

Osteoporosis prevention

Consider the unthinkable

Roman Pawlak, Ph.D, RD



Important terms

- Bone mineral density – bone thickness
- Alkaline phosphatase – measurement of bone resorption
- Osteoblasts – bone making cells
- Osteoclasts – bone demolishing cells
- Osteocalcin – increased amount is indicative of excessive bone resorption
- Pyridinoline – increased amount is indicative of bone degradation

What factor(s) play a
role in osteoporosis
prevention?

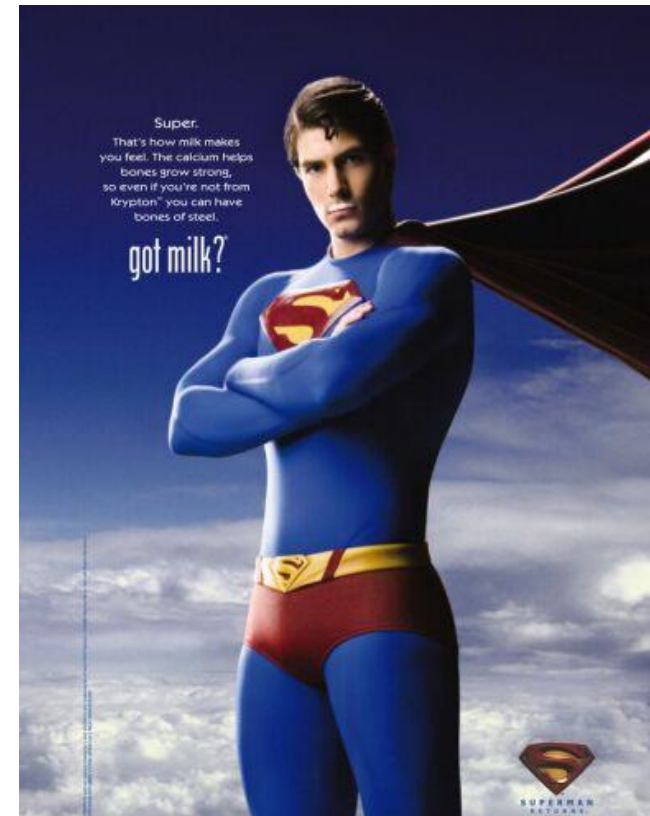
How much Ca do we need
to ingest?

What is the usual Ca intake
among Americans?

Gender and Age (Years)

% Not Meeting Calcium recommendations

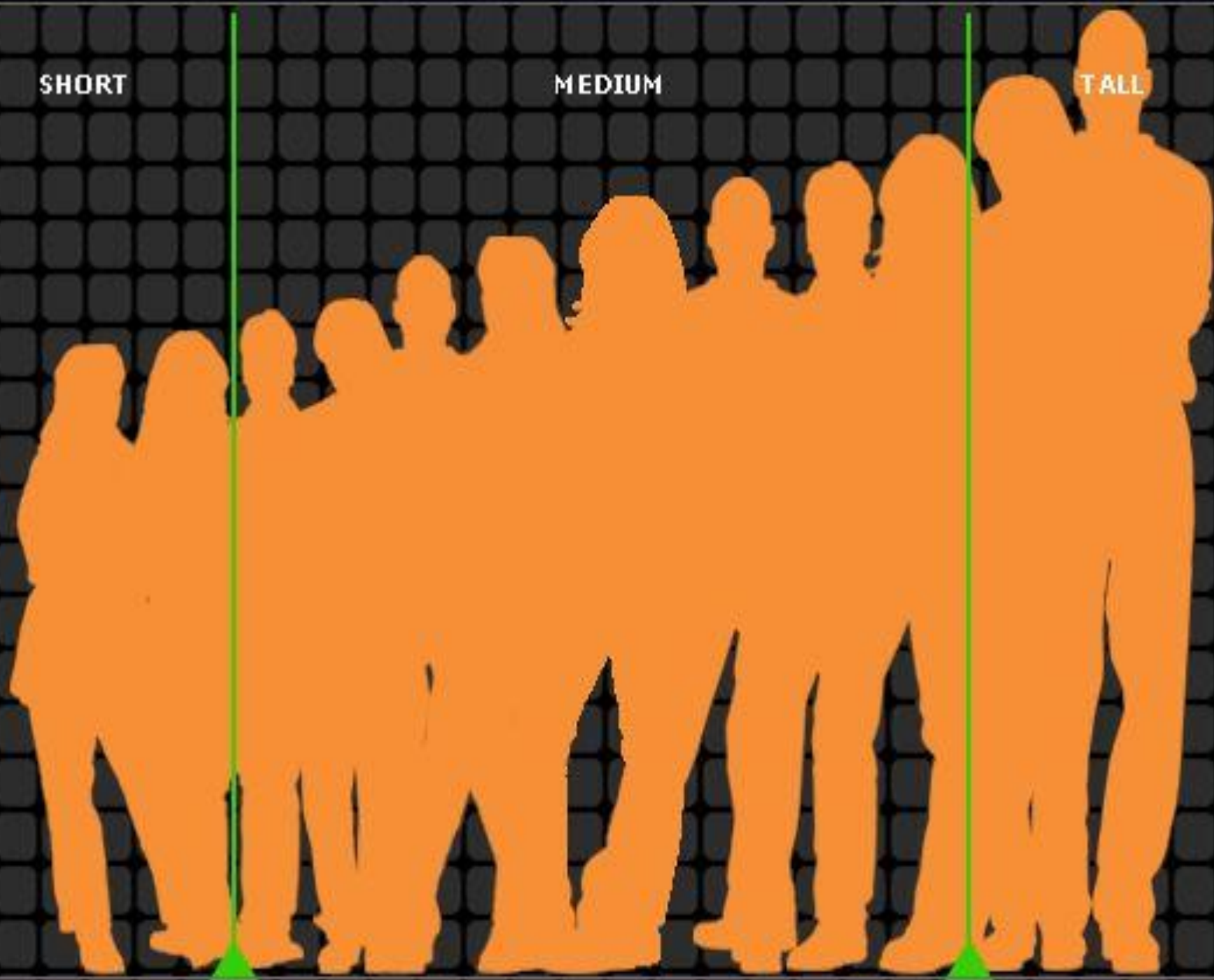
Children ages 5 and younger	30%
Girls ages 6-11	70%
Boys ages 6-11	60%
Teenage girls ages 12-19	88%
Teenage boys ages 12-19	68%
Adult women ages 20+	90%
Adult men ages 20+	73%



SHORT

MEDIUM

TALL





Current calcium intake recommendations (mg/day)

	Australia 1991 Recommended Dietary Intake	United Kingdom 1991 Reference Nutrient Intake	European Union 1993 Population Reference Intake	United States and Canada 1997 Adequate Intake
Pregnancy (last trimester)	1100	700	700	1000–1300
Lactation	1200	1250	1200	1000–1300
Infancy	300 (human milk) 500 (cow milk)	525	400	210–270
Childhood	530-800	350–550	400-550	500–800
Puberty and adolescence				
Boys	1000–1200	1000	1000	1300
Girls	800–1000	800	800	1300
Maturity				
Males	800	700	700	1000
Females	800	700	700	1000
Later life				
Males >65 years	800	700	700	1200
Postmenopausal women	1000	700	700	1200

FAO/WHO expert consultation on human vitamin and mineral requirements
 Wilkinson Enns et al., U.S. Department of Agriculture Agricultural Research Service,
<http://www.ars.usda.gov/SP2UserFiles/Place/12355000/pdf/fenrv14n2p56.pdf>

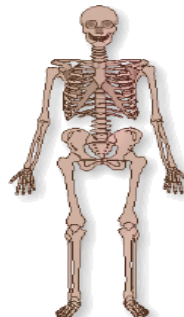
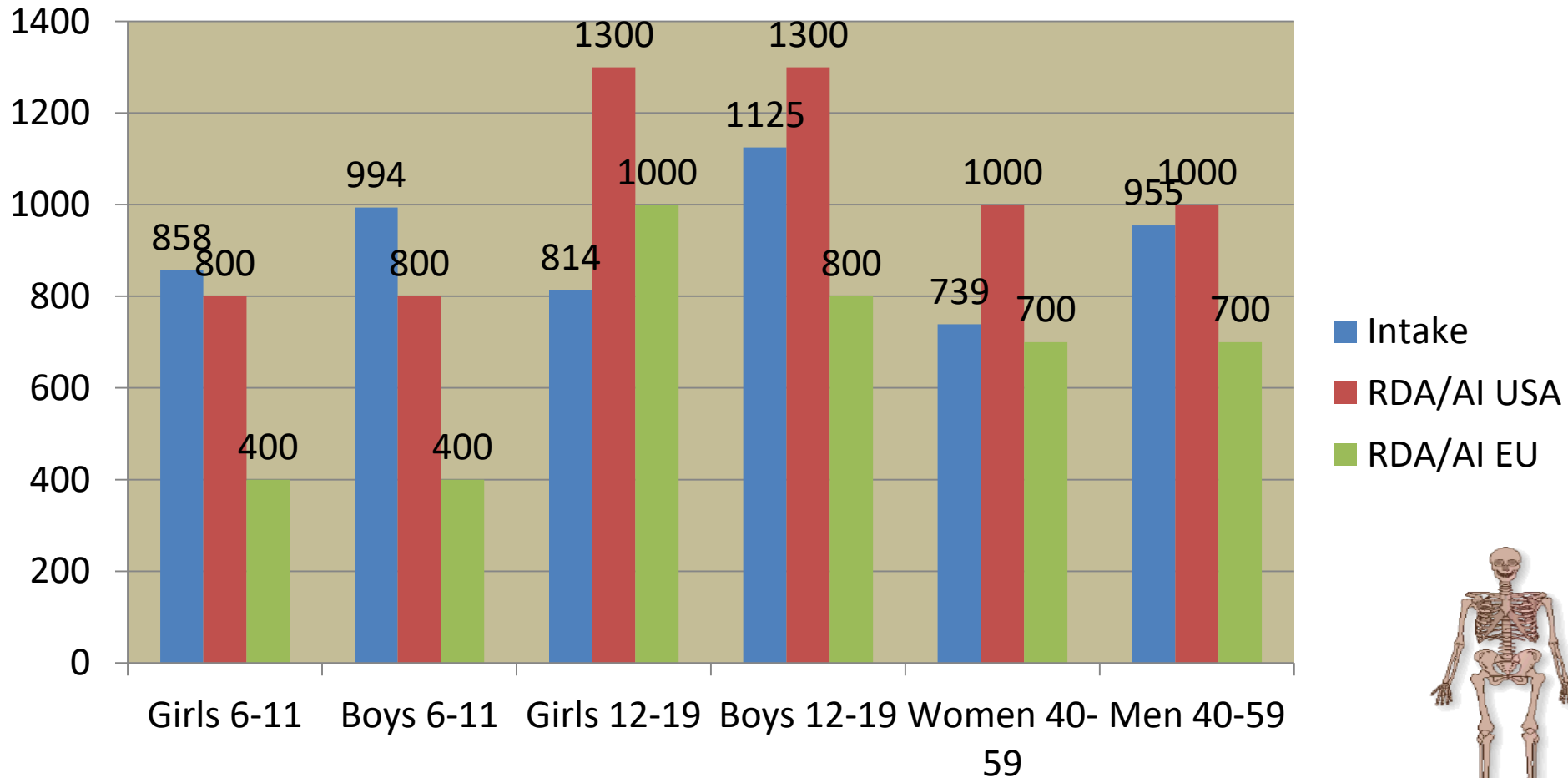
Calcium requirements: new estimations for men and women by cross-sectional statistical analyses of calcium balance data from metabolic studies¹⁻⁴

Curtiss D Hunt and LuAnn K Johnson

Am J Clin Nutr 2007;86:1054–63

“The findings suggest that the calcium requirement for men and women is lower than previously estimated.”

Ca intake vs. recommendation



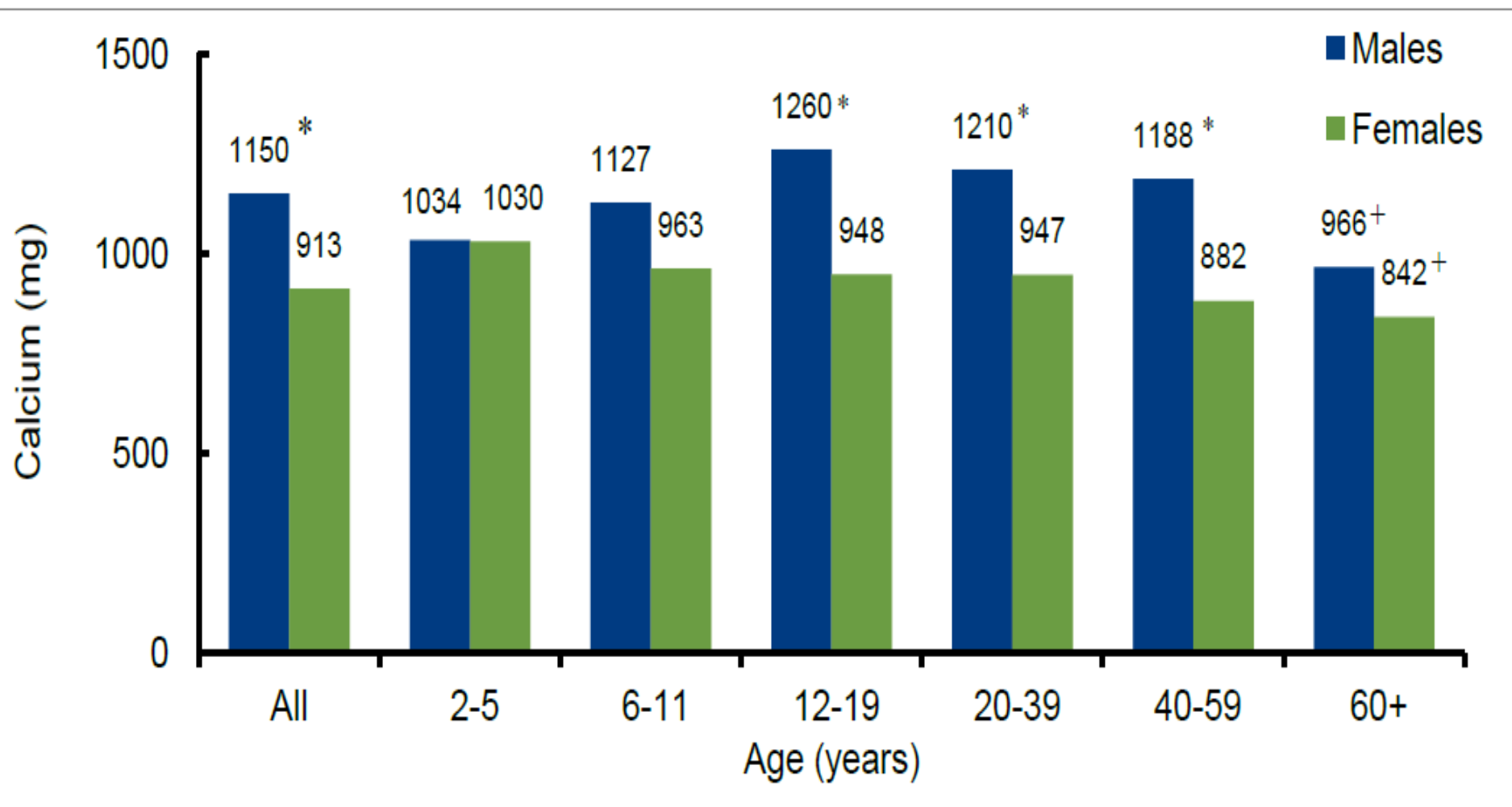
Usual intake of calcium, from NHANES (2003-2004)

- In all subjects 2 years or greater, the usual intakes of Ca was 910 ± 367 mg. ... The percentage of this population that exceeded the AI for Ca was 32.3.
- In adults 19 years or greater the usual intakes of Ca was 869 ± 362 mg. ... The percentage of the population that exceeded the AI for Ca was 26.2.

Calcium intake of the U.S. population

What We Eat in America, NHANES 2009-2010

Hoy & Goldman. Food Surveys Research Group Dietary Data Brief No. 13, 2014



How important is dietary Ca
intake in osteoporosis
prevention?

Calcium Intakes and Femoral and Lumbar Bone Density of Elderly U.S. Men and Women: National Health and Nutrition Examination Survey 2005–2006 Analysis

Anderson et al. J Clin Endocrinol Metab, 2012;97:4531–4539

Subjects (N = 1384) included elderly residents statistically representative of the United States, women and men aged 50 yr and older in the National Health and Nutrition Examination Survey 2005–2006 cohort.

“Total calcium intakes ranged from means of 400 mg/d in quintile 1 to 2100 in quintile 5. ... A usual high calcium intake beyond the recommended dietary allowance of elderly women and men, most commonly achieved by calcium supplements, did not provide any benefit for hip or lumbar BMD. A dietary intake of calcium approaching or meeting the current recommendations was not related to higher BMD of the hip or lumbar spine in late life compared with lower intakes of calcium in older adults.”

RISK FACTORS FOR HIP FRACTURE IN WHITE WOMEN

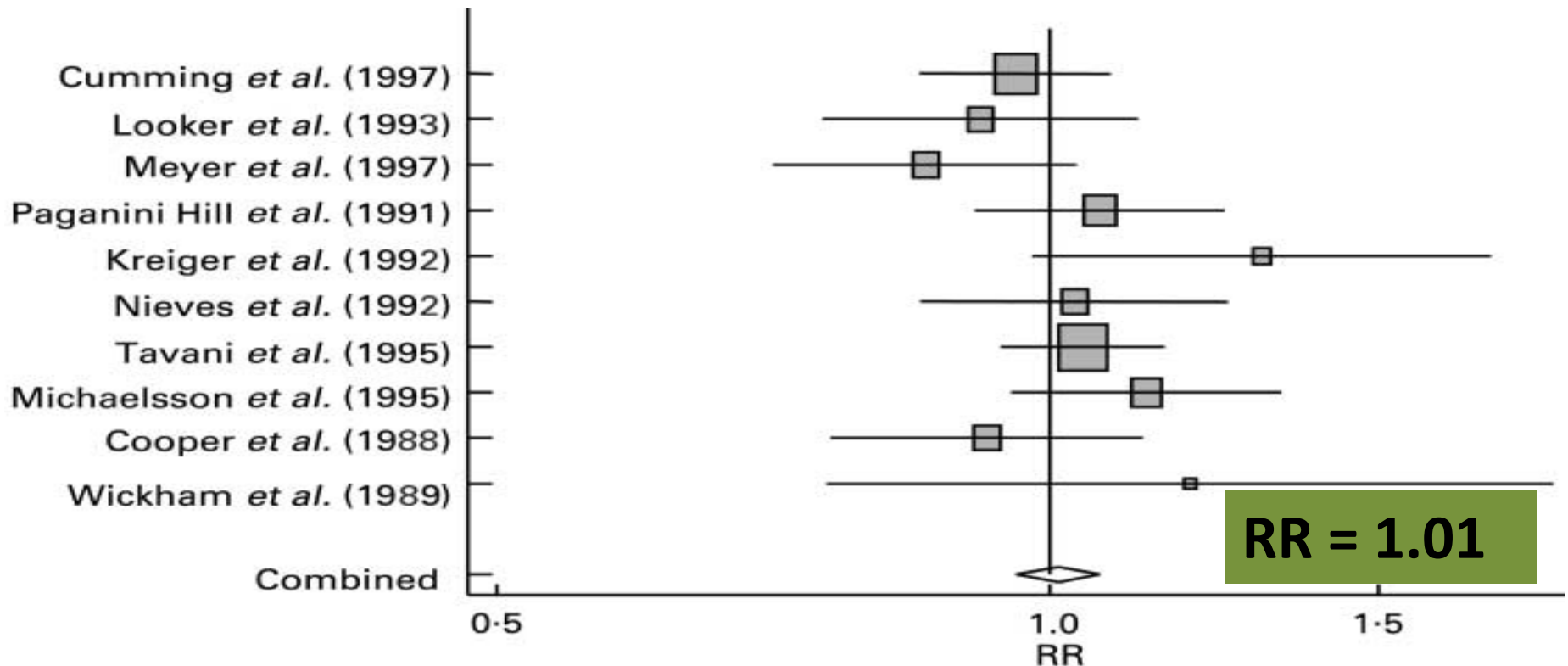
Cummings, et al. NEJM. 1995;333(12):767-773

“Like most but not all prospective observational studies, ours found no relation between calcium intake and protection from hip fracture, even in women with very low intakes.”

Does dietary calcium have a protective effect on bone fractures in women? A meta-analysis of observational studies

Xu L., et al, British Journal of Nutrition, 2004;91:625–634

Pooled risk ratio for dietary calcium on hip fracture in ten observational studies in women aged ≥ 35 years



Does dietary calcium have a protective effect on bone fractures in women? A meta-analysis of observational studies

Xu L., et al, British Journal of Nutrition, 2004;91:625–634

“Observational studies failed to show any association between dietary Ca intake and risk of hip fracture (risk ratio 1·01, 95% CI 0·96, 1·07 for each increment of 300 mg dietary Ca intake/d).”

Calcium intake and hip fracture risk in men and women: a meta-analysis of prospective cohort studies and randomized controlled trials¹⁻³

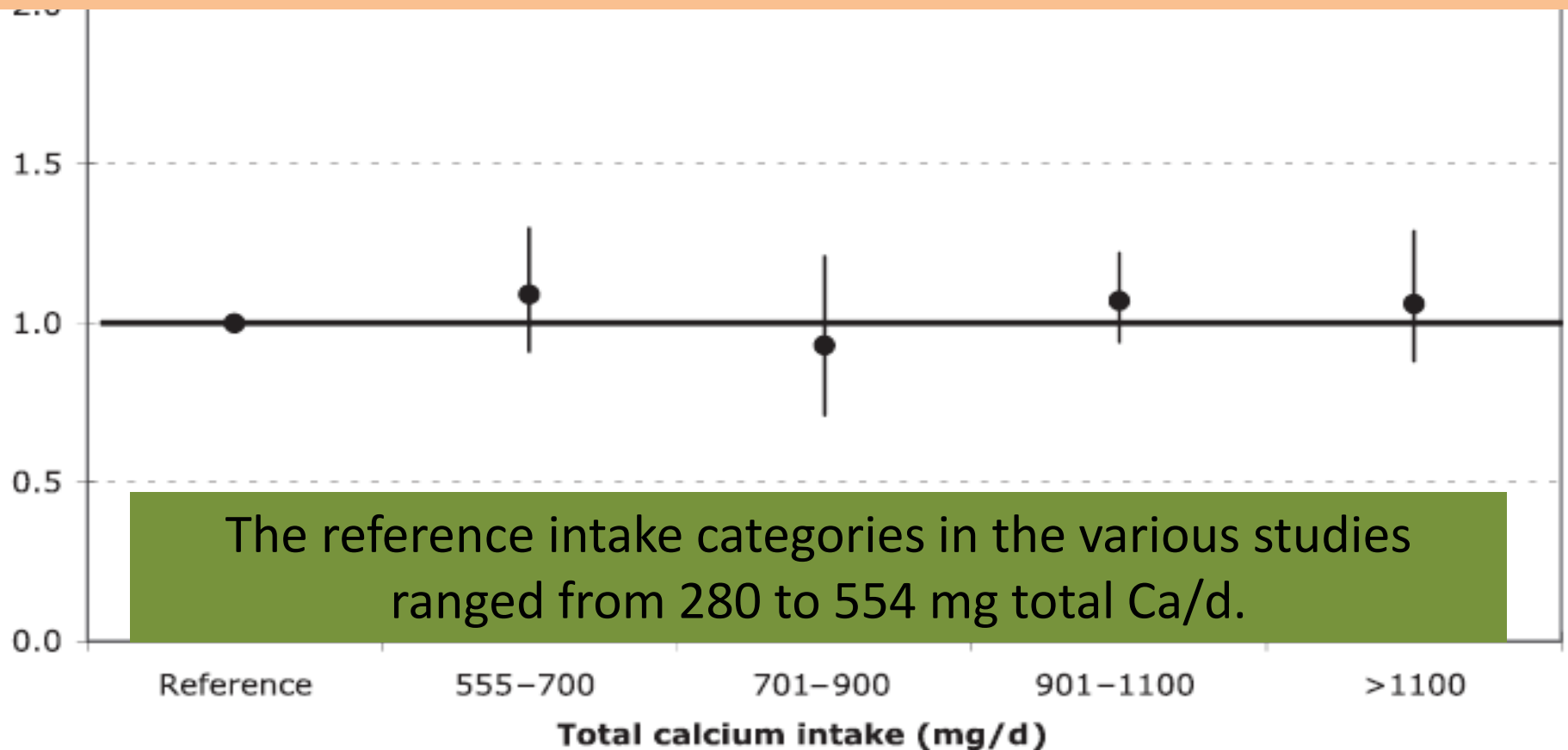
Bischoff-Ferrari HR., et al. AJCN, 2007;86:1780-1790

- **Women - 7 prospective cohort studies**
 - N = 170,991
 - Hip fractures = 2954
- **Men - 5 prospective cohort studies**
 - N = 68 606men
 - Hip fractures = 214

Calcium intake and hip fracture risk in men and women: a meta-analysis of prospective cohort studies and randomized controlled trials¹⁻³

Bischoff-Ferrari HR., et al. *AJCN*, 2007;86:1780-1790

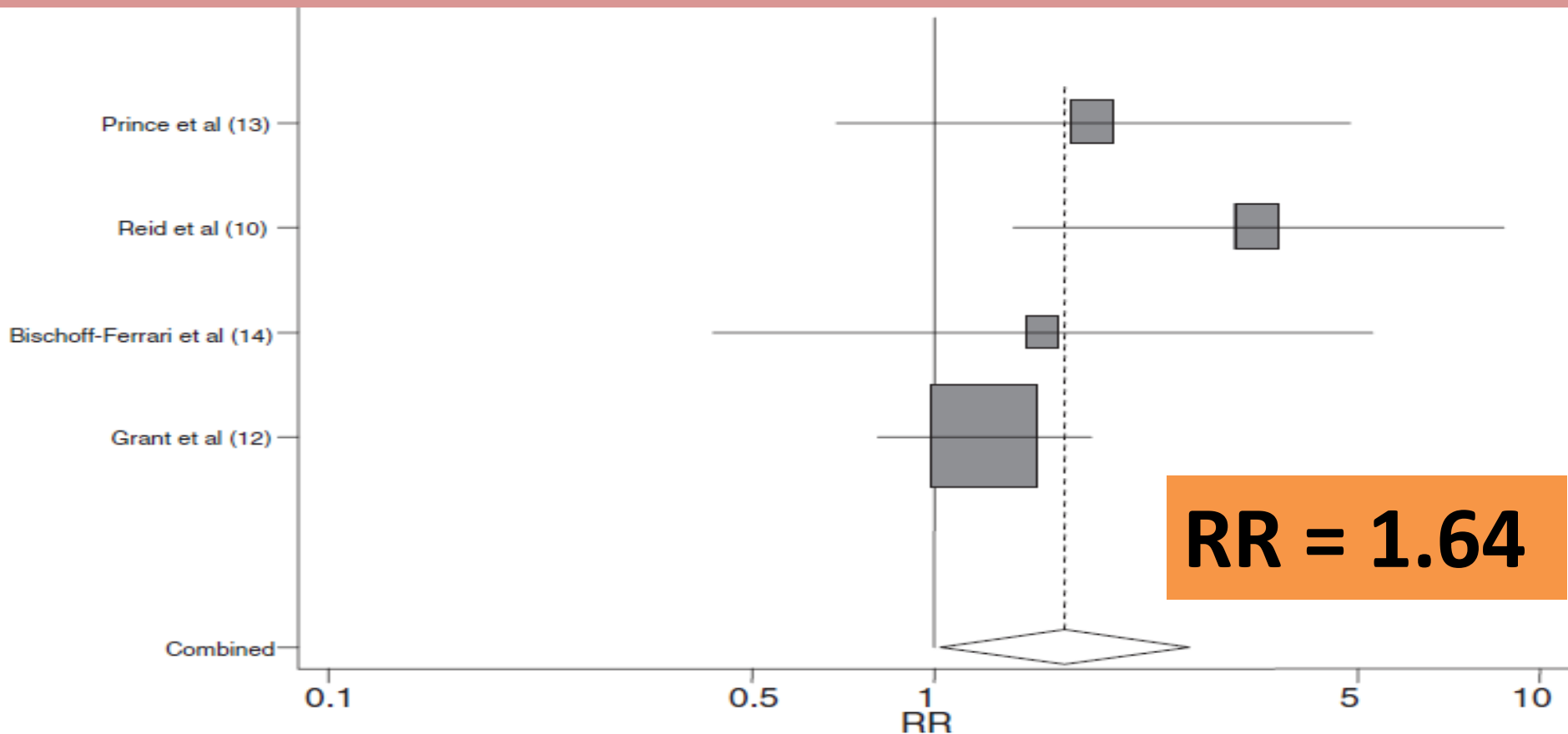
Calcium intake and hip fracture risk in the women from the prospective cohort studies.



Calcium intake and hip fracture risk in men and women: a meta-analysis of prospective cohort studies and randomized controlled trials¹⁻³

Bischoff-Ferrari HR., et al. *AJCN*, 2007;86:1780-1790

Risk of hip fractures among Ca supplemented group (800 to 1200 mg/d) vs. placebo



Calcium intake and hip fracture risk in men and women: a meta-analysis of prospective cohort studies and randomized controlled trials¹⁻³ Bischoff-Ferrari HR., et al. *AJCN*, 2007;86:1780-1790

Pooled results from randomized controlled trials show no reduction in hip fracture risk with calcium supplementation, and an increased risk is possible.”

Milk, Dietary Calcium, and Bone Fractures in Women: A 12-Year Prospective Study

Feskanich et al., Am. J. Public Health 1997;87(6):992-997

RR of hip fractures among 77,761 women aged 34 to 59

Milk, Glasses	Person- Years	Hip Fractures			
		Cases	RR ^b	Multivariate	
				RR ^c	95% CI
≤1/wk	213 264	41	1.00	1.00	...
2–6/wk	140 518	33	1.22	1.36	0.86, 2.16
1/d	152 795	31	1.05	1.23	0.76, 1.98
≥2/d	138 644	28	1.08	1.45	0.87, 2.43
<i>P</i> for trend ^d			.92	.22	

Milk, Dietary Calcium, and Bone Fractures in Women: A 12-Year Prospective Study

Feskanich et al., Am. J. Public Health 1997;87(6):992-997

RR of hip fractures among 77,761 women aged 34 to 59

	Person-Years	Hip Fractures		
		Cases	RR ^b	95% CI
Total dietary calcium, mg/day				
≤450	167 189	27	1.00	...
451–625	159 033	43	2.02	1.23, 3.32
626–900	163 707	33	1.85	1.06, 3.22
>900	155 101	30	2.04	1.12, 3.71
<i>P</i> for trend ^c			.07	
Dairy calcium, mg/day				
≤175	157 287	25	1.00	...
176–350	174 992	39	1.61	0.97, 2.68
351–550	155 929	37	1.94	1.15, 3.28
>550	156 824	32	1.93	1.09, 3.42
<i>P</i> for trend ^c			.05	
Nondairy calcium, mg/day				
≤200	131 938	35	1.00	...
201–275	203 891	45	0.91	0.57, 1.48
276–350	166 620	23	0.66	0.36, 1.23
>350	142 581	30	1.17	0.60, 2.31
<i>P</i> for trend ^c			.29	

Milk, Dietary Calcium, and Bone Fractures in Women: A 12-Year Prospective Study

Feskanich et al., Am. J. Public Health 1997;87(6):992-997

“No significant association was observed between teenage milk consumption and the risk of adult fracture.”

A meta-analysis of milk intake and fracture risk: low utility for case finding

Kanis JA., et al. *Osteoporosis Int.* 2005;16(7):799-804

Cohort	Sample size	Person-years	Mean age (years)	Age range (years)	% female	Low calcium intake (%)	Any fracture	Osteoporotic fracture	Hip fracture
EVOS/EPOS	13,445	40,388	63.8	41-91	52	60	720	720	45
CaMos	9401	26,656	62.1	25-103	69	37	586	316	42
DOES	2065	15,920	70.4	57-95	61	40	516	405	104
Rotterdam	5408	32,447	67.7	55-94	59	3	636	473	130
Sheffield	2173	6901	80.0	74-96	100	16	292	243	63
Gothenburg II	7071	29,645	58.9	21-89	100	14	441	312	29
Total	39,563	151,957	64.3	21-103	69	35	3191	2469	413

A meta-analysis of milk intake and fracture risk: low utility for case finding

Kanis JA., et al. Osteoporosis Int. 2005;16(7):799-804

“A low intake of calcium (less than 1 glass of milk daily) was not associated with a significantly increased risk of any fracture, osteoporotic fracture or hip fracture.”

Milk intake and risk of mortality and fractures in women and men: cohort studies

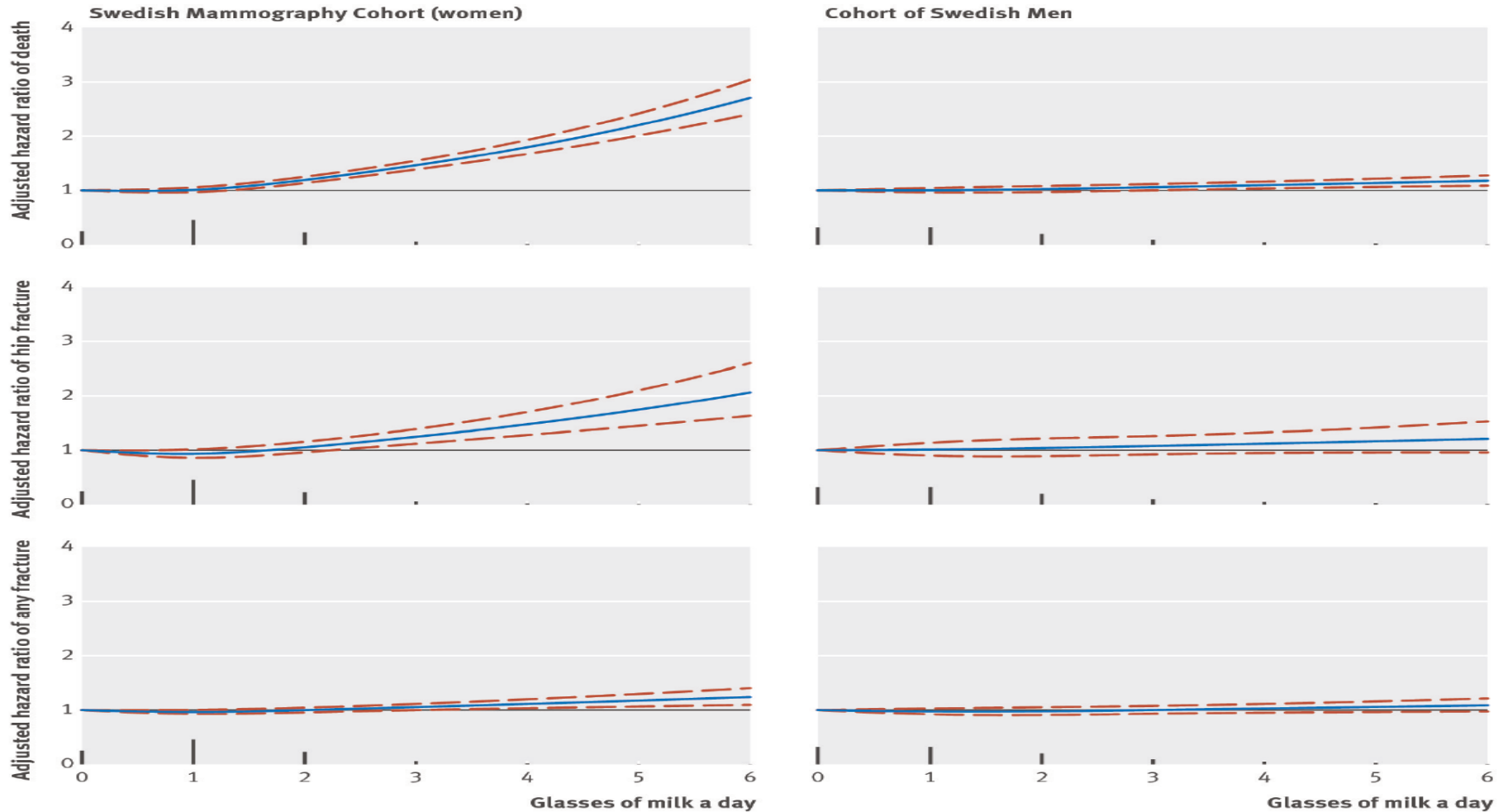
Michaëlsson et al. BMJ 2014;349:g6015

- Two Swedish cohorts:
 - N = 61,433 women (39-74 years at baseline 1987-90)
 - Mean follow-up of 20.1 years
 - 15,541 women died
 - 17,252 had a fracture
 - 4,259 had a hip fracture

 - N = 45,339 men (45-79 years at baseline 1997)
 - Mean follow-up of 11.2 years
 - 10,112 men died
 - 5,066 had a fracture
 - 1,166 hip fracture cases

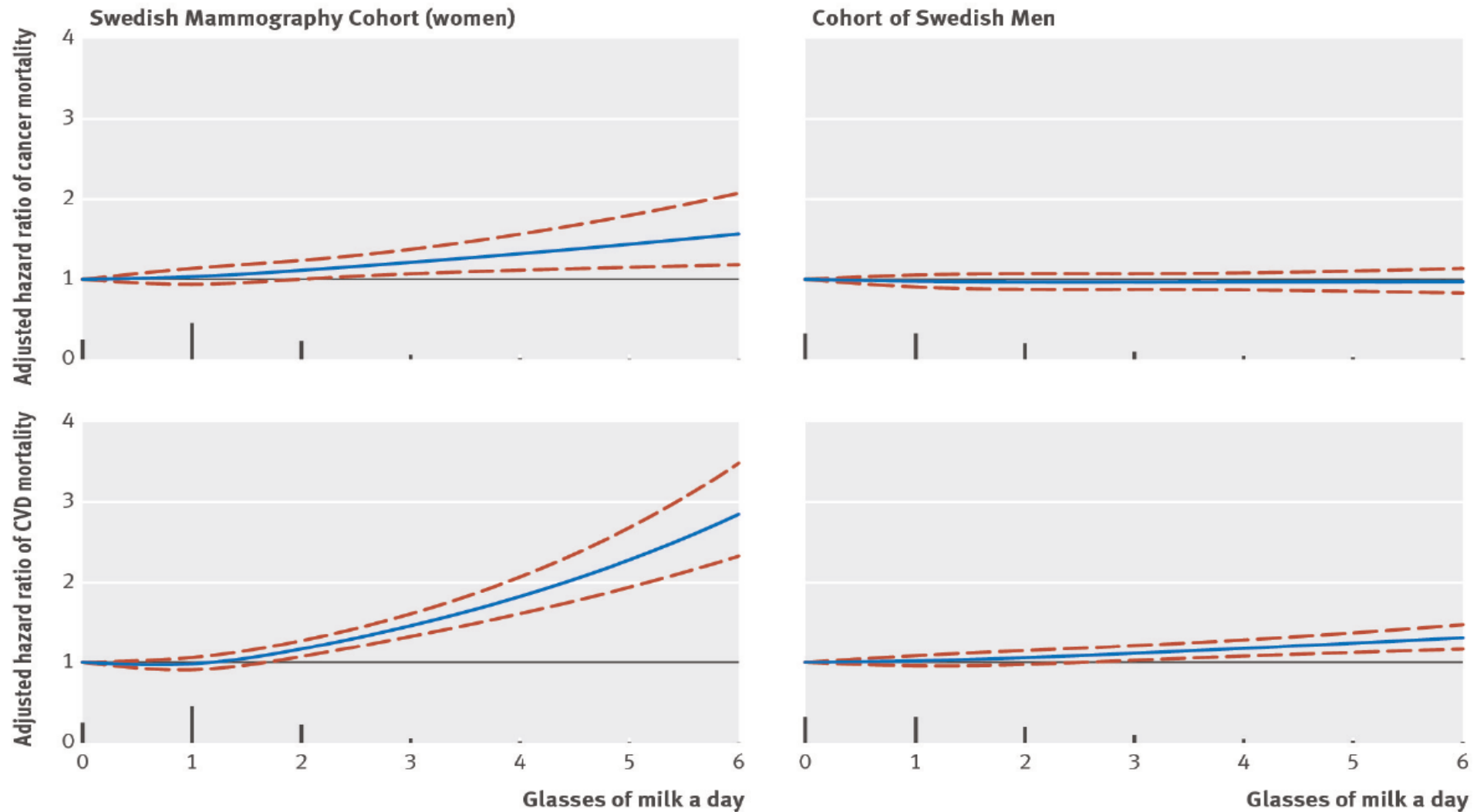
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Milk intake and risk of mortality and fractures in women and men: cohort studies

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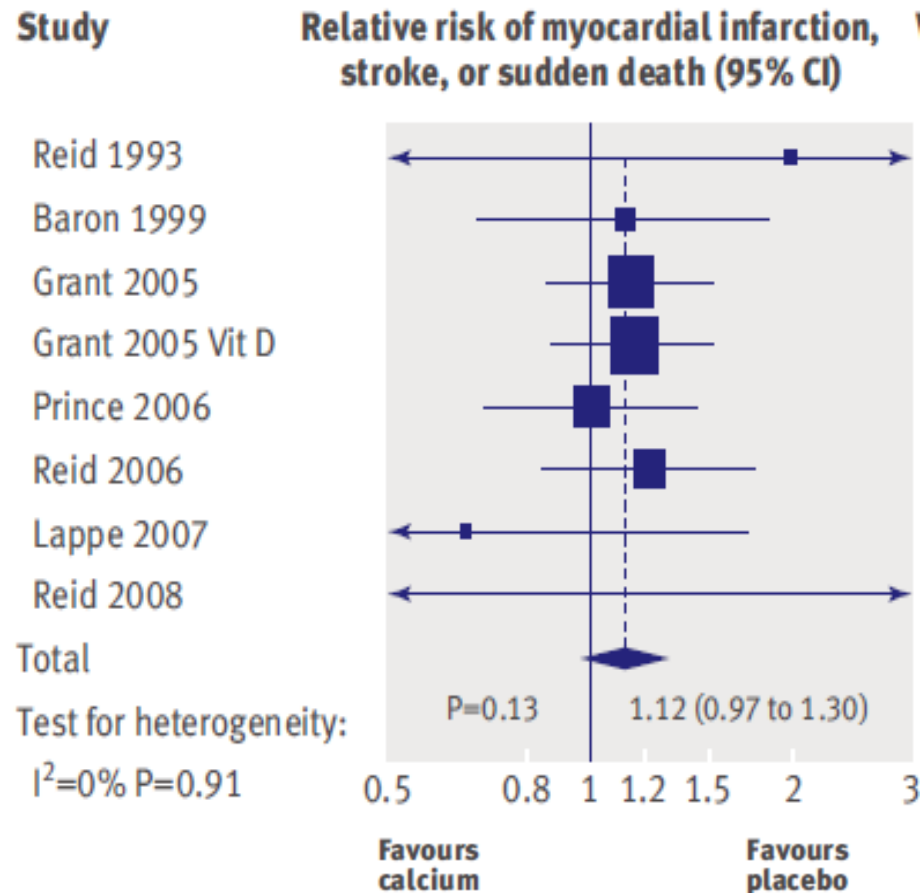
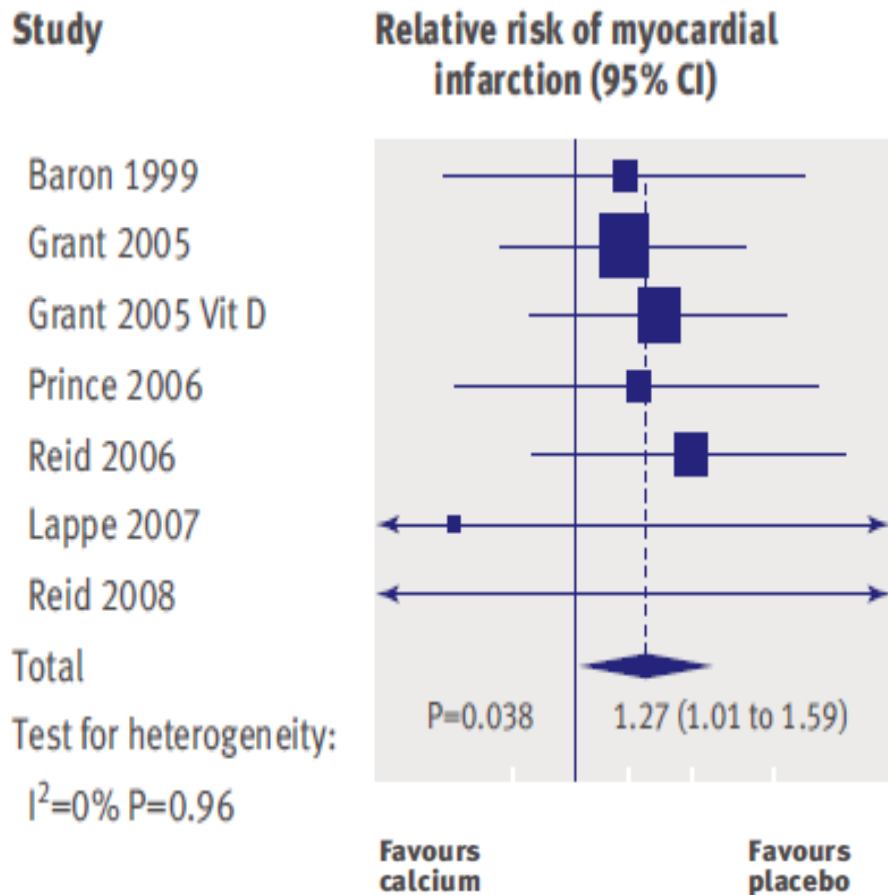
Milk intake and risk of mortality and fractures in women and men: cohort studies

Michaëlsson et al. BMJ 2014;349:g6015

“For every glass of milk the adjusted hazard ratio of all cause mortality was 1.15 (1.13 to 1.17) in women and 1.03 (1.01 to 1.04) in men. For every glass of milk in women no reduction was observed in fracture risk with higher milk consumption for any fracture (1.02, 1.00 to 1.04) or for hip fracture (1.09, 1.05 to 1.13). The corresponding adjusted hazard ratios in men were 1.01 (0.99 to 1.03) and 1.03 (0.99 to 1.07).”

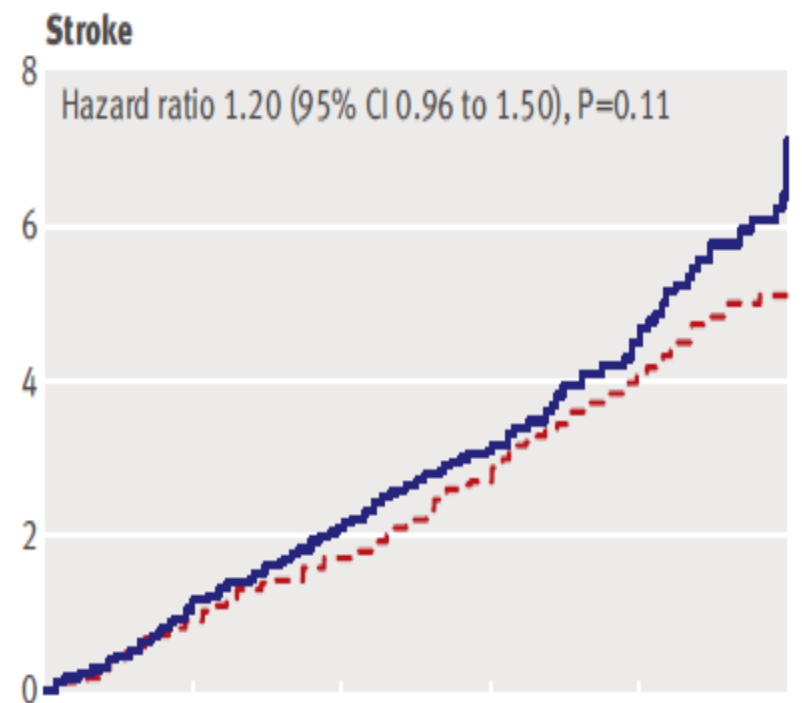
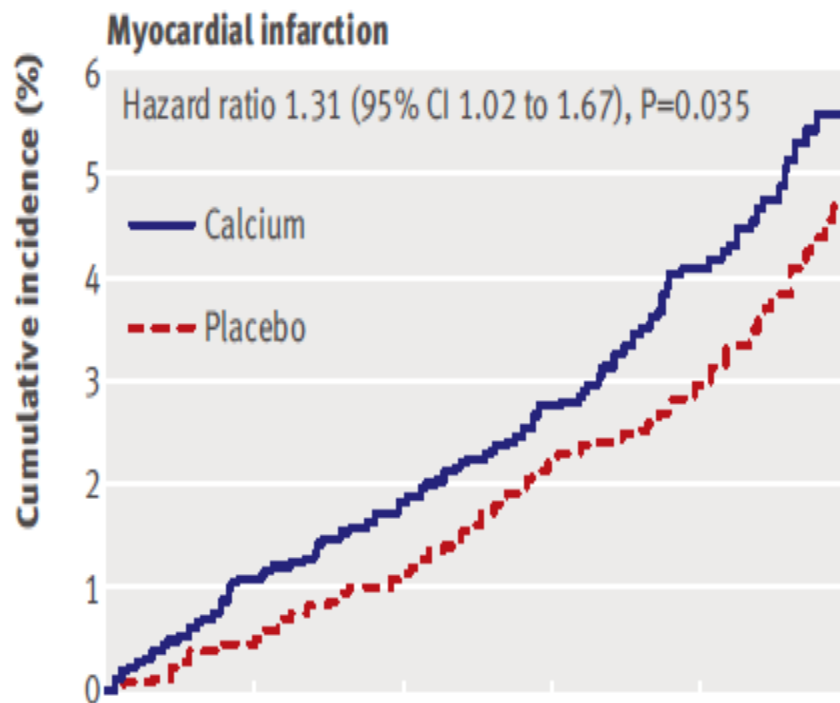
BMJ Effect of calcium supplements on risk of myocardial infarction and cardiovascular events: meta-analysis

Bollard MJ., et al. *MJ* 2010;341:c3691 doi:10.1136/bmj.c3691



BMJ Effect of calcium supplements on risk of myocardial infarction and cardiovascular events: meta-analysis

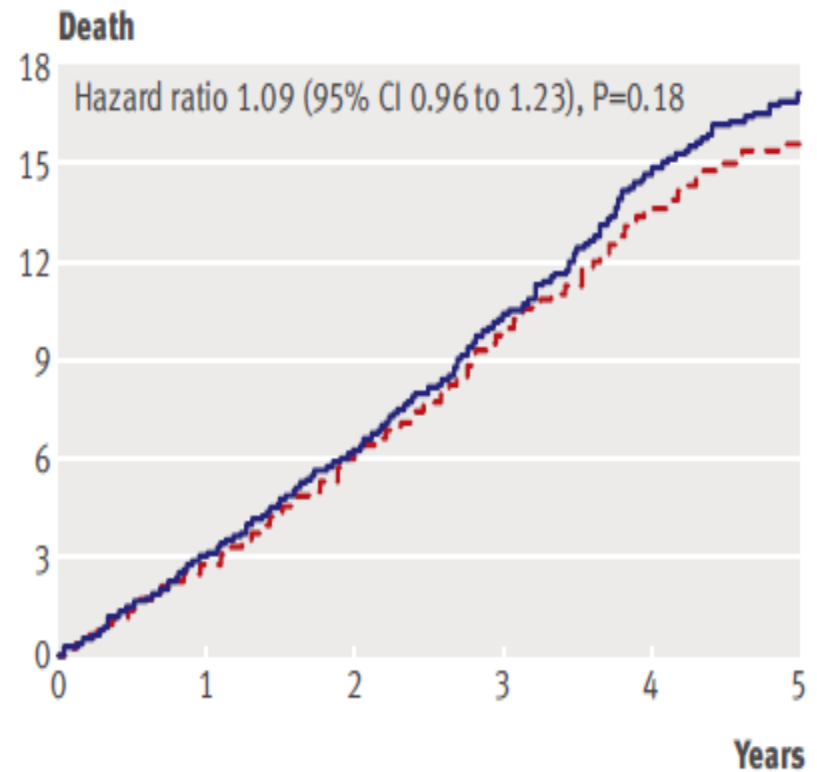
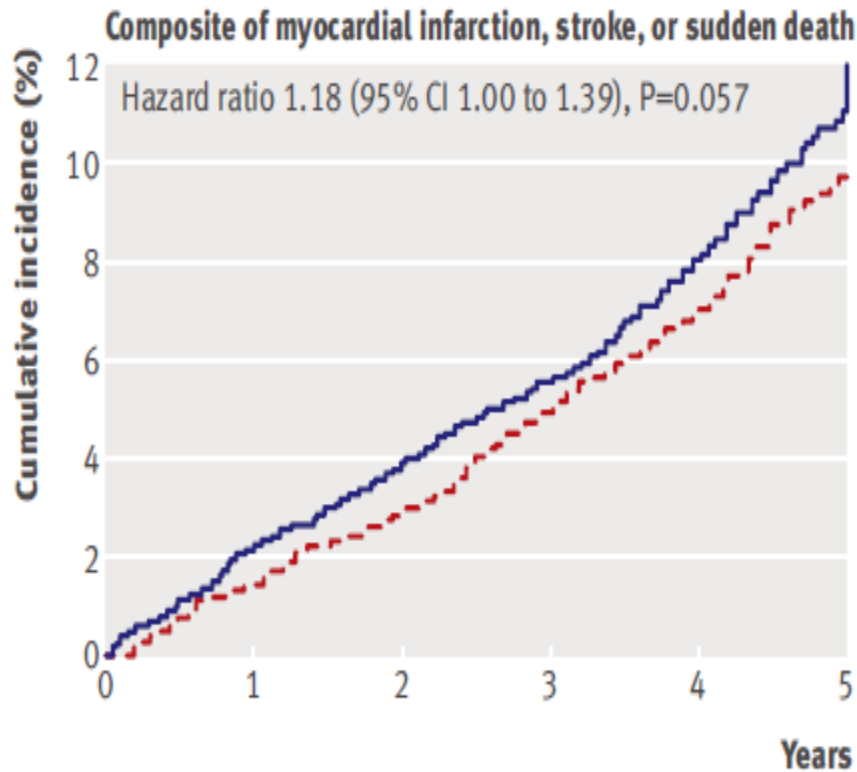
Bollard MJ., et al. *MJ* 2010;341:c3691 doi:10.1136/bmj.c3691



No at risk												
Calcium	4097	3870	3539	2670	1294	373	4097	3865	3541	2659	1294	373
Placebo	4054	3865	3588	2728	1320	388	4054	3859	3589	2730	1312	386

BMJ Effect of calcium supplements on risk of myocardial infarction and cardiovascular events: meta-analysis

Bollard MJ., et al. *MJ* 2010;341:c3691 doi:10.1136/bmj.c3691



No at risk	0	1	2	3	4	5	0	1	2	3	4	5
Calcium	4097	3848	3517	2635	1271	360	4097	3889	3580	2699	1322	389
Placebo	4054	3848	3566	2692	1292	376	4054	3875	3618	2767	1340	399

BMJ Effect of calcium supplements on risk of myocardial infarction and cardiovascular events: meta-analysis

Bollard MJ., et al. MJ 2010;341:c3691 doi:10.1136/bmj.c3691

“As calcium supplements are widely used these modest increases in risk of cardiovascular disease might translate into a large burden of disease in the population. A reassessment of the role of calcium supplements in the management of osteoporosis is warranted.”

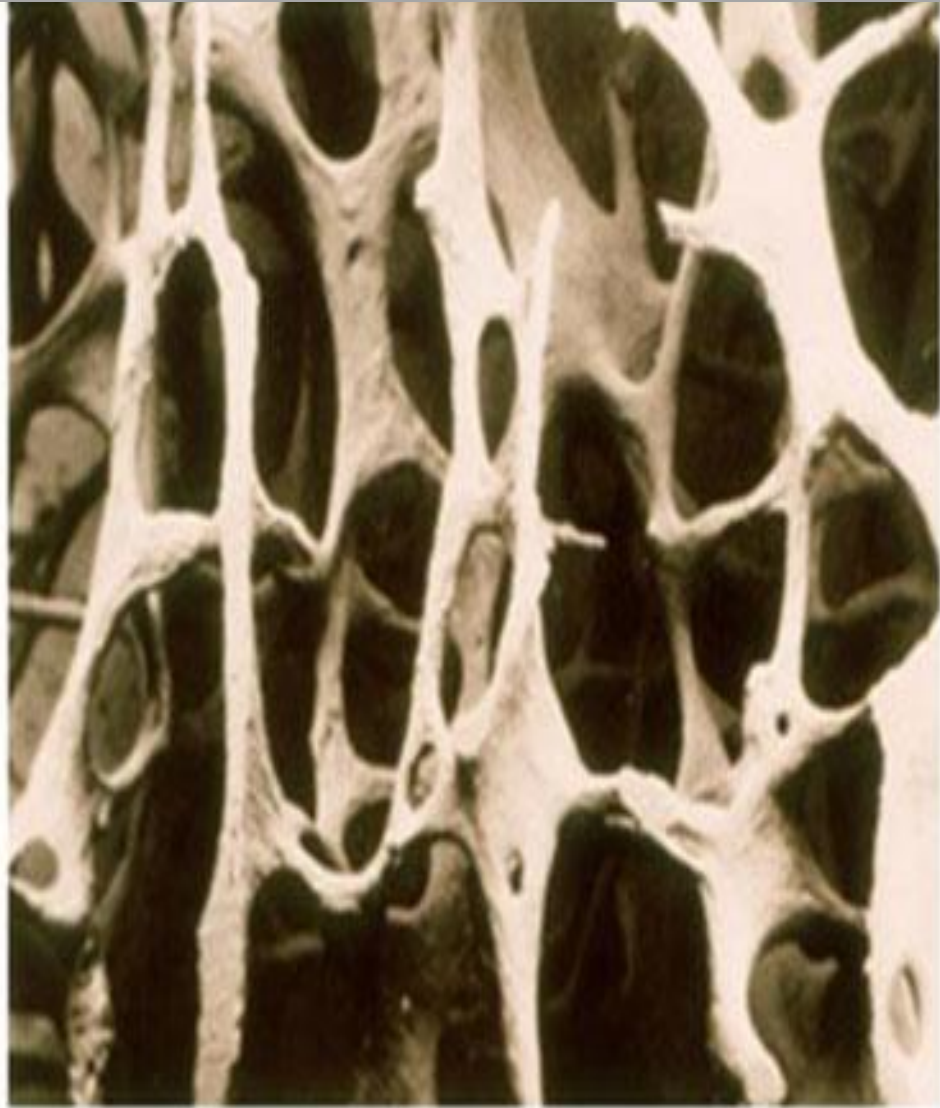
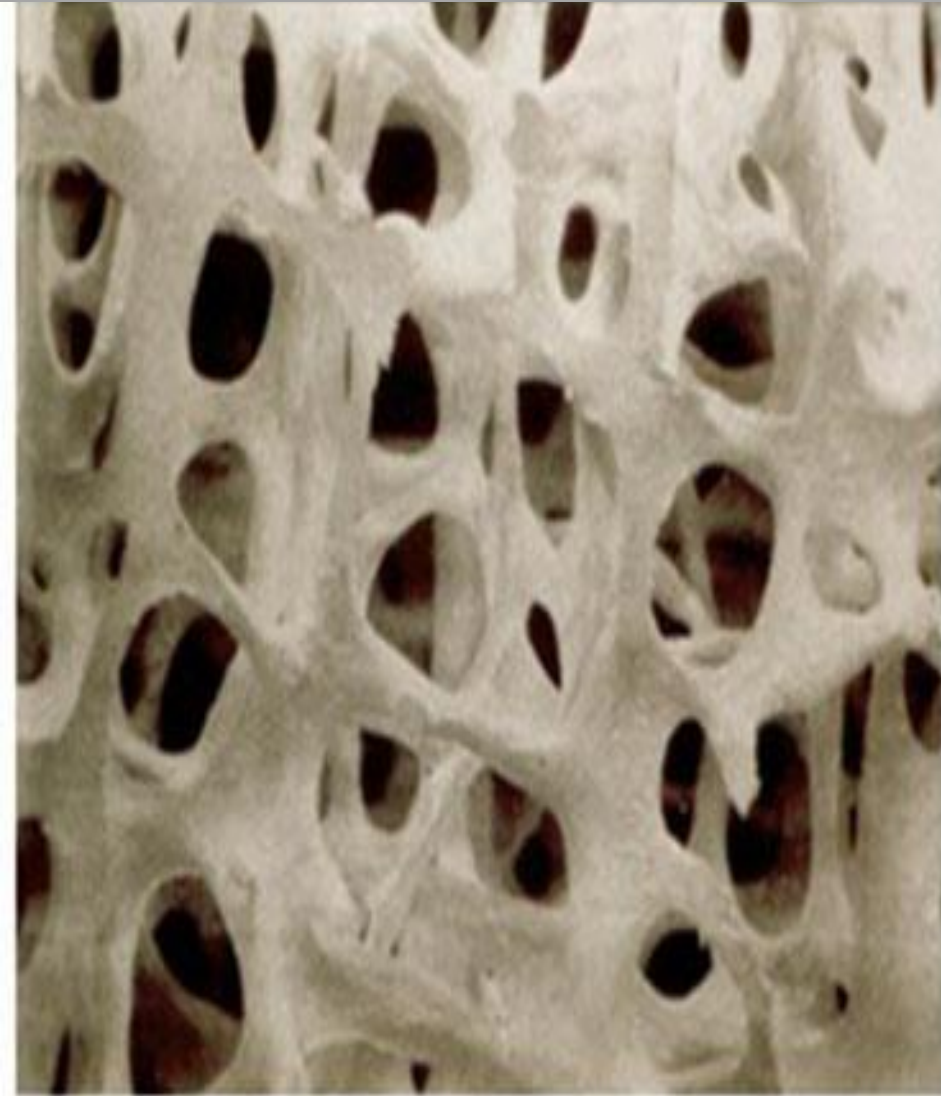
Evidence that Calcium Supplements Reduce Fracture Risk Is Lacking

Seeman E. *Clin J Am Soc Nephrol* 2010;5:S3–S11

“Credible evidence that calcium supplements reduce the risk of vertebral, nonvertebral, or hip fractures is lacking. ... Consensus statements that support the widespread use of calcium are opinion-based; they accept claims of beneficial effects despite flaws in study design, execution, and analysis; and they reject reported adverse effects because of them. Until well designed, well executed, and well analyzed studies demonstrate a net benefit in morbidity, mortality, and cost, recommendations supporting the widespread use of calcium supplementation remain belief-based and not evidence-based.

Osteoporosis prevention efforts that focus more calcium and/or dairy intake focus on an ineffective osteoporosis strategy with undesirable side effects

Consider the unthinkable



**What factors do impact
the risk of osteoporotic
fractures?**

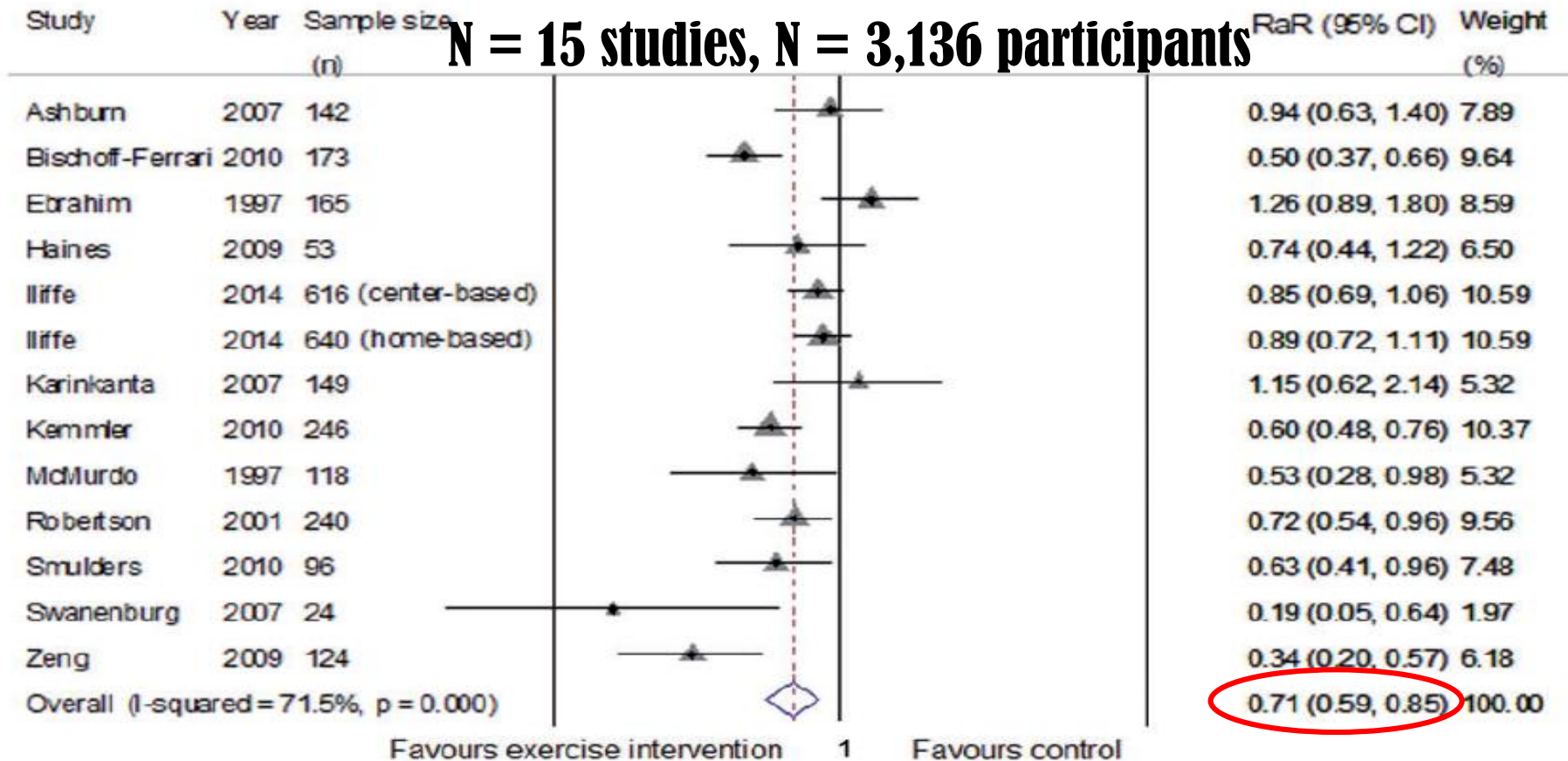
Physical activity

Exercise interventions and prevention of fall-related fractures in older people: a meta-analysis of randomized controlled trials

Zhao et al. Int J Epidemiology, 2017, 149–161

Rate of falls

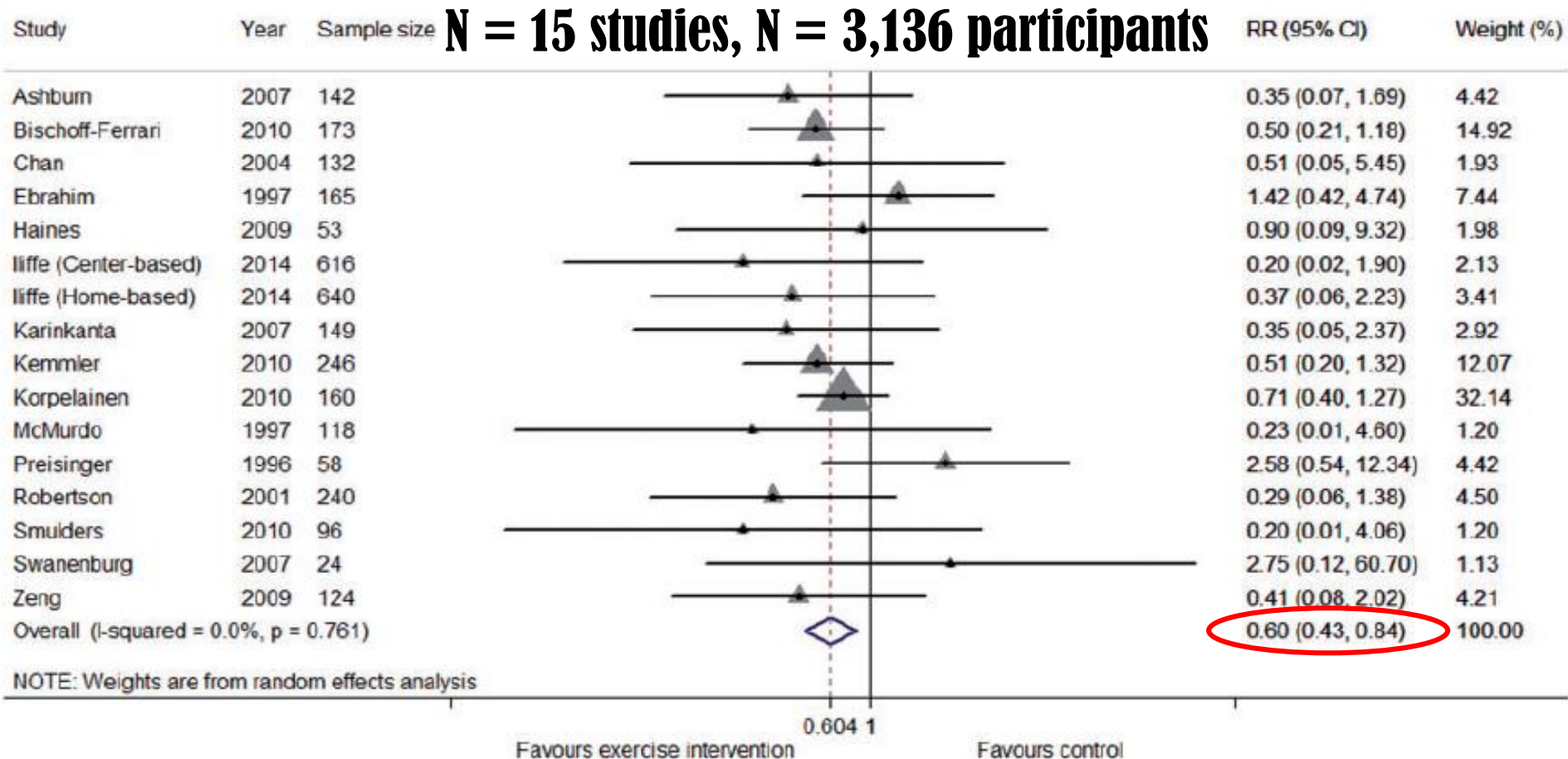
Rate of falls



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Zhao et al. Int J Epidemiology, 2017, 149–161

Fall related fractures



Key Guidelines for older adults

- **For additional and more extensive health benefits, older adults should increase their aerobic physical activity to 300 minutes (5 hours) a week of moderate-intensity, or 150 minutes a week of vigorous-intensity aerobic physical activity**
- **Older adults should also do muscle-strengthening activities that are moderate or high intensity and involve all major muscle groups on 2 or more days a week**

What dietary/nutritional factors impact the risk of osteoporotic fractures?

Food intake patterns

Prospective Associations of Dietary and Nutrient Patterns with Fracture Risk: A 20-Year Follow-Up Study

Melaku et al. *Nutrients*, 2017,9,1198; doi:10.3390/nu9111198

- **China Health and Nutrition Survey**
- **15,572 adults aged ≥ 18 years**
- **Two dietary (traditional and modern) and**
- **Two nutrient (plant- and animal-sourced) patterns were identified**

Prospective Associations of Dietary and Nutrient Patterns with Fracture Risk: A 20-Year Follow-Up Study

Melaku et al. *Nutrients*, 2017,9,1198; doi:10.3390/nu9111198

“After adjusting for potential confounders, study participants in the third tertiles (highest intake) of the modern dietary and animal-sourced nutrient patterns’ cumulative scores had a 34% (HR = 1.34; 95% CI: 1.06–1.71) and 37% (HR = 1.37; 95% CI: 1.08–1.72) increase in fracture risks compared to those in the first tertiles, respectively.”

Greater Intake of Fruit and Vegetables Is Associated with Greater Bone Mineral Density and Lower Osteoporosis Risk in Middle-Aged and Elderly Adults

Qiu et al. PLoS One, 2017; 12(1): e0168906.

- **A population-based cross-sectional study**
- **N = 2083 women and 1006 men**
- **Age = 40–75 years**
- **Setting: Guangzhou, China**

Greater Intake of Fruit and Vegetables Is Associated with Greater Bone Mineral Density and Lower Osteoporosis Risk in Middle-Aged and Elderly Adults

Qiu et al. PLoS One, 2017; 12(1): e0168906.

The odds ratios of osteoporosis between tertile 3 (highest) and tertile 1 (lowest) FV intake were:

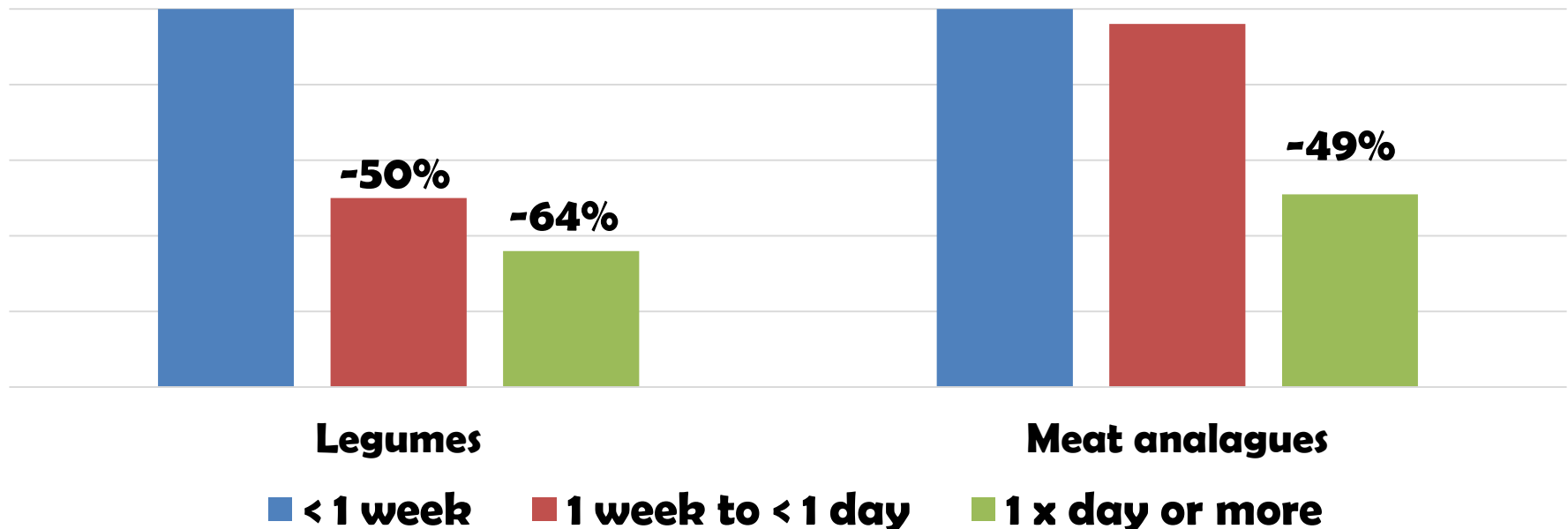
- 27% lower in lumbar spine**
- 63% lower in total hip**
- 29% lower in femoral neck**

Legumes and meat analogues consumption are associated with hip fracture risk independently of meat intake among Caucasian men and women: the Adventist Health Study-2

Lousuebsakul-Matthews et al. Public Health Nutr. 2014;17(10):2333–2343

- Adventist Health Study-2
- N = 33,208

Hip fracture risk by intake of selected foods



Nutrient intake patterns

Dietary influences on bone mass and bone metabolism: further evidence of a positive link between fruit and vegetable consumption and bone health?

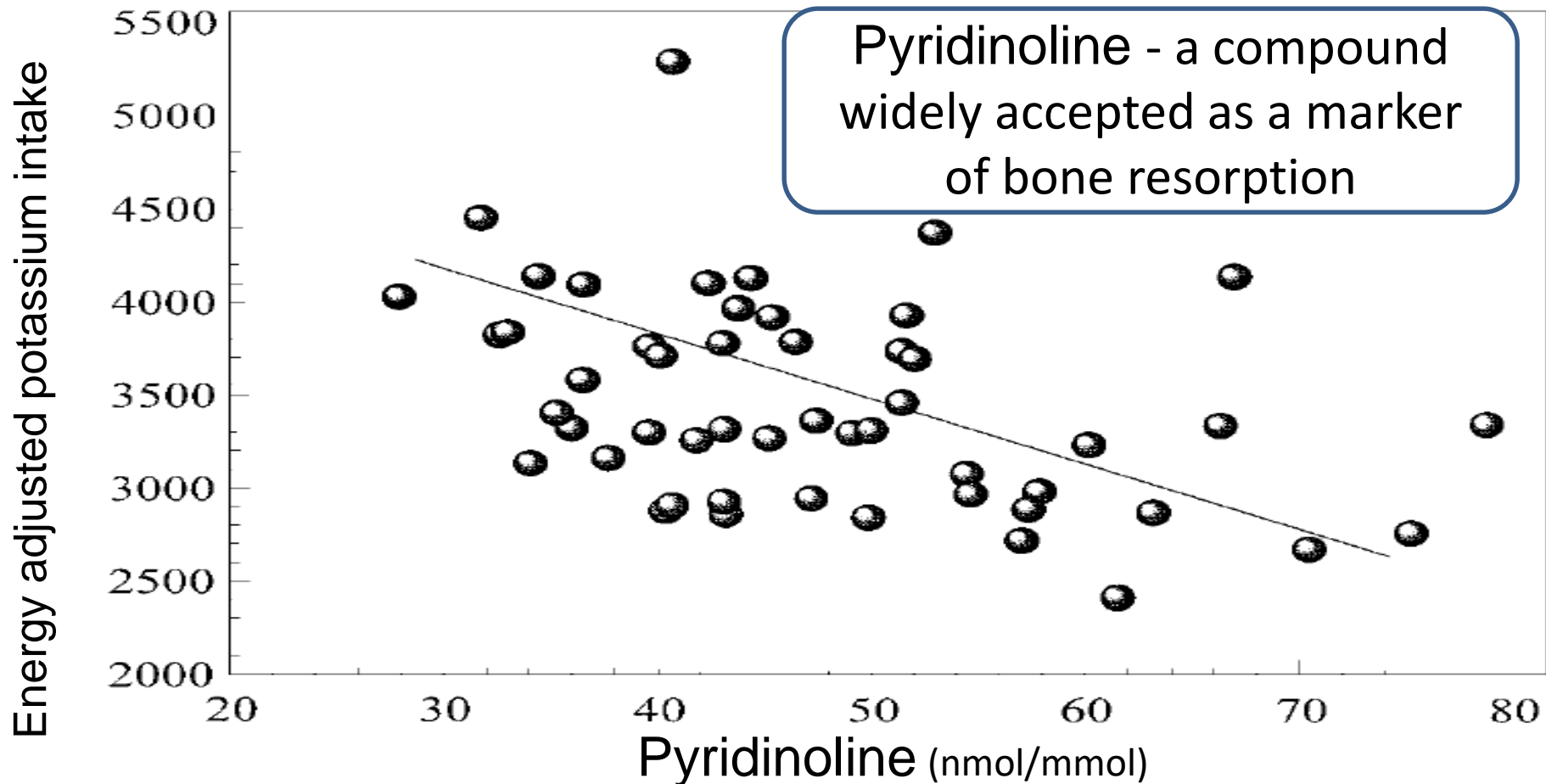
New et al., AJCN 2000;71:142-151

“... intakes of nutrients found in abundance in fruit and vegetables, namely, potassium, β -carotene, vitamin C, and magnesium, were positively associated with bone health.” (p. 148)

Potassium

Dietary influences on bone mass and bone metabolism: further evidence of a positive link between fruit and vegetable consumption and bone health?

New et al., AJCN 2000;71:142-151



Dietary sources of potassium

Food items	Amount µg/3.5 oz
Tomatoes, sun-dried	3,427
Soybean, mature raw	1,797
Mushrooms, shiitake	1,534
Black beans, raw	1,500
Kidney beans, raw	1,490
Pinto beans, raw	1,393
Atzuki beans, raw	1,254
Mung beans, raw	1,246
Navy beans, raw	1,185
Pistachio nuts	1,025
Tomato paste	1,014
Pumpkin seeds	919
Sunflower seeds	850
Raisins	825
Yam, raw	816

Vitamin K intake and the risk of fractures. A meta-analysis

Hao et al. *Medicine* (2017) 96:17

- Four cohort studies and one nested case–control study,
- Total of 1114 fractures cases and 80,982 participants
- Vitamin K intake in all included studies refers exclusively to the intake of phylloquinone (vitamin K1), which is the predominant form of vitamin K in foods.

Vitamin K intake and the risk of fractures. A meta-analysis

Hao et al. Medicine (2017) 96:17

- We observed a statistically significant inverse association between dietary vitamin K intake and risk of fractures (highest vs. the lowest intake, **RR=0.78**, 95% CI: 0.56–0.99; ...).
- When stratified by follow-up duration, the RR of fracture for dietary vitamin K intake was **0.76** (95% CI: 0.58–0.93) in studies with more than 10 years of follow-up.

Vitamin K intake and hip fractures in women: a prospective study

Feskanich et al. Am J Clin Nutr 1999;69:74–9

- **Nurses' Health Study cohort**
- **N = 72,327 women**
- **Age 38–63 years**
- **N (hip fractures) = 270**

Vitamin K intake and hip fractures in women: a prospective study

Feskanich et al. Am J Clin Nutr 1999;69:74–9

“Women in quintiles 2–5 of vitamin K intake had a significantly lower age-adjusted relative risk (RR: 0.70; 95% CI: 0.53, 0.93) of hip fracture than women in the lowest quintile (< 109 mg/d).

Risk did not decrease between quintiles 2 and 5 and risk estimates were not altered when other risk factors for osteoporosis, including calcium and vitamin D intakes, were added to the models.”

Vitamin K intake and hip fractures in women: a prospective study

Feskanich et al. Am J Clin Nutr 1999;69:74–9

“Risk of hip fracture was also inversely associated with lettuce consumption (RR: 0.55; 95% CI: 0.40, 0.78) for one or more servings per day compared with one or fewer servings per week), the food that contributed the most to dietary vitamin K intakes.”

Dietary sources of vitamin K

Food items	Amount µg/3.5 oz
Kale, cooked	817
Swiss chard	830
Kale, raw	705
Collards, boiled	624
Mustard greens, boiled	593
Spinach, boiled	541
Spinach, raw	483
Basil, fresh	415
Mustard greens, raw	256
Onion scallions	207
Brussels sprouts, raw	177
Onion greens	156
Broccoli, boiled	141
Lettuce, raw	126

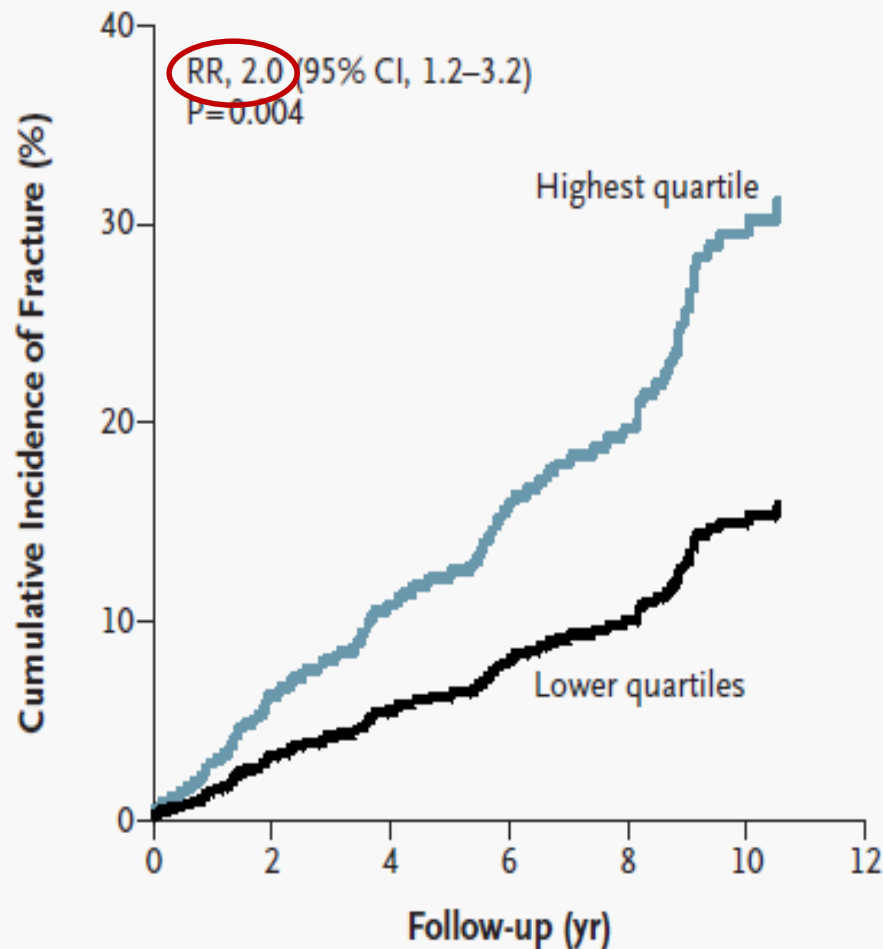


Vitamin B12
&
homocysteine

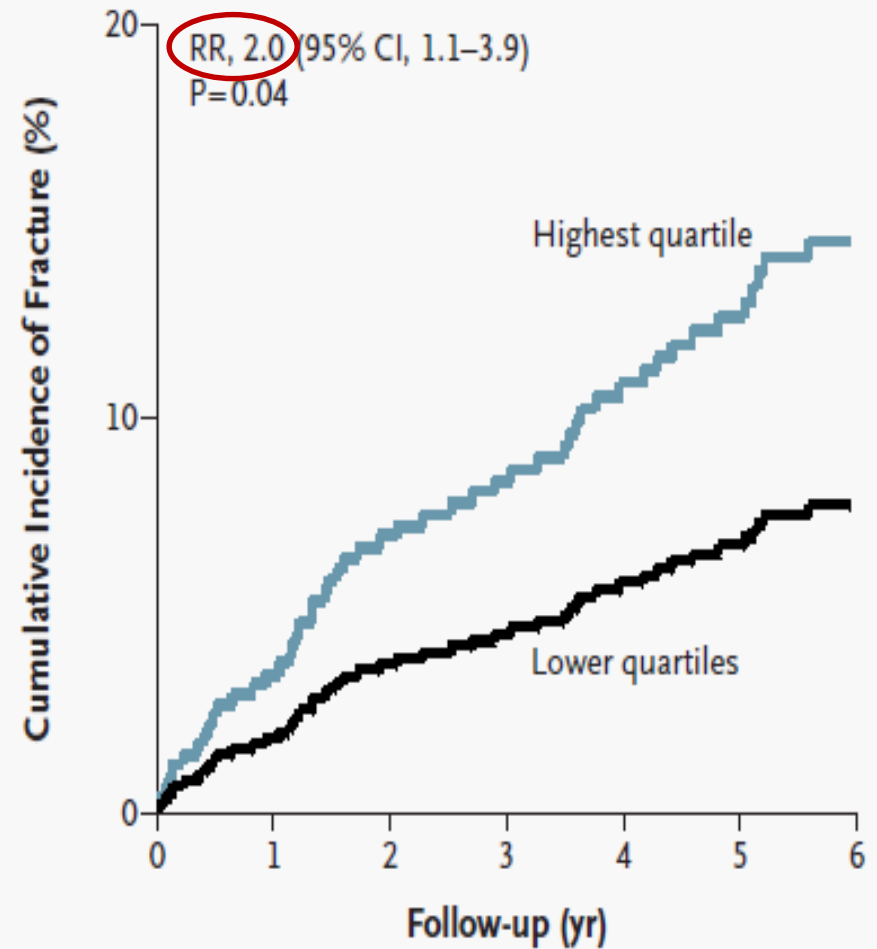
Homocysteine Levels and the Risk of Osteoporotic Fracture

Joyce et al, N Engl J Med, 2004;May 13;350(20):2042-2049

A Rotterdam Study, Cohort 1



B Rotterdam Study, Cohort 2



Vitamin B12, Folate, Homocysteine, and Bone Health in Adults and Elderly People: A Systematic Review with Meta-Analyses.

van Wijngaarden et al. *Journal of Nutrition and Metabolism*, 2013; <http://dx.doi.org/10.1155/2013/486186>

“Meta-analysis of four prospective studies including 7,475 people showed a modest decrease in fracture risk of 4% per 50 pmol/L increase in vitamin B12 levels, which was borderline significant (RR = 0.96, 95% CI = 0.92 to 1.00).

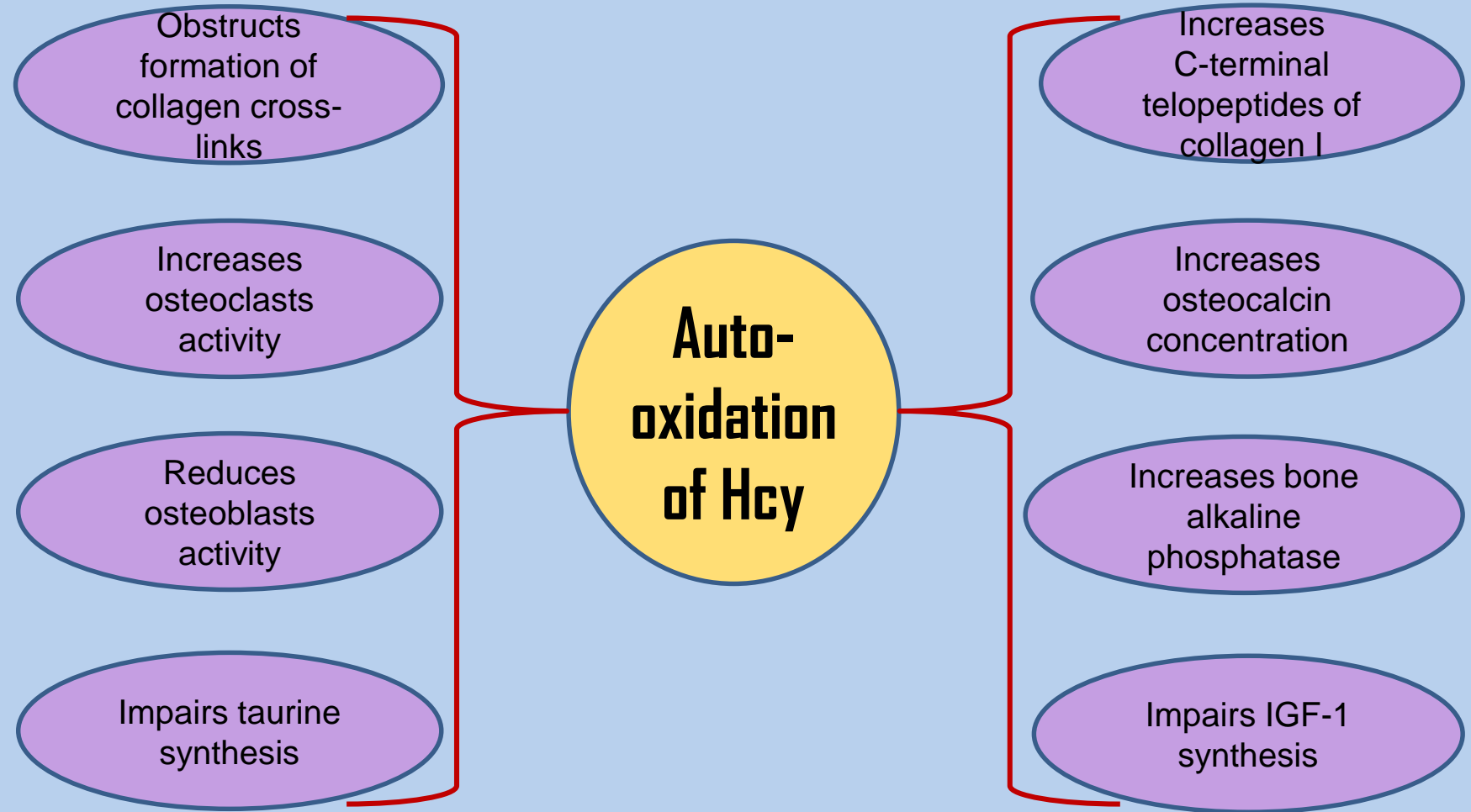
Vitamin B12, Folate, Homocysteine, and Bone Health in Adults and Elderly People: A Systematic Review with Meta-Analyses.

van Wijngaarden et al. Journal of Nutrition and Metabolism, 2013;
<http://dx.doi.org/10.1155/2013/486186>

Meta-analysis of eight studies including 11,511 people showed an increased fracture risk of 4% per $\mu\text{mol/L}$ increase in homocysteine concentration (RR = 1.04, 95% CI = 1.02 to 1.07)."

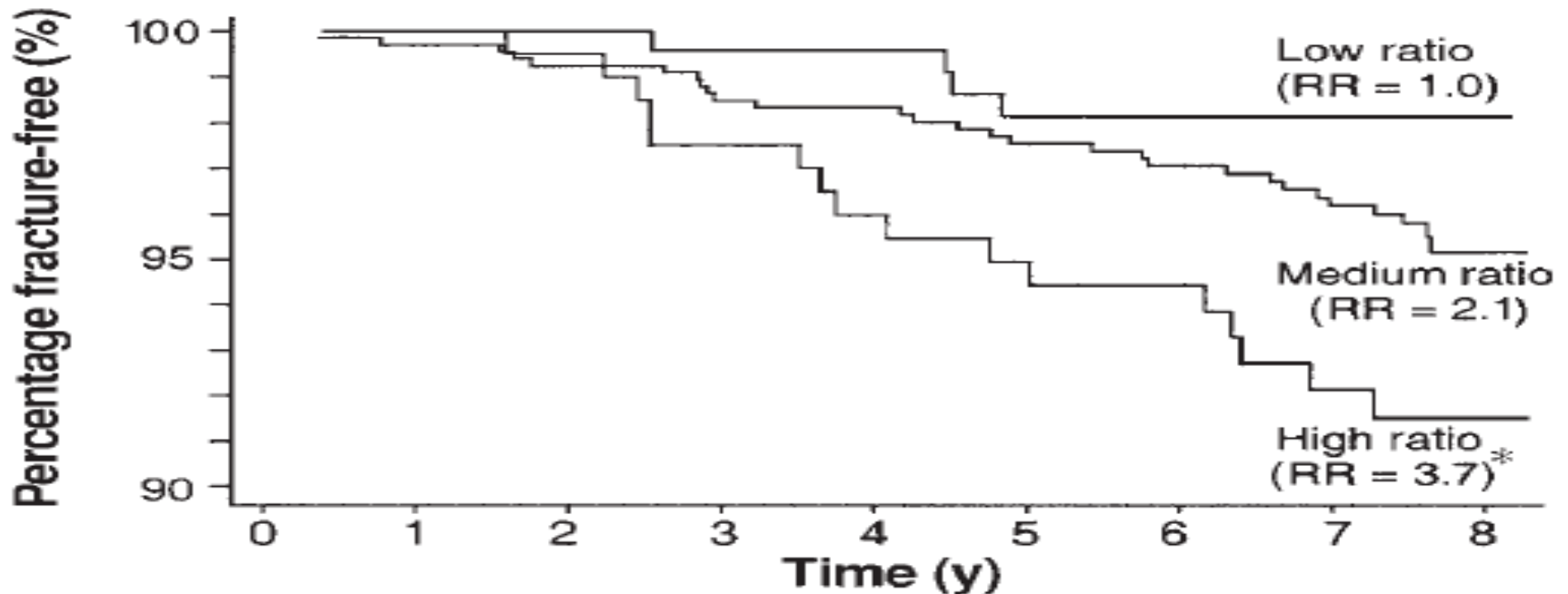
Vitamin B12 deficiency and Hyperhomocysteinemia: Risk factors for low bone density, bone turnover, and bone fractures among vegetarian adults.

Babatunde T. & Pawlak R. Submitted to Journal of Chronic Disease Management



Dietary protein

Hip fracture-free survival in 1035 women by ratio of animal to vegetable protein intake



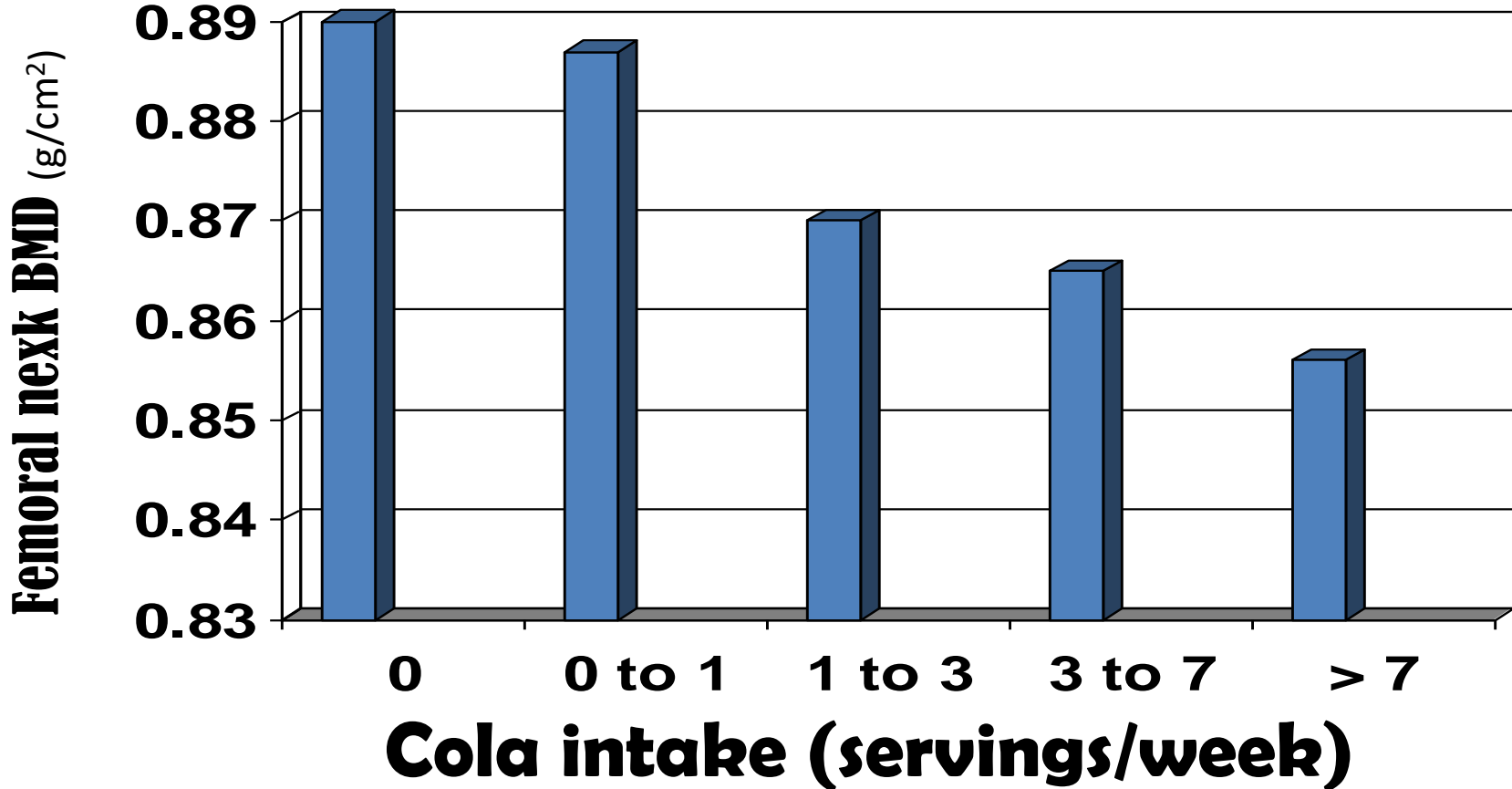
	Low ratio	Medium ratio	High ratio	<i>P</i> for trend
Ratio of animal to vegetable protein intake	1.2 ± 0.27	2.3 ± 0.44	4.2 ± 1.2	0.001
Animal protein intake (g)	23.6 ± 6.8	35.1 ± 6.5	48.2 ± 9.3	0.001
Vegetable protein intake (g)	19.6 ± 3.6	15.4 ± 2.7	11.6 ± 2.8	0.001

adjusted for age, energy intake, total calcium intake (dietary plus supplements), total protein intake, weight, current estrogen use, physical activity, smoking status, and alcohol intake. **P* = 0.04. RR, relative risk

Sellmeyer et al., Am J Clin Nutr 2001;73:118–22.

Colas, but not other carbonated beverages, are associated with low bone mineral density in older women: The Framingham Osteoporosis Study

Tucker et al., Am J Clin Nutr 2006;84:936–942



Soda consumption and risk of hip fractures in postmenopausal women in the Nurses' Health Study

Fund et al. Am J Clin Nutr, 2014 Sep; 100(3): 953–958

- Nurses Health Study
- N = 73,572; N (hip fractures) = 1873

“In multivariable models, each additional serving of total soda per day was associated with a significant 14% increased risk of hip fracture (RR: 1.14; 95% CI: 1.06, 1.23). The attributable risk in our cohort for total soda consumption was 12.5%. Risk was significantly elevated in consumers of both regular soda (RR: 1.19; 95% CI: 1.02, 1.38) and diet soda (RR: 1.12; 95% CI: 1.03, 1.21) and also did not significantly differ between colas and noncolas or sodas with or without caffeine.”

Osteoporosis prevention – nutrients

- Adequate intake of potassium
- Adequate intake of vitamin K
- Adequate vitamin B12 status
- Adequate vitamin D status – adequate sun exposure
- Decrease dietary phosphorus intake
- Decrease dietary sodium intake
- Decrease animal protein intake???
- Adequate intake of photoestrogens???

Osteoporosis prevention – foods

1. Eat plenty of heart healthy foods including a variety of fruits and vegetables especially green leafy vegetables and legumes
2. Include soybeans food such as soymilk, tofu, flax seeds
3. Decrease foods high in sodium (canned foods, pickled foods, etc.)
4. Make sure your vitamin B12 status is adequate
5. Eliminate drinking of soft drinks
6. Decrease intake of meat and other animal products



Calcium Intake in the United States from Dietary and Supplemental Sources across Adult Age Groups: New Estimates from the National Health and Nutrition Examination Survey 2003–2006

Mangano et al. J Am Diet Assoc. 2011;111(5):687–695

Median CA intake

Age (years)	Dietary CA (mg/day)	Supplemental CA (mg/day)
Men		
19-30	973	74
31-40	1030	106
41-50	908	136
51-60	843	141
61-70	801	162
71-80	760	190
≥ 80	739	236

Calcium Intake in the United States from Dietary and Supplemental Sources across Adult Age Groups: New Estimates from the National Health and Nutrition Examination Survey 2003–2006

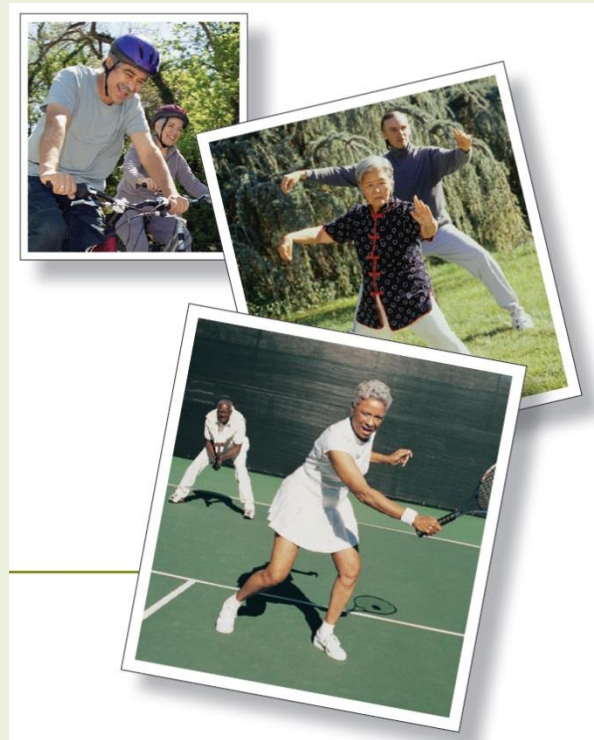
Mangano et al. J Am Diet Assoc. 2011;111(5):687–695

Median CA intake

Age (years)	Dietary CA (mg/day)	Supplemental CA (mg/day)
Women		
19-30	840	169
31-40	806	143
41-50	700	213
51-60	671	280
61-70	674	391
71-80	673	380
≥ 80	603	373

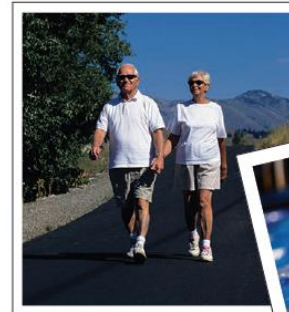
Aerobic Activity

- *Aerobic (endurance or cardio) activity* - the body's large muscles move in a rhythmic manner for a sustained period of time.
- Examples:
 - walking,
 - running,
 - bicycling,
 - jumping rope,
 - swimming.



Aerobic Activity

- Intensity – how hard?
- Frequency – how often?
- Duration – how long?



Muscle-strengthening Activity

- *Muscle-Strengthening (resistance training) activity* - causes the body's muscles to work or hold against an applied force or weight.
- Examples:
 - Lifting weight
 - Pushing using elastic band
 - Using body weight (push-ups)

Muscle-strengthening Activity

- Intensity – how much weight?
- Frequency – how often?
- Repetitions – how many times?



Greater Intake of Fruit and Vegetables Is Associated with Greater Bone Mineral Density and Lower Osteoporosis Risk in Middle-Aged and Elderly Adults

Qiu et al. PLoS One, 2017; 12(1): e0168906.

“After adjustment for potential covariates, we observed dose-dependent associations between total FV intake and BMD and osteoporosis risk. The mean BMD was higher in tertile 3 *vs.* tertile 1 by 1.33% (TH) and 1.31% (FN) for FV, and 1.10% (WB), 1.57% (TH), and 2.05% (FN) for fruit (all *P*-trends < 0.05). Significant beneficial associations with BMD at some sites were also found in most fruit categories but not in total vegetables or their subgroups.”

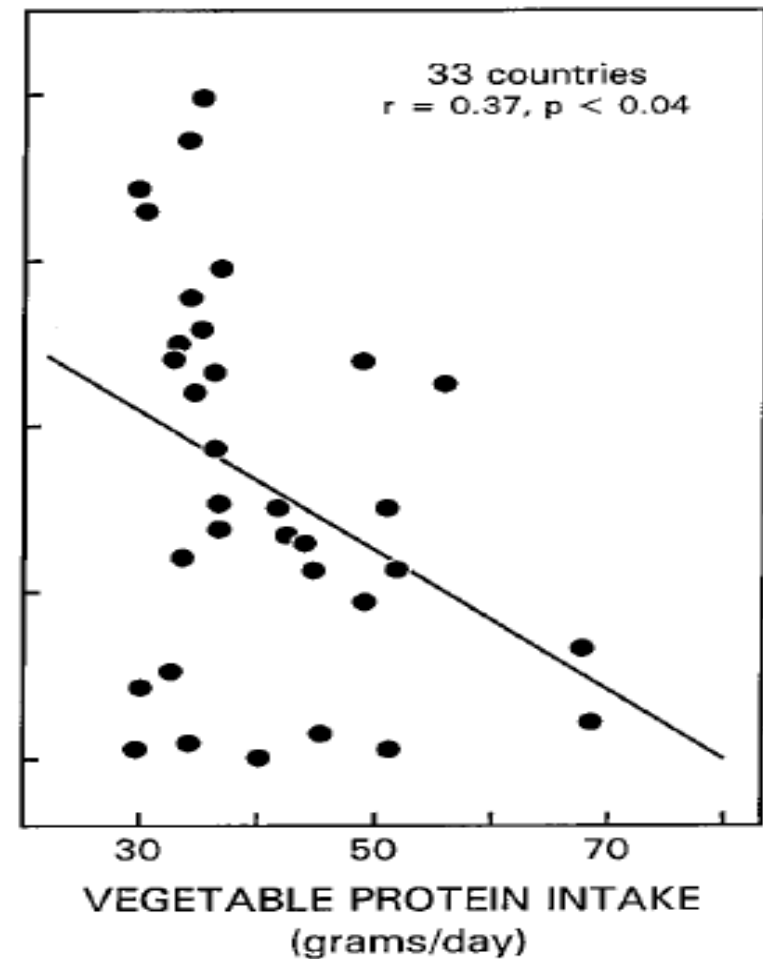
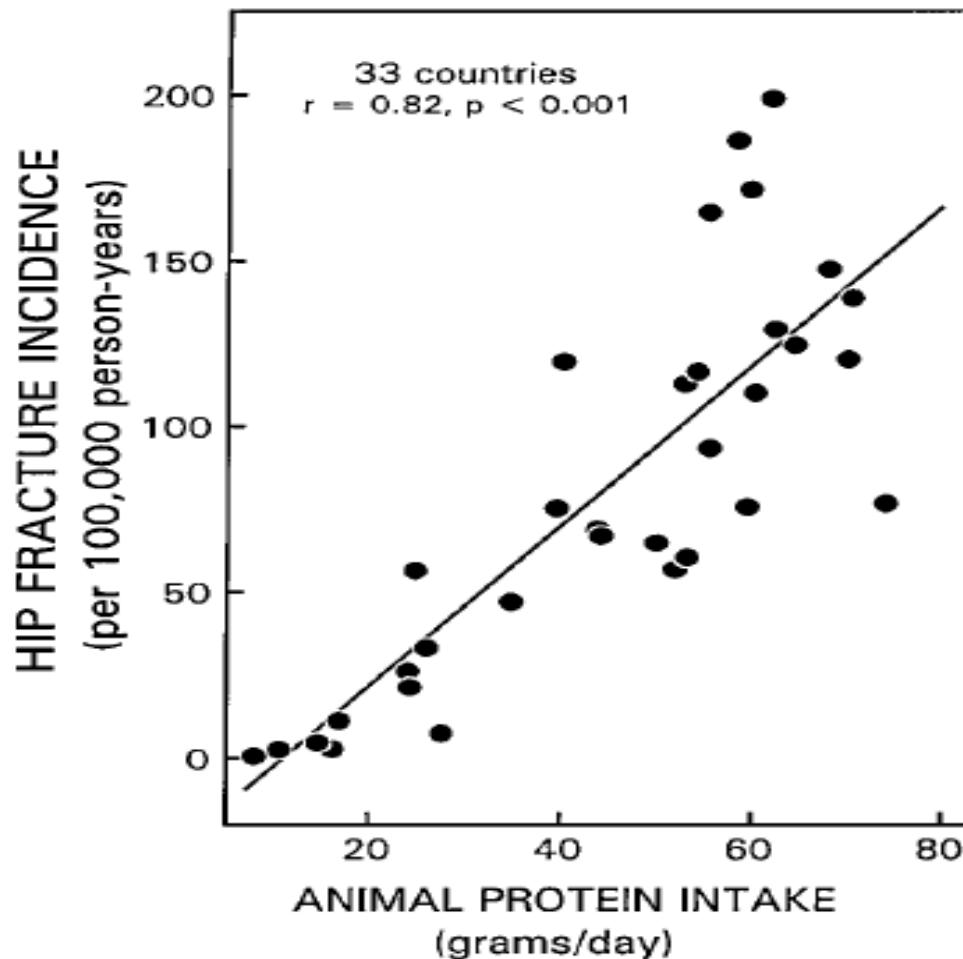
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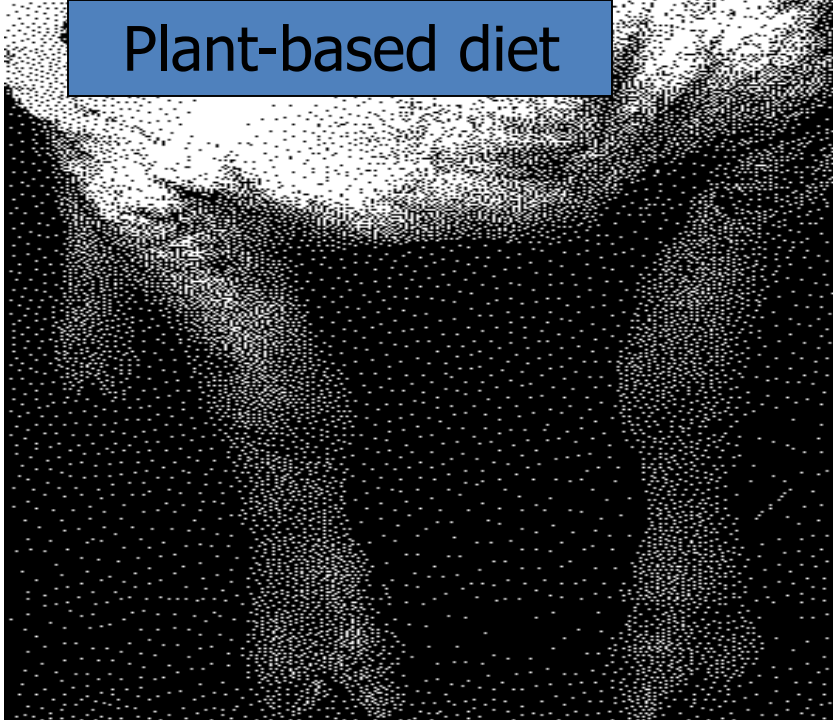
“The odds ratios (95% confidence interval) of osteoporosis ... in tertile 3 (vs. 1) were 0.73 (0.58–0.92), 0.37 (0.22–0.60), and 0.71 (0.52–0.97) for FV; 0.82 (0.66–1.03), 0.48 (0.30–0.77) and 0.89 (0.61–1.12) for fruit; and 0.80 (0.64–1.01), 0.57 (0.35–0.92) and 0.76 (0.55–1.05) for vegetables at the LS, TH, and FN, respectively. The favorable association between FV intake and the occurrence of osteoporosis was evident only in subjects with lower BMI (<24.0 kg/m², *P-trends* < 0.05).”

Worldwide incidence of hip fracture in elderly women: relation to consumption of animal vs. plant foods

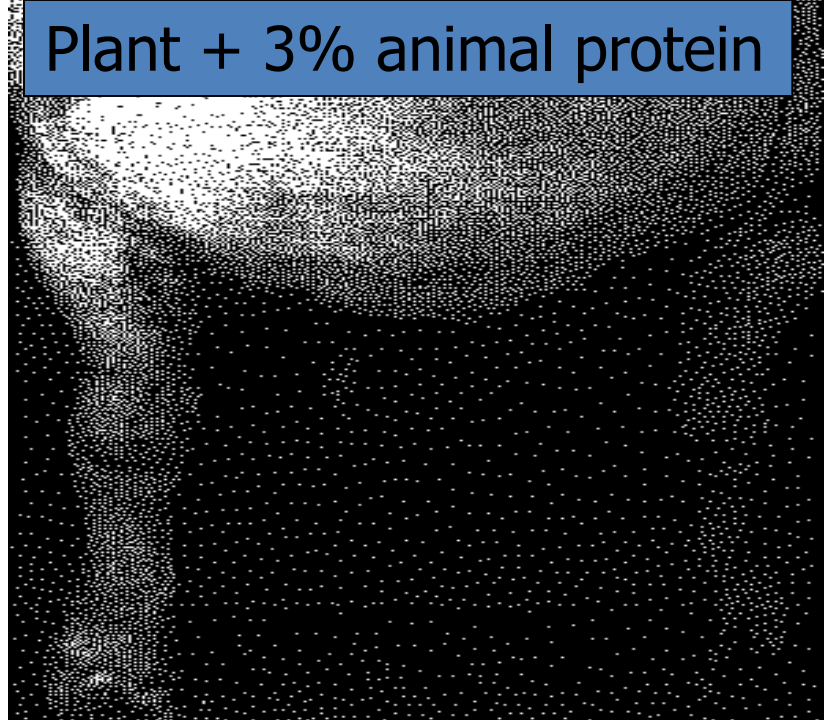
Frassetto et al., Journal of Gerontology: Medical Sciences. 2000;55A(10):M585-M592



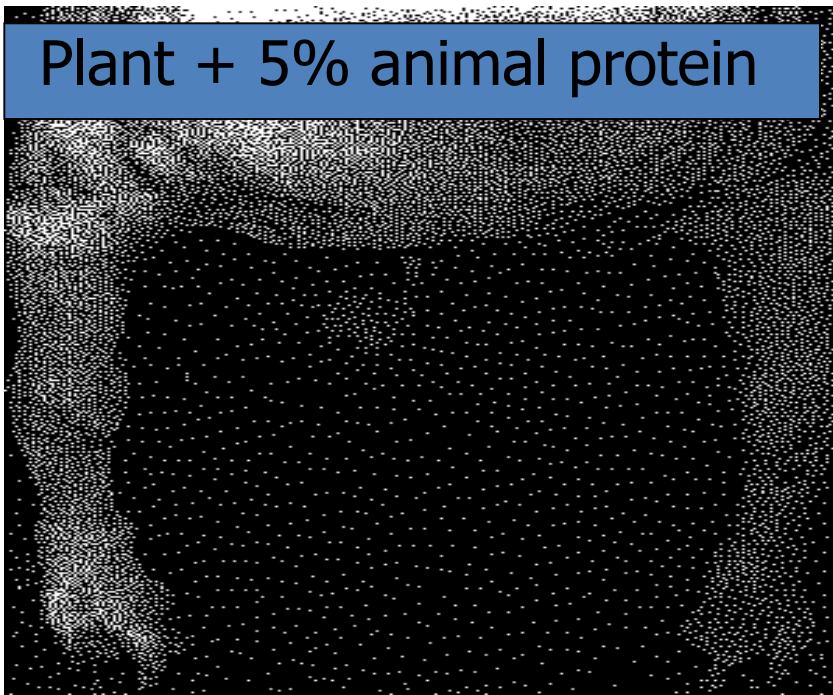
Plant-based diet



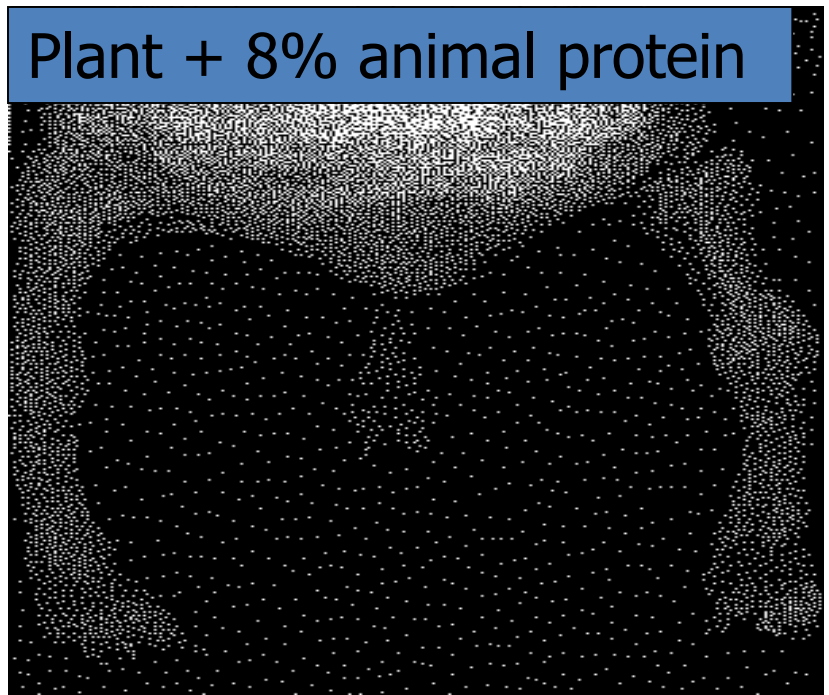
Plant + 3% animal protein



Plant + 5% animal protein

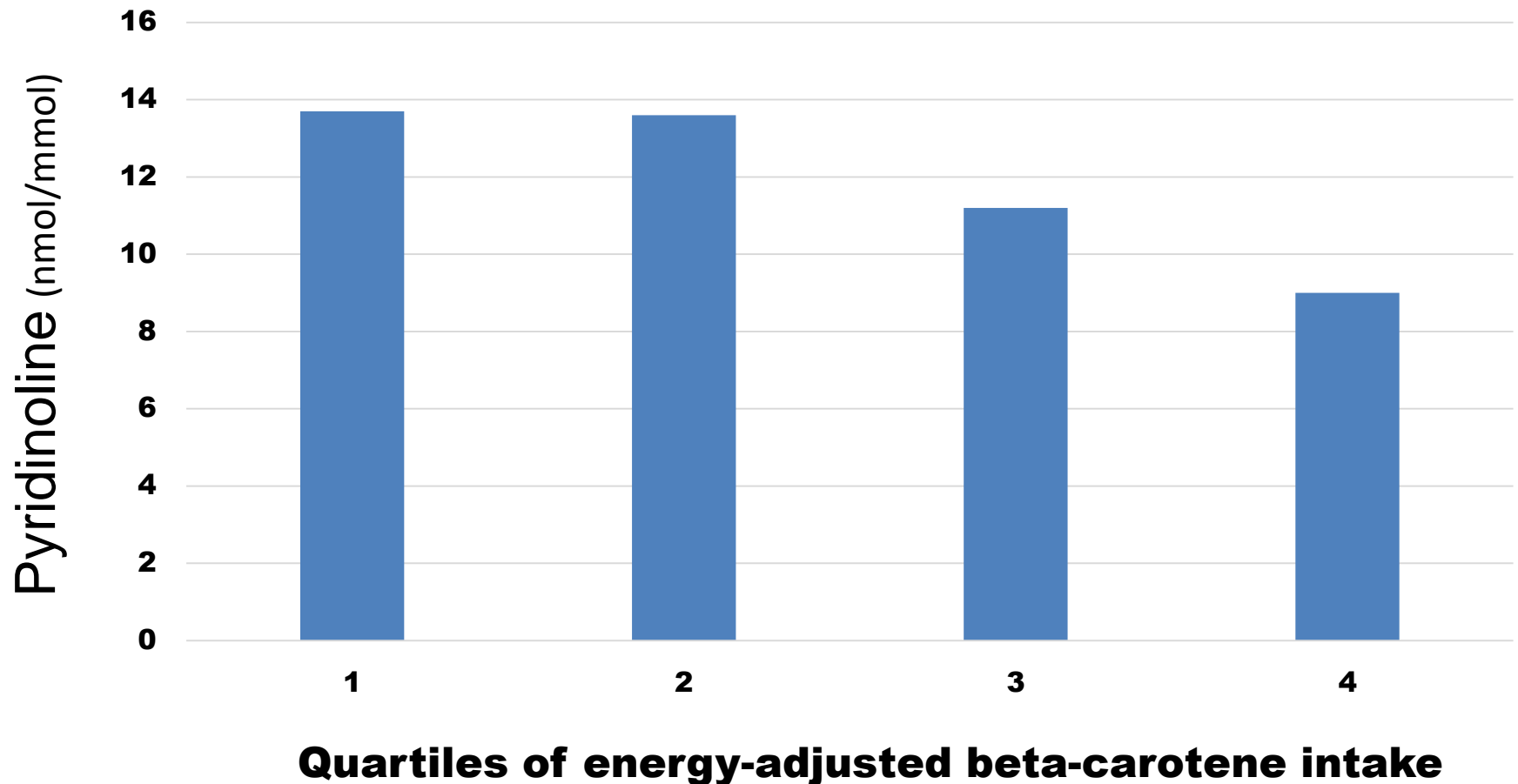


Plant + 8% animal protein



Dietary influences on bone mass and bone metabolism: further evidence of a positive link between fruit and vegetable consumption and bone health?

New et al., AJCN 2000;71:142-151



Vitamin K intake and risk for a hip fracture

Relative risks of hip fracture in elderly men and women by quartile of phylloquinone intake

Quartile	Number of participants with hip fractures	Median phylloquinone intake ($\mu\text{g}/\text{d}$)	Multivariate RR (95% CI) ¹	Multivariate RR (95% CI) adjusted for BMD ²
1	16 of 223	56	1.00	1.00
2	11 of 222	105	0.53 (0.22, 1.28)	0.52 (0.20, 1.32)
3	10 of 228	156	0.59 (0.25, 1.39)	0.65 (0.25, 1.70)
4	7 of 227	254	0.35 (0.13, 0.94)	0.35 (0.12, 1.02)
<i>P</i> for trend ³	—	—	0.047	0.054

¹ Adjusted for sex, smoking status, calcium and vitamin D supplement use, alcohol consumption, BMI, age, energy intake, physical activity score, and vitamin D, calcium, and caffeine intakes.

² Adjusted for femoral neck bone mineral density (BMD), sex, smoking status, calcium and vitamin D supplement use, alcohol consumption, BMI, age, energy intake, physical activity score, and vitamin D, calcium, and caffeine intakes.

³ Linear trend across quartiles of phylloquinone intake, with median value per quartile.