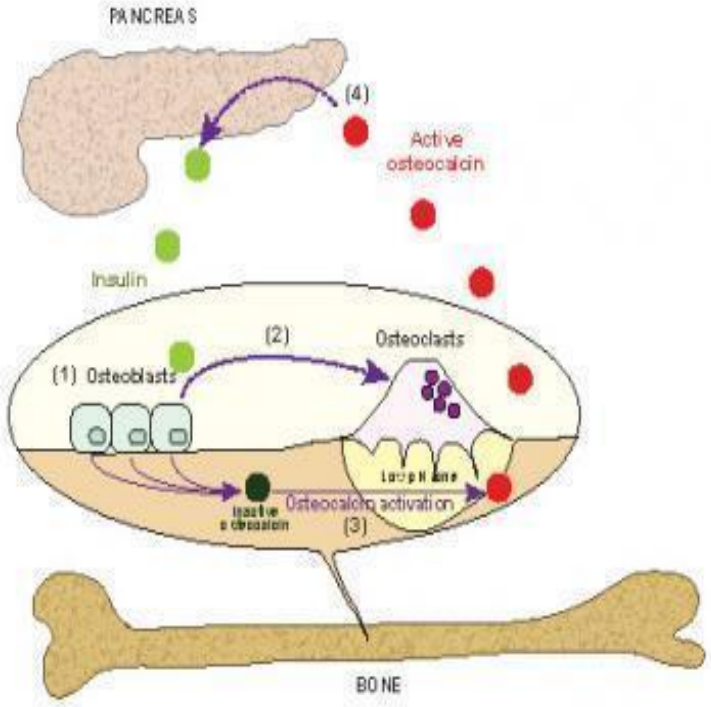
Bone turnover markers (BTM) reflect whole body rates of bone resorption & formation.

Useful in research settings – shorter timeframe than measures of bone mineral density.

Could Diabetes Be in Your Bones?

- **Link Between Metabolic Disease, Bone Mass; Breakdown of Bone Keeps Blood Sugar in Check**

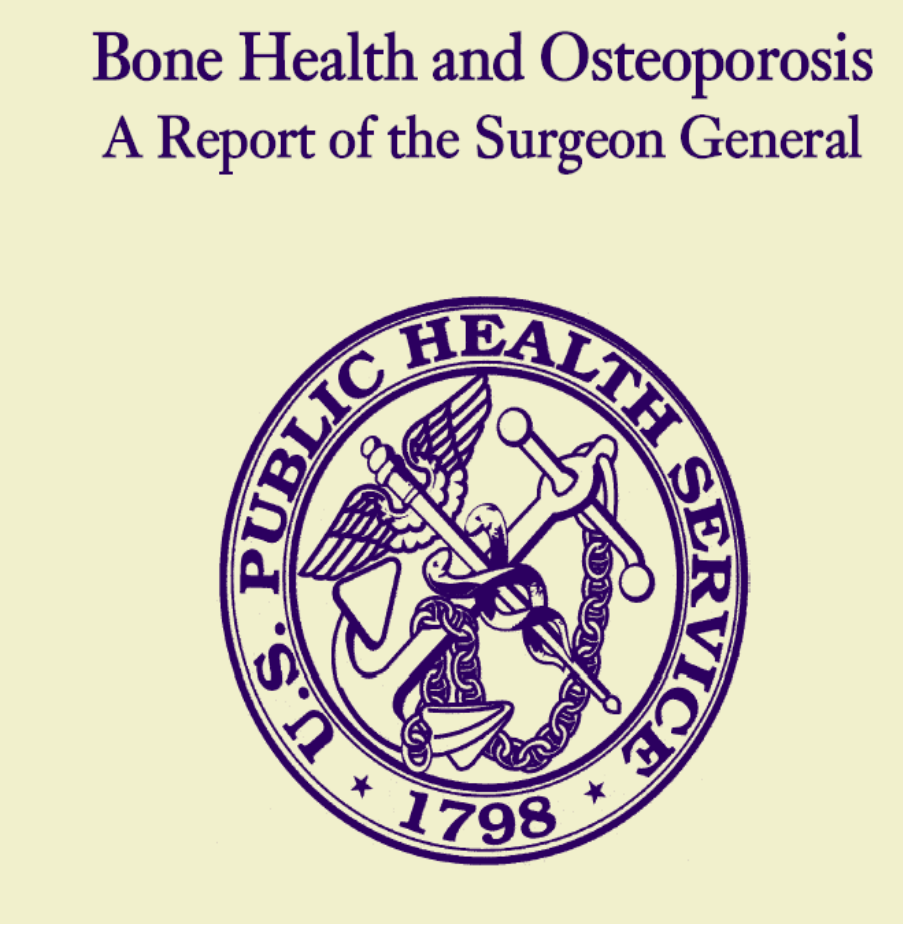
- In a feed-forward loop, insulin signals in osteoblasts activate a hormone, osteocalcin, that promotes glucose metabolism.



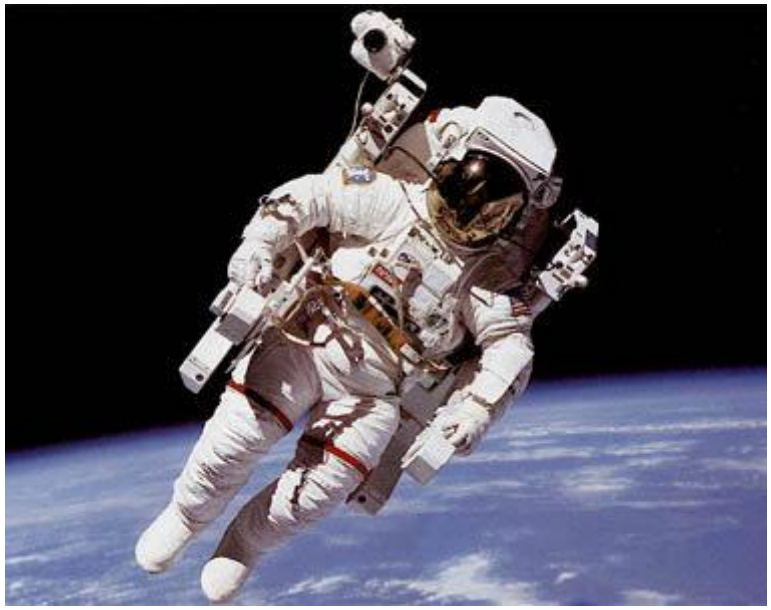
Ferron et al (2010) Cell 23;142(2):296-308

Nutrition, exercise and bone health

'Physical activity and adequate calcium and vitamin D intake are now known to be major contributors to bone health for individuals of all ages.'



Exercise and bone health outcomes…..



NASAs Floating treadmill!

- In the absence of gravity, human bones don't have to perform their primary function of supporting the body's weight. As a result, space station astronauts experience disuse osteoporosis, a type of bone loss common in immobile patients.

- Astranaouts can lose as much as 1.5 percent of their bone mass per month. That's the same amount of bone a post-menopausal woman can lose in a year.

Osteogenic influences of exercise on bone

- Mechanical influences
- Hormonal influences
  - Growth hormone
  - IGF-1
  - Sex hormones
  - Calciotropic hormones (eg PTH, calcitonin, 1,25 dihydroxyvitamin D)

For review see Maimoun & Sultan (2009) Calcified Tissue Int 85; 277-286.

Controlled trials of exercise and bone health during growth

- Early and sustained effects of exercise on bone depends on the type and intensity of exercise and the maturity level of the child

- The American College of Sports Medicine recommend activities which generate high-ground reaction forces such as jumping, skipping and running

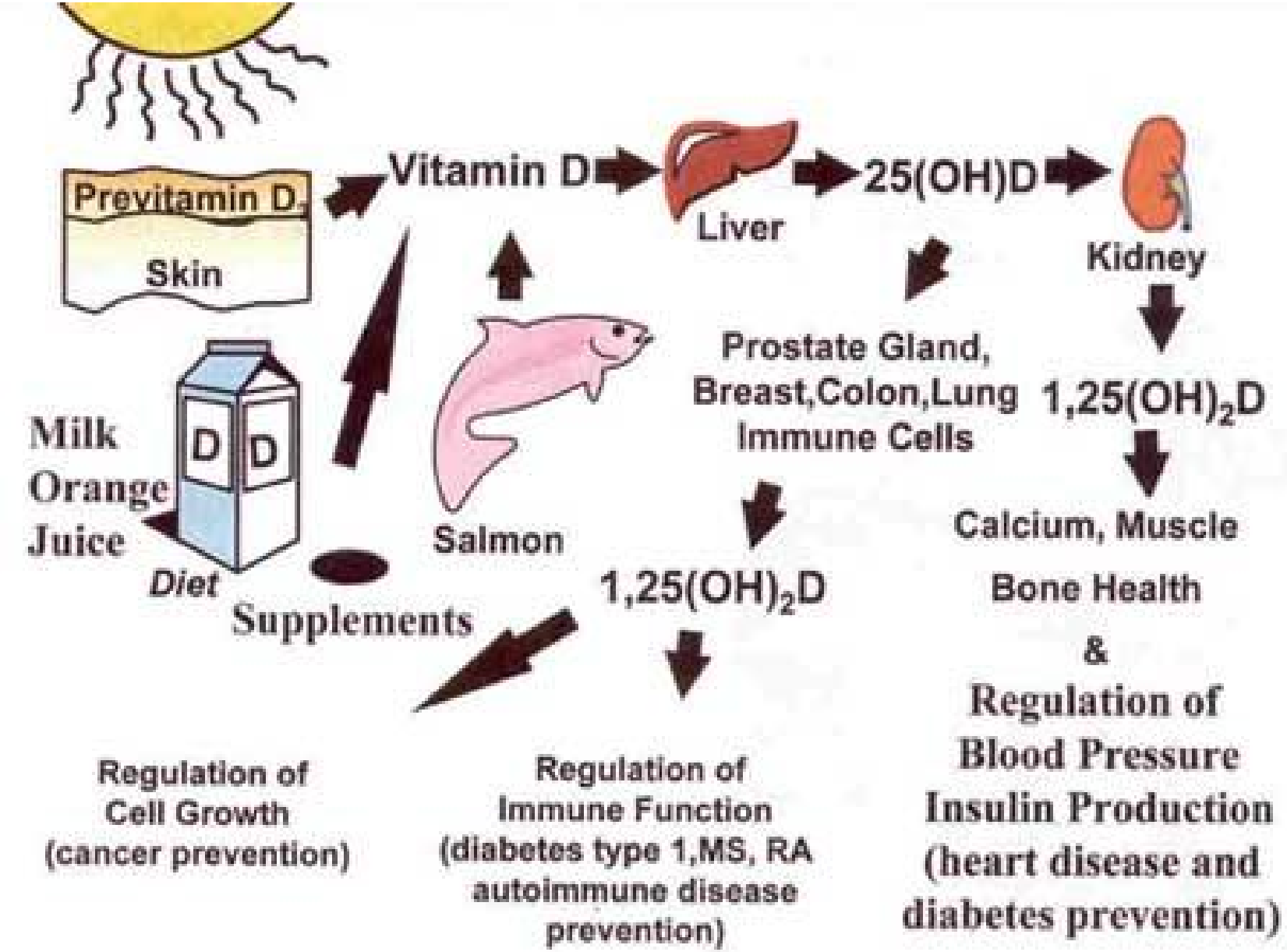
- Due to differences in skeletal maturity, specific interventions may need to be started at a younger age in girls than boys

For review see Rizzoli et al (2010) Bone 46; 294-305.

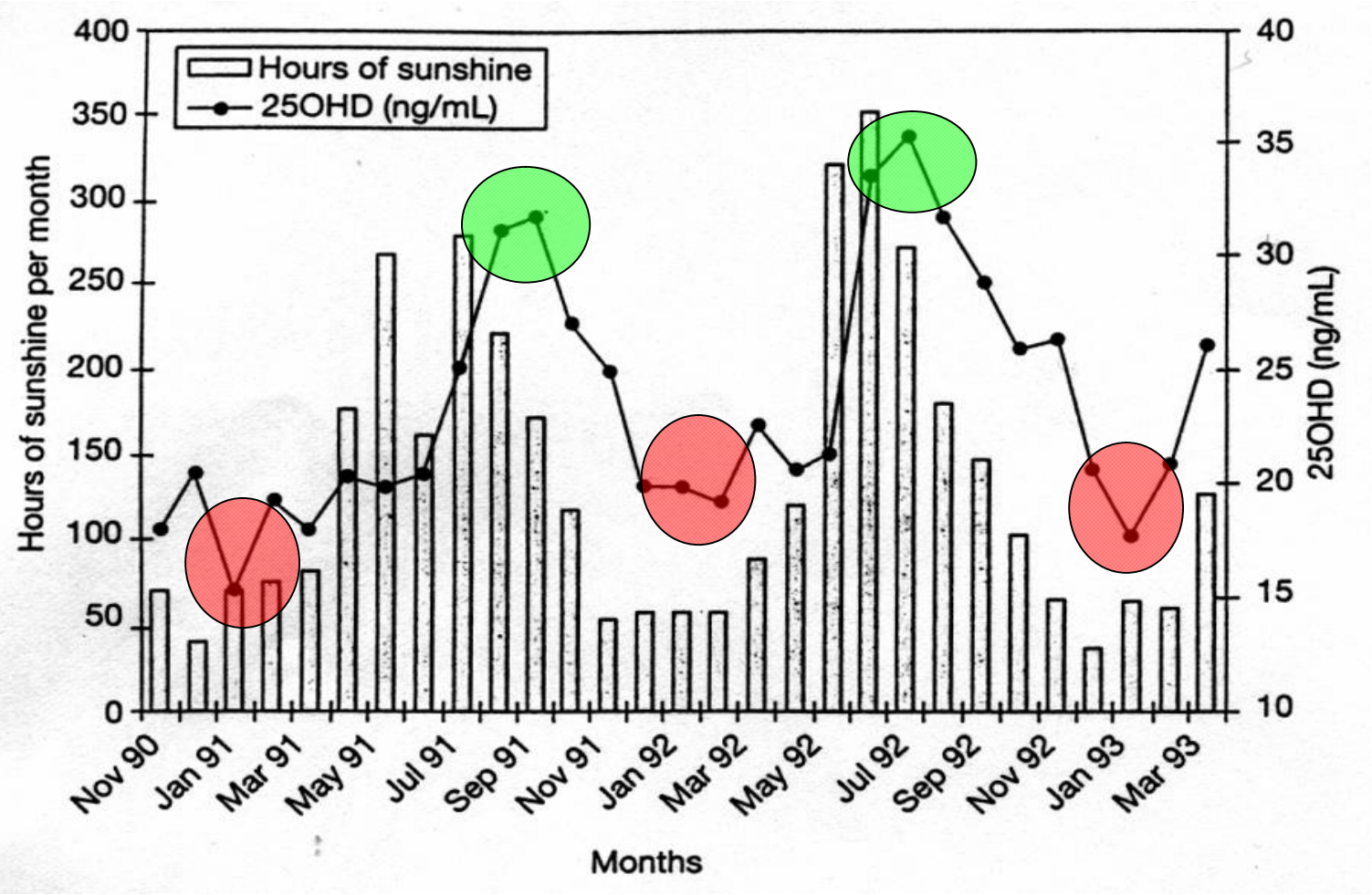
Diet and bone health: More than just calcium and vitamin D!!

Beneficial	*Detrimental factors/nutrients*
Calcium	Excess alcohol
Copper	Excess caffeine
Zinc	Excess sodium
Fluoride	Excess fluoride
Magnesium	Excess/insufficient protein
Phosphorus	Excess phosphorus
Potassium	Excess/insufficient vitamin A
Vitamin C	Excess *n*-6 PUFA
Vitamin D & K	
B-vitamins	
n-3 fatty acids	
Protein	
Fruit and vegetables	
Bioactives (eg CLA, phytoestrogens)	

Cashman (2007) Postgrad Med J Apr;83:230-5


Previtamin D
Skin
Vitamin D
Liver
25(OH)D
Kidney
Milk
Orange
Juice
D
D
Diet
Supplements
Salmon
Prostate Gland,
Breast,Colon,Lung
Immune Cells
1,25(OH)2D
Calcium, Muscle
Bone Health
&
Regulation of
Blood Pressure
Insulin Production
(heart disease and
diabetes prevention)
1,25(OH)2D
Regulation of
Immune Function
(diabetes type 1,MS, RA
autoimmune disease
prevention)
Regulation of
Cell Growth
(cancer prevention)

Seasonal aspect of vitamin D status

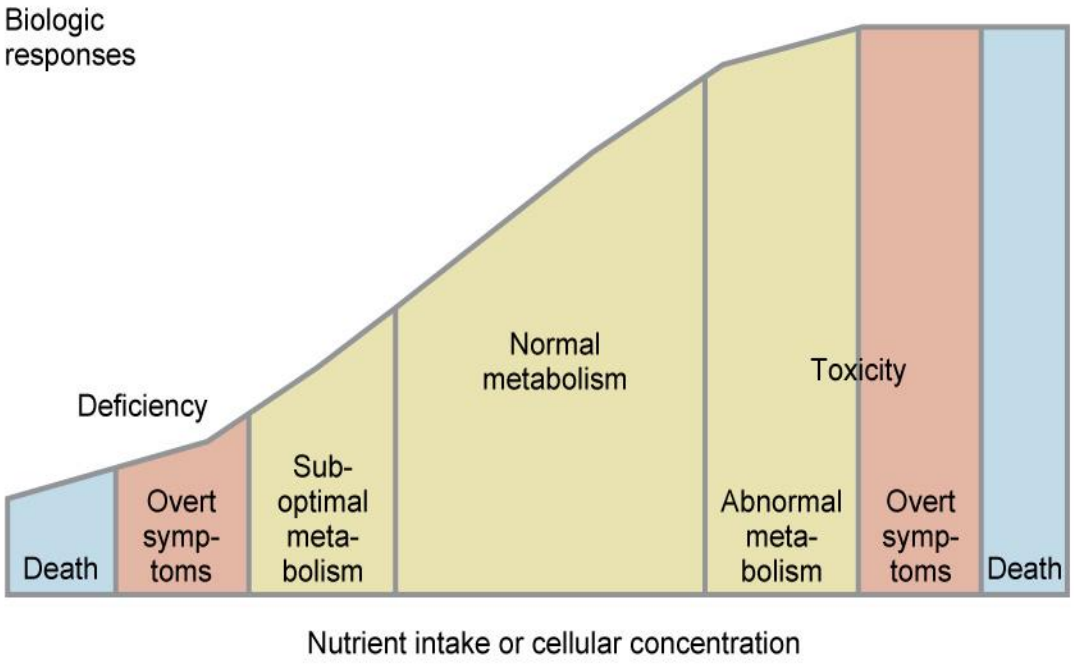


(Data taken from Scandinavian study, 55º North)

Vitamin D effects on bone

- Effects on intestinal calcium absorption
- Effects on PTH and bone turnover
- Effects on BMD
- Effects on muscle strength and falls
- Effects on fracture risk

Vitamin D deficiency V sufficiency



Serum 25-hydroxyvitamin D levels are reflective of sunlight exposure and dietary intake

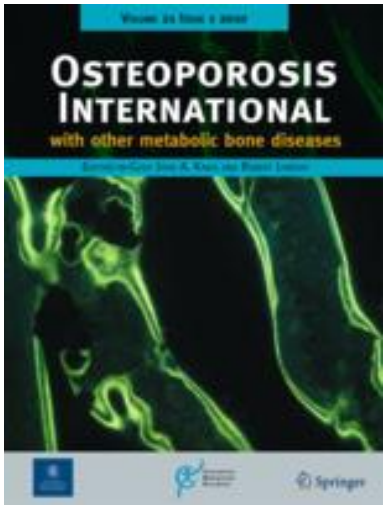
Levels <25 nmol/l indicate deficiency

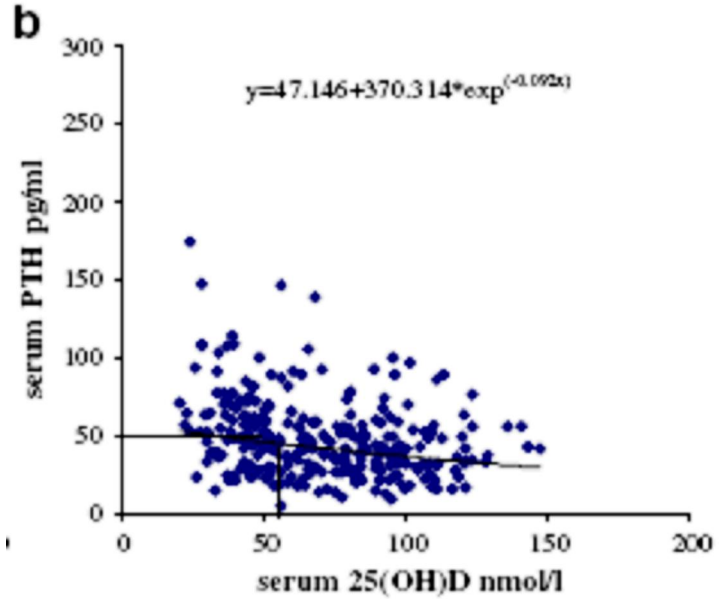
No consensus on what defines insufficiency

In the largest study of 25OHD levels in the UK (n 7437), during the winter/spring, 25OHD levels < 25, 40 and 75 nmol/l were found in 15·5, 46·6 and 87·1% of the population, respectively

*Hypponen E & Power C (2007) Am J Clin Nutr. 2007; **85**(3): 860-8.*

Serum 25-hydroxyvitamin D and PTH during adolescence





Hill et al (2010) Osteoporosis Int 21; 695-700

Dietary vitamin D requirements

Recently published Institute of Medicine DRV's

29th November 2010

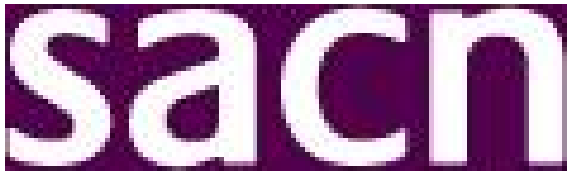
RDA = 15 µg/day for individuals up to 70yrs

RDA = 20 µg/day for individuals > 70yrs

Ross et al. 2010 Institute of Medicine. Dietary Reference Intakes for Calcium and Vitamin D. Washington.

The situation in the UK

Scientific Advisory Committee for Nutrition established a 'Vitamin D working Group' in 2010 to provide a risk assessment on vitamin D to the government



Terms of reference: To review the Dietary Reference Values for vitamin D intake and make recommendations.

Final Report due Feb 2014

Identified areas of research to inform the SACN report

- What intensity and duration of sunlight is required to maintain an ‘adequate’ vitamin D status in the UK while not compromising skin health?
- What is the nature of the inter-dependence between calcium and vitamin D?
- Is serum 25-hydroxyvitamin D suitable biomarker of ‘effect’?

Vitamin D receives EFSA approval for falls prevention!

11th October 2011: The panel concluded that a cause and effect relationship has been established between the intake of vitamin D and a reduction in the risk of falling.

In order to obtain the claimed effect, 800 I.U. (20 µg) of vitamin D from all sources should be consumed daily. The target population is men and women 60 years of age and older.

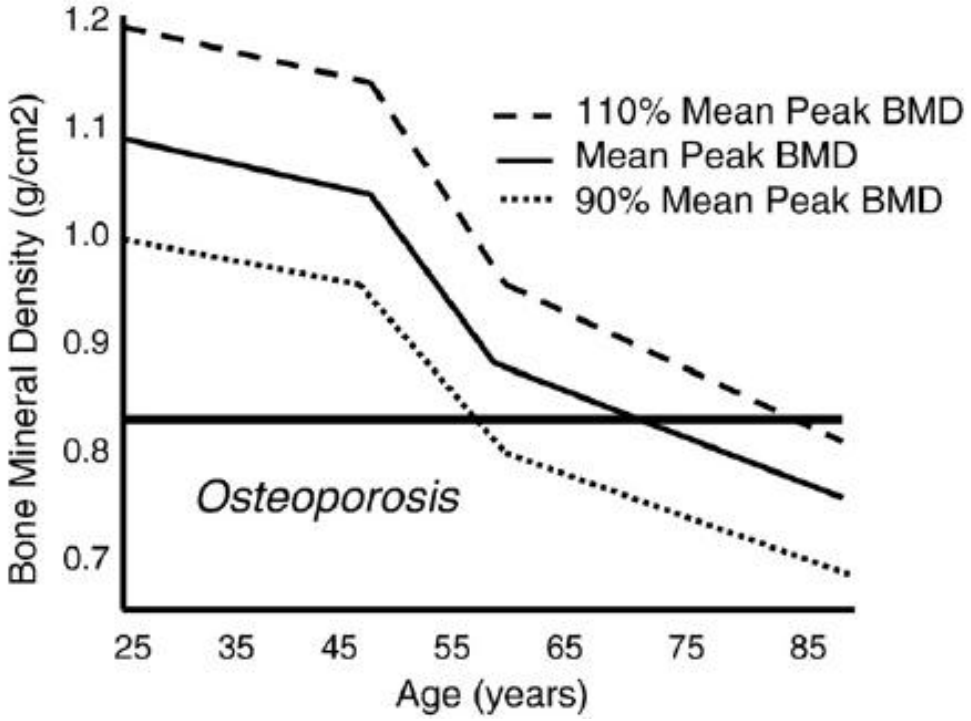
Ageing research at Newcastle:

- Newcastle 85+ longitudinal cohort (*n* > 1000)
- Assess, in great detail, the spectrum of health in the oldest old
- Examine the associations of health trajectories and outcomes with biological, clinical and social factors as the cohort ages (including diet, physical activity and bone health relationships).
- Identify factors which contribute to the maintenance of health and independence.
- Advance understanding of the biological nature of human ageing.

Newcastle University

Early life interventions are important

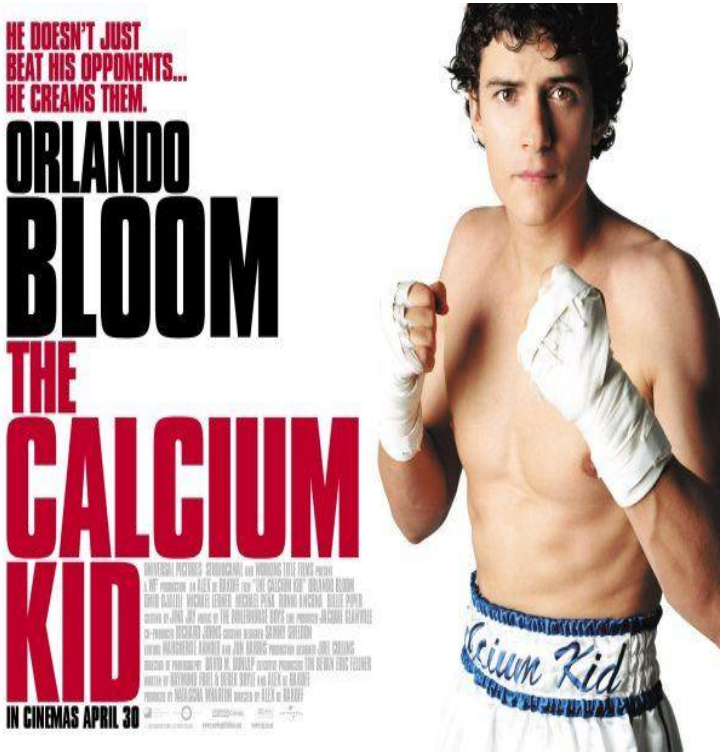
Using a computer simulation of the bone remodeling process, the onset of osteoporosis is predicted to be delayed by 13 years if mean BMD is 10% higher than the mean among young adults



Hernandez et al (2003) Osteoporos Int 14; 843-7

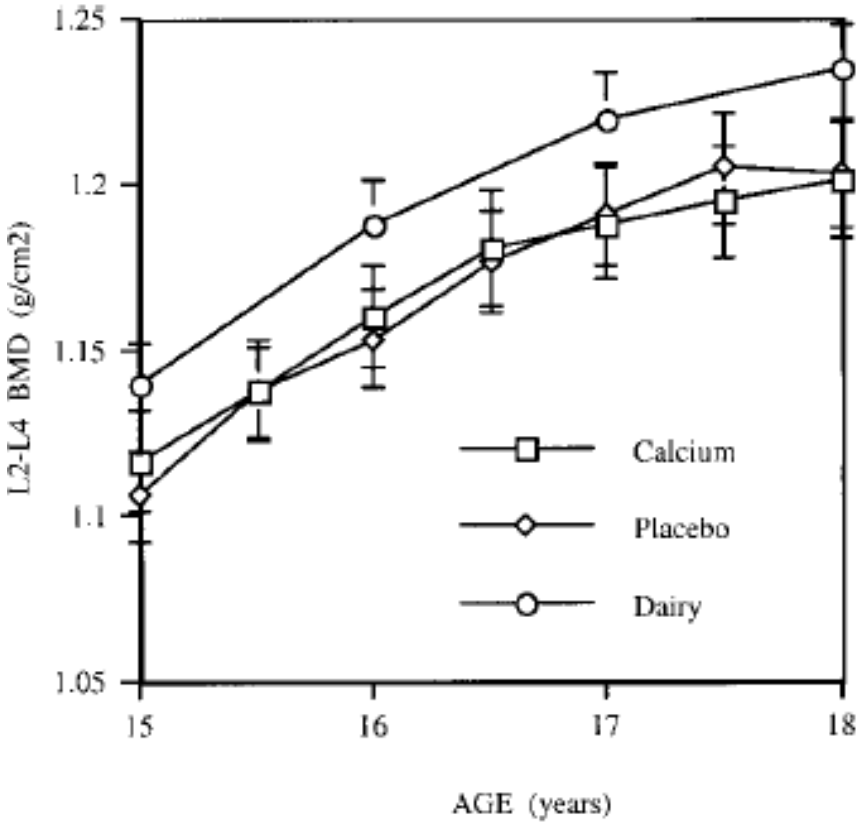
Calcium supplementation and bone mineral mass accrual

- Consistent evidence that calcium supplementation is beneficial
- Magnitude of the effect depends on the stage of development eg pre-menarcheal V post-menarcheal
- Is site specific (i.e. greater gains in appendicular skeletal sites such as radius and femur compared with for example the lumbar spine



For review see Rizzoli et al (2010) Bone 46; 294-305.

Dairy products V's calcium effects on bone



After 3 years of follow-up both calcium and dairy product intake positively influenced BMD of the hip and the forearm while dairy product intake also positively influenced BMD of the spine

Matkovic et al (2004) J Nutr:701S-705S.

Synergistic effects of nutrition and exercise on bone

Calcium supplementation and aerobics style exercise improves bone mineral status in 16-18 years

- 15.5-month study of calcium supplementation (1000 mg) in 144 16-18 y-old adolescent girls
- The subjects were randomly allocated to three 45-min exercise-to-music classes/wk or non-exercise group.
- Calcium supplementation significantly increased size-adjusted bone mineral content.
- Effect greatest in subjects with good compliance (percentage difference +/- SE): whole body, 0.8 +/- 0.3% (P < or = 0.01); lumbar spine, 1.9 +/- 0.5% (P < or = 0.001); ultradistal radius, 1.3 +/- 0.6% (P < or = 0.05); total hip, 2.7 +/- 0.6% (P < or = 0.001); femoral neck, 2.2 +/- 0.7% (P < or = 0.001); trochanter, 4.8 +/- 0.9% (P < or = 0.001)

Stear et al (2003) Am J Clin Nutr 77; 985-992.

Calcium and exercise

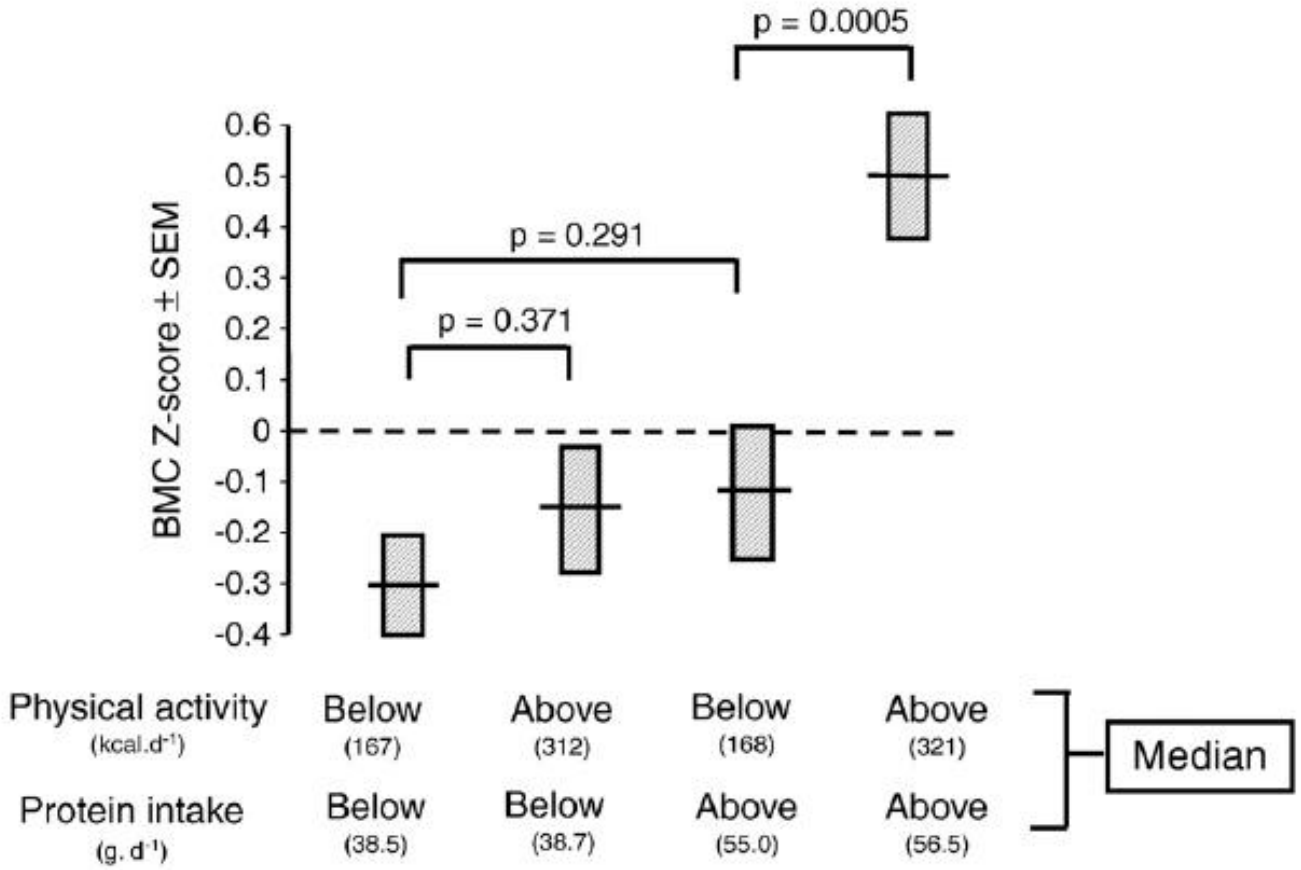
- Calcium intakes >1000mg calcium a day in addition to exercise results in greater BMC accruel than either low calcium and exercise or high calcium alone in 8-13 year olds

- There may be an important interaction between the mechanic requirement of exercise and the availability of calcium (and possibly the availability of other nutrients) to reach the greatest bone mass increases

- Much research is needed in this area

Courteix et al (2005) Int J Sports Med 26; 332-338

Synergistic effect of protein and exercise on bone



Chevalley et al (2008) JBMR 23; 131-142

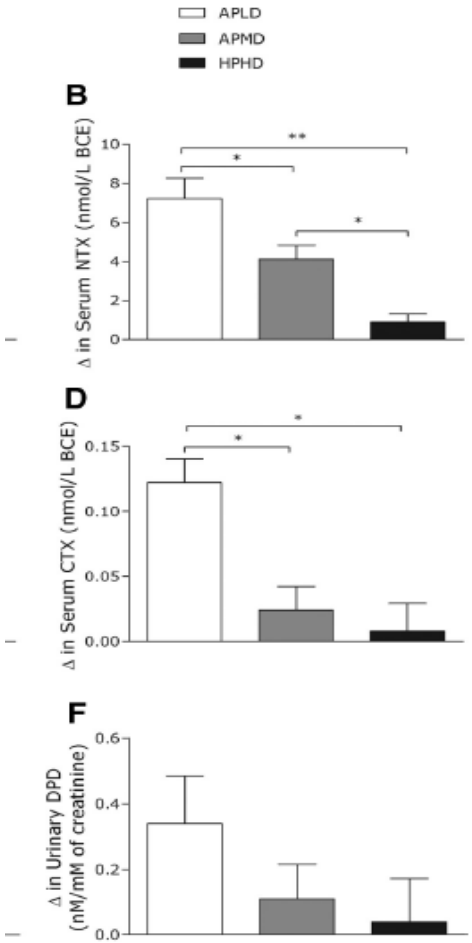
Diets higher in Dairy Foods and Protein support Bone Health During Weight Loss

- 16 week weight loss intervention
- 90 Pre-menopausal women
  - Same exercise protocol
  - 500kcal/day energy deficit relative to basal requirements
- Randomized into 3 groups:
  - High Protein and High Dairy (HPHD)
  - Adequate Protein and Medium Dairy (APMD)
  - Adequate Protein and Low Dairy (APLD)

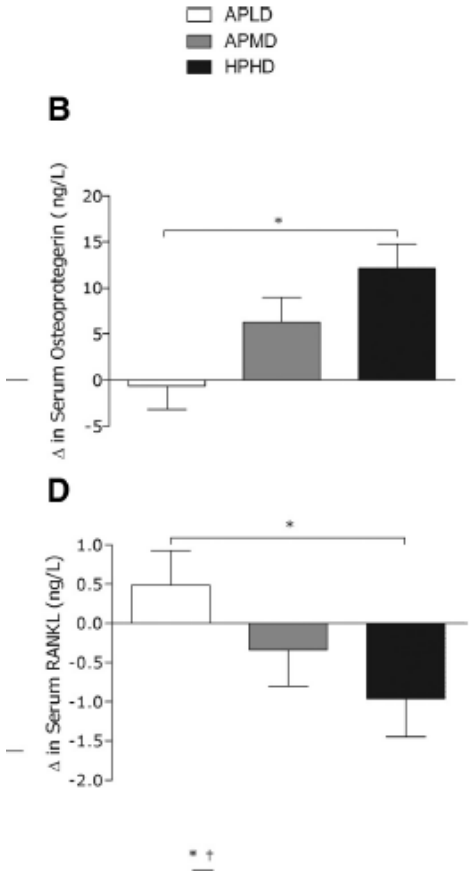
	HPHD	APMD	APLD
Protein Energy (%)	30	15	15
Dairy Foods (as a % of protein energy)	15	7.5	>2
Dietary Calcium	1600	1000	<500

Josse et al (2012) J Clin Endocrinol Met 97; 251-260.

Changes in bone turnover markers



Changes in OPG and RANKL levels



Josse et al (2012) J Clin Endocrinol Met 97; 251-260.

Summary…

- Impact exercise positively influences bone health but the magnitude of its effect depends on the lifestage of the skeleton.
- In terms of nutrition, current vitamin D intakes are inadequate in the UK which may have consequences for bone health in the long run. The outcome of the SACN report in 2014 will have important consequences for vitamin D nutrition policy and direction in the UK.
- A higher bone mineral mass may contribute to fracture risk reduction in adolescents and may delay osteoporosis in later life.
- Evidence supports a synergistic effect between certain nutrients (calcium and protein) and exercise on promoting bone health during bone growth. However much research is needed in terms of defining effective dosing/loading regimes.
- Research needs to focus on using foods containing a mixture of bone active compounds (e.g. dairy foods) in combination with different exercise regimes on bone health. Such interventions could also offer potential in terms of obesity management which ultimately contribute to adolescent health in general.


THANK
YOU