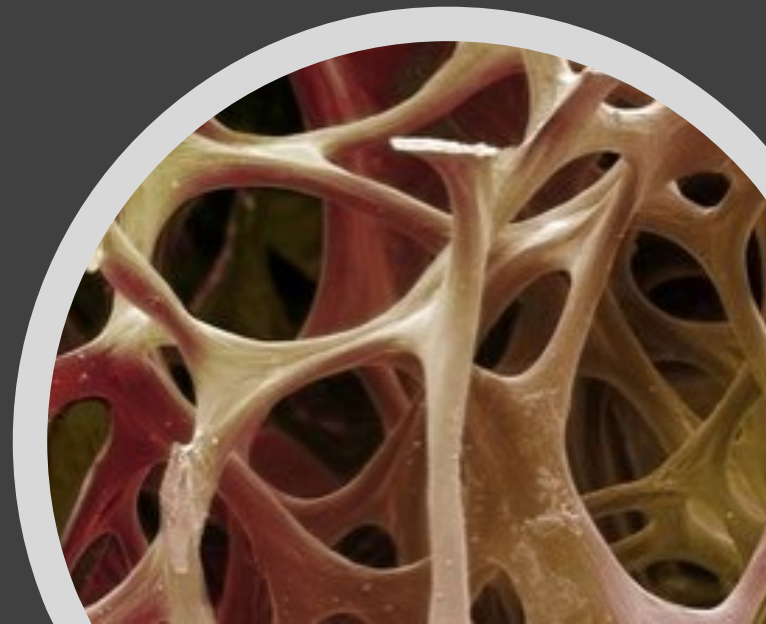
Bone Health:
New Developments

Nick Birch

Consultant Spinal Specialist



Osteoscan UK Ltd

www.osteoscanuk.com

Diagnostics: The Osteopenia Fracture Conundrum

Therapeutics: Reversing Bone Loss, Curing Osteoporosis

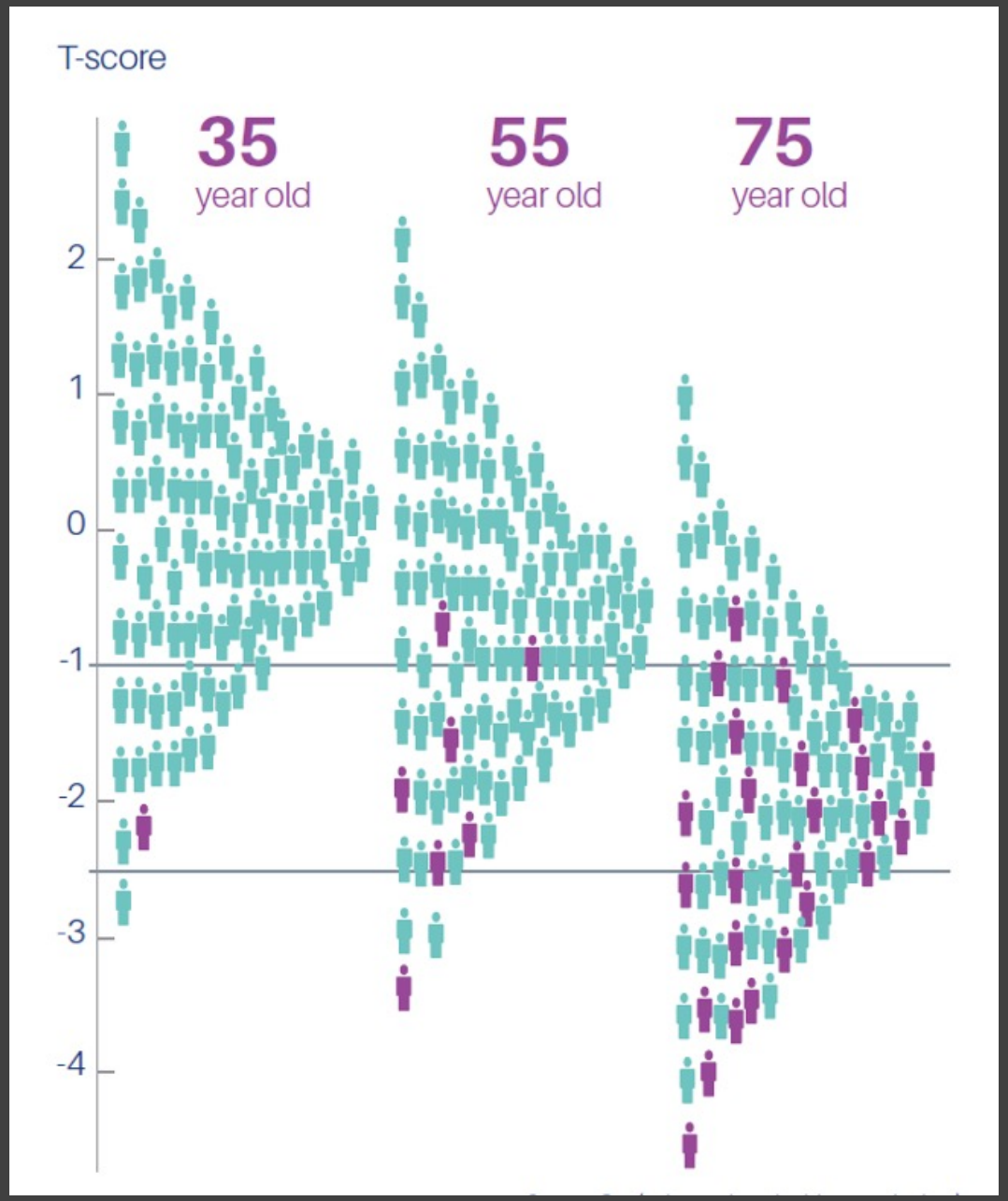
Dietetics: Meat-free diet and Bone Health

Exercise: Vibration Therapy and Bone health

Diagnostics:

The Osteopenia Fracture Conundrum

Risk of Fragility Fractures in Women According to Age

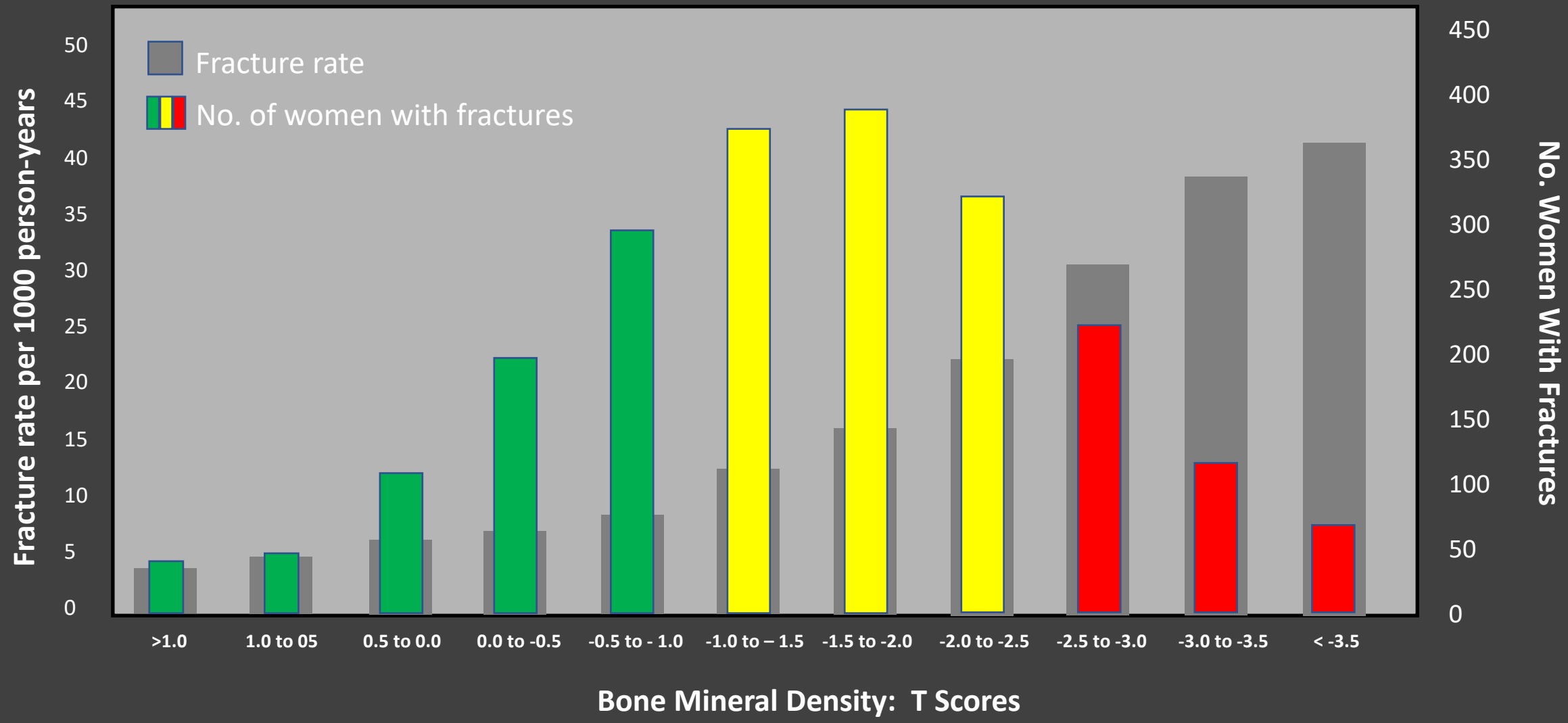


Age 35: 1 in 100

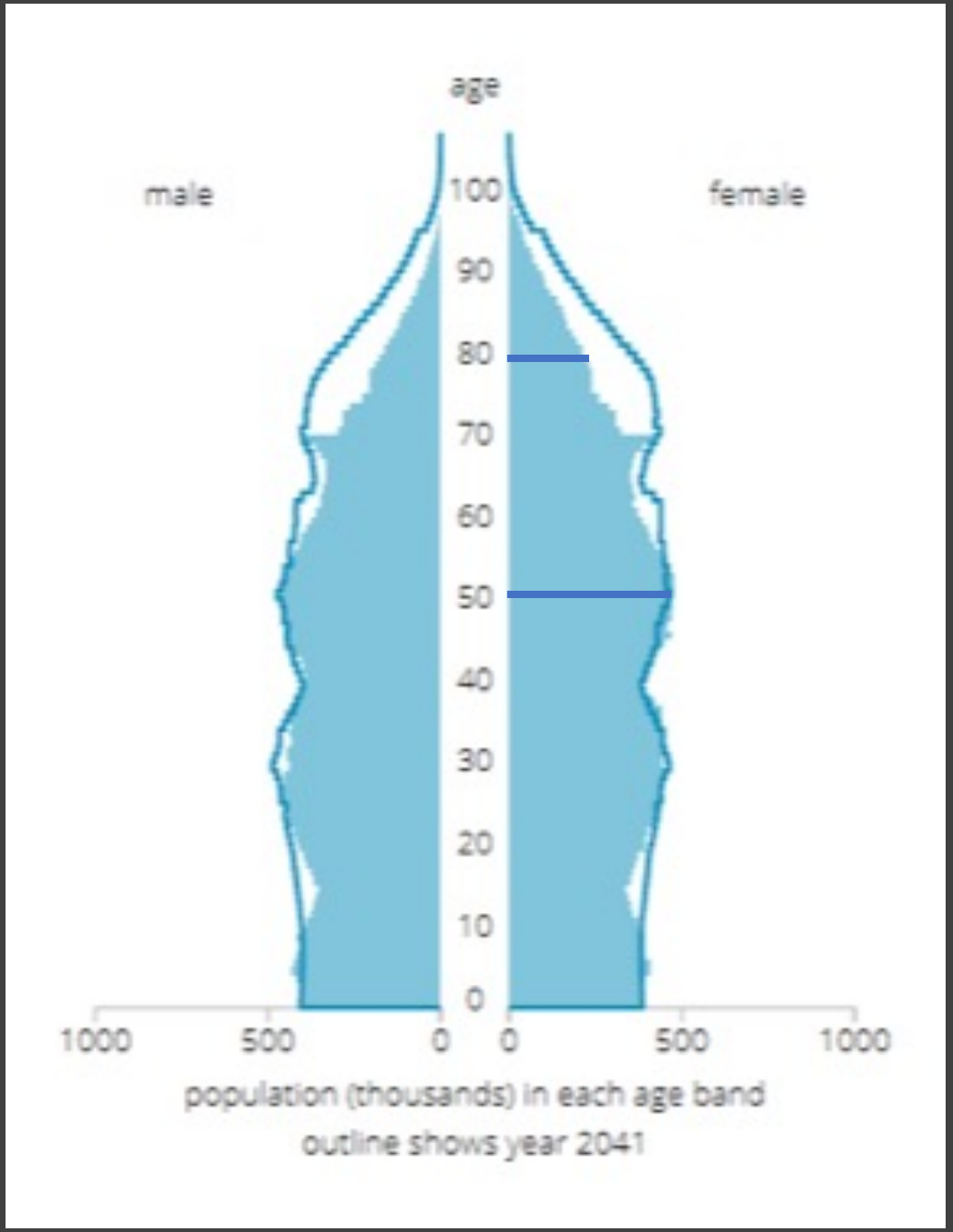
Age 55: 7 in 100

Age 75: 24 in 100

Rate and Number of Fractures in Women According to Bone Mineral Density



Population Distribution by Age



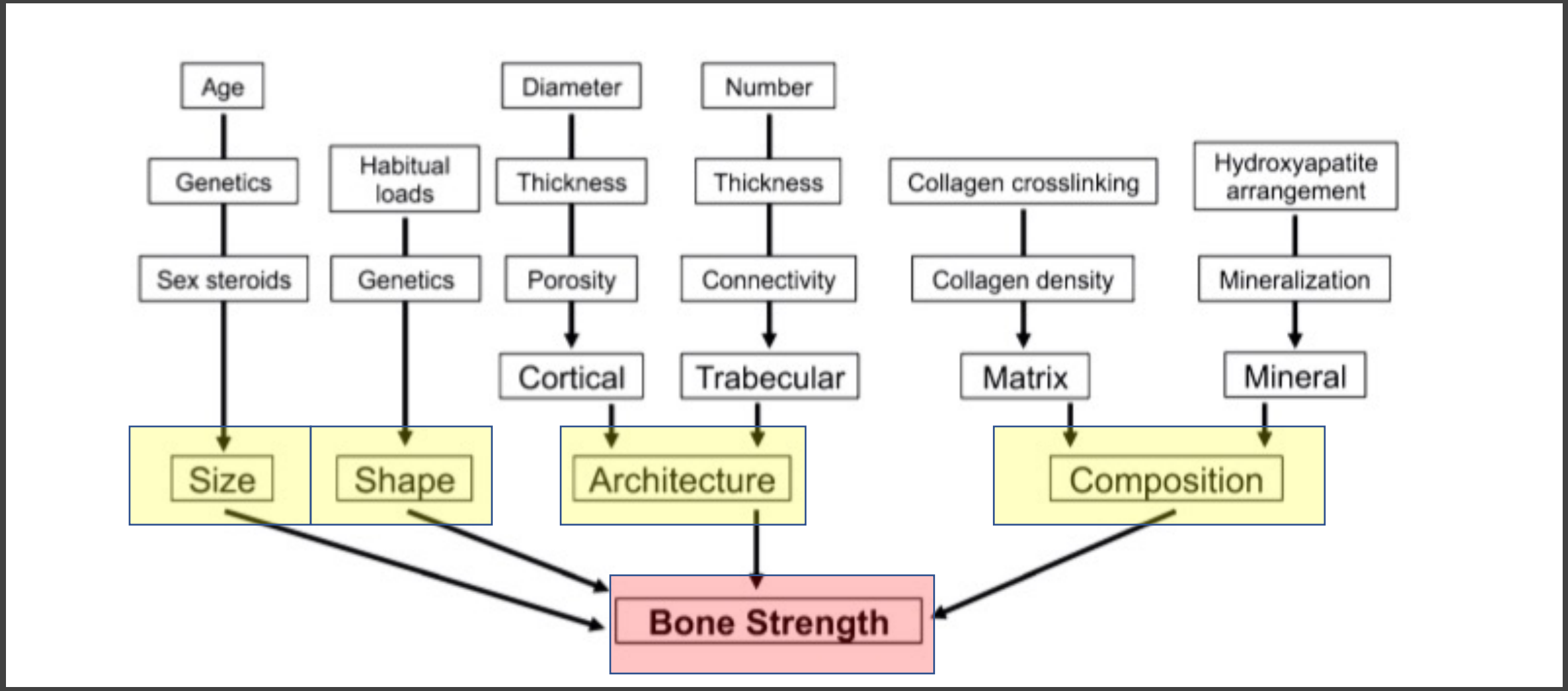
The ability of bone to resist fracture is the best indicator of bone quality

Potentially related to several bone properties:

Mineralisation
Bone mineral density (BMD)
Bone turnover rate
Microarchitecture
Geometry

SOLOMON EPSTEIN, MD
Mayo Clinic Proceedings 2005; 80 (3):379-388

Factors Contributing to Bone Health

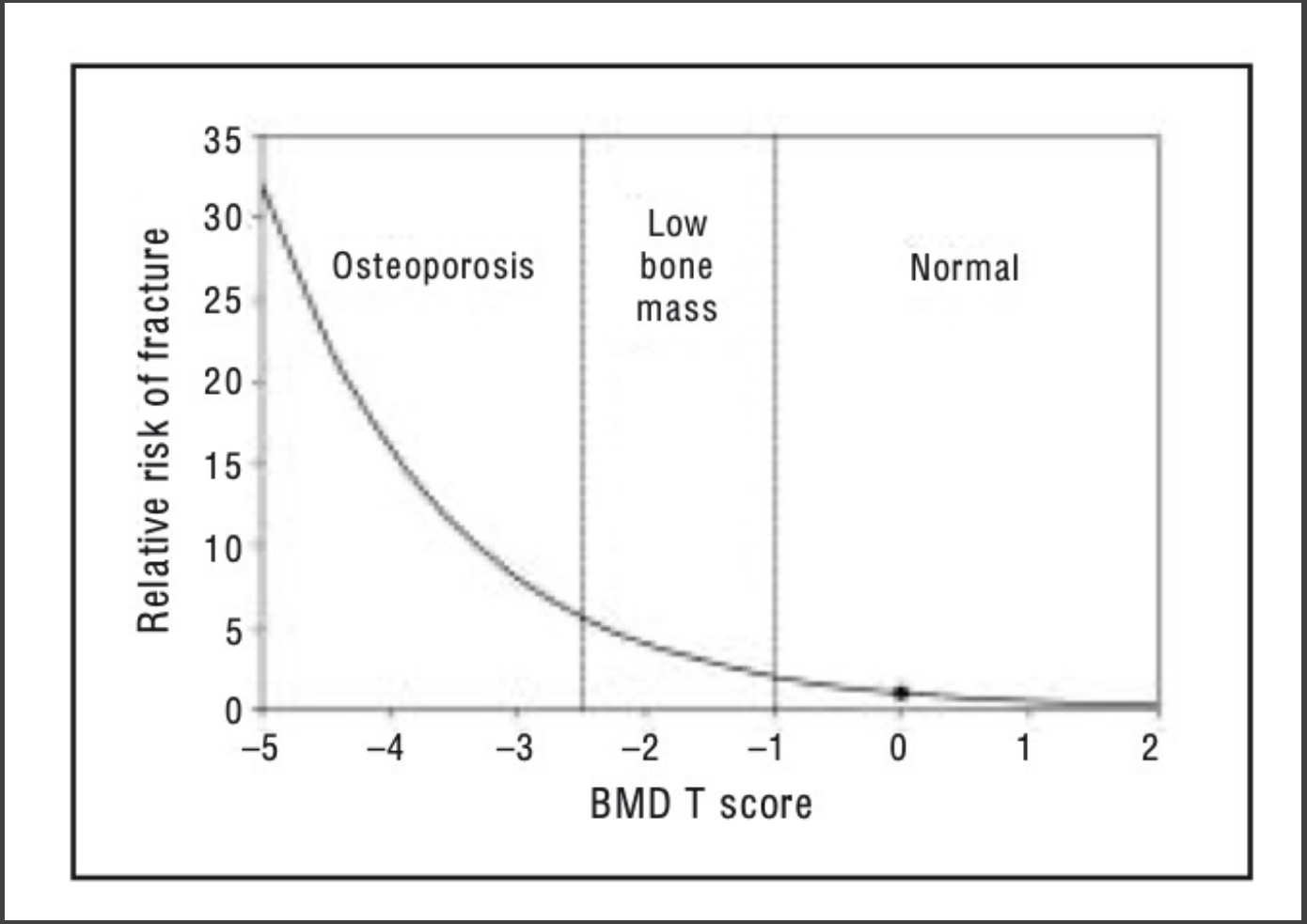


BMD remains the standard for evaluating fracture risk and is easily measured in vivo (DEXA / REMS)

BMD is influenced by both bone mineral content and bone geometry (micro- and macro-architecture) of the site measured

An approximately exponential relationship exists between bone density and some measures of bone strength

Modest increases in bone density are associated with disproportionately large increases in bone strength



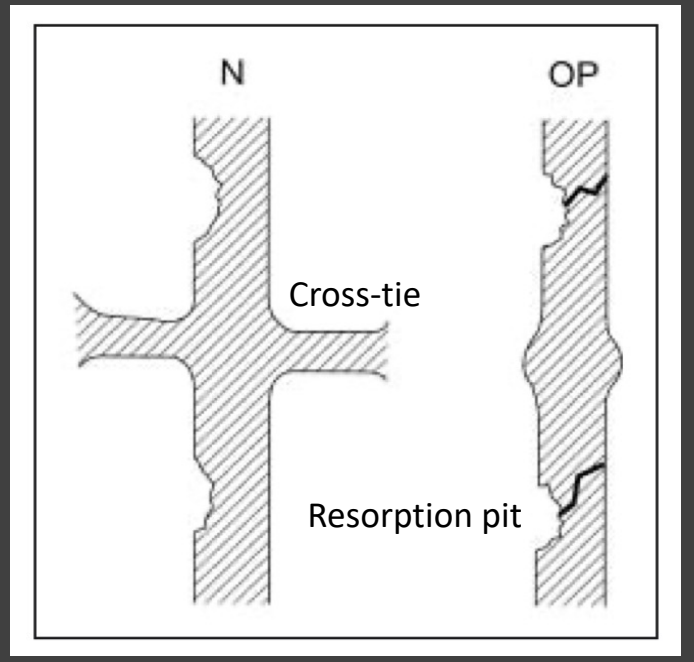
High rate of bone turnover e.g. post menopause increases the number of resorption pits

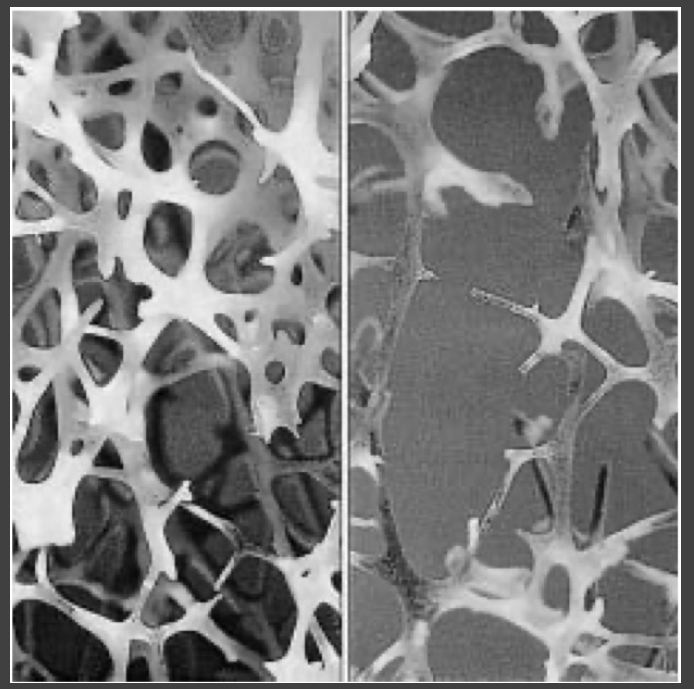
Resorption pits act as focal areas of weakness and reduce bone strength increasing the risk of micro-fractures and macro-fractures

Excessive resorption can lead to complete trabecular perforation and permanent loss of connectivity

With advancing age, there is a preferential loss of horizontal trabeculae (cross-ties)

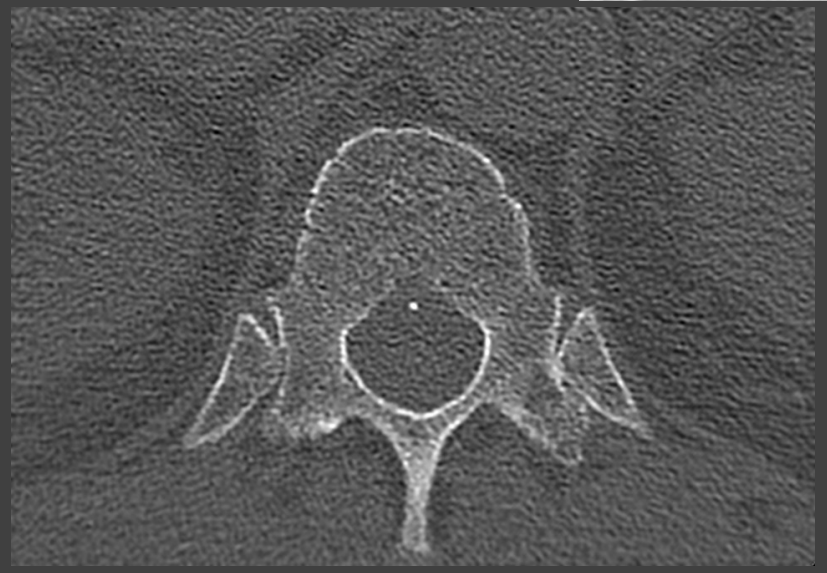
Such architectural disruption substantially decreases the load needed before buckling occurs





Plain x-ray

Limited ability to understand internal bone architecture on standard imaging



CT scan

MRI scan

Bone health assessment when T score is -1.0 to – 2.5

BMD + Trabecular Bone Score / Fragility Score = quality of bone or “toughness”

Light-weight carbon fibre lattice
Well-built and incredibly strong

Tacoma Narrows suspension bridge
Massive but structurally flawed and failed catastrophically

DEXA Output: "The Gold Standard"

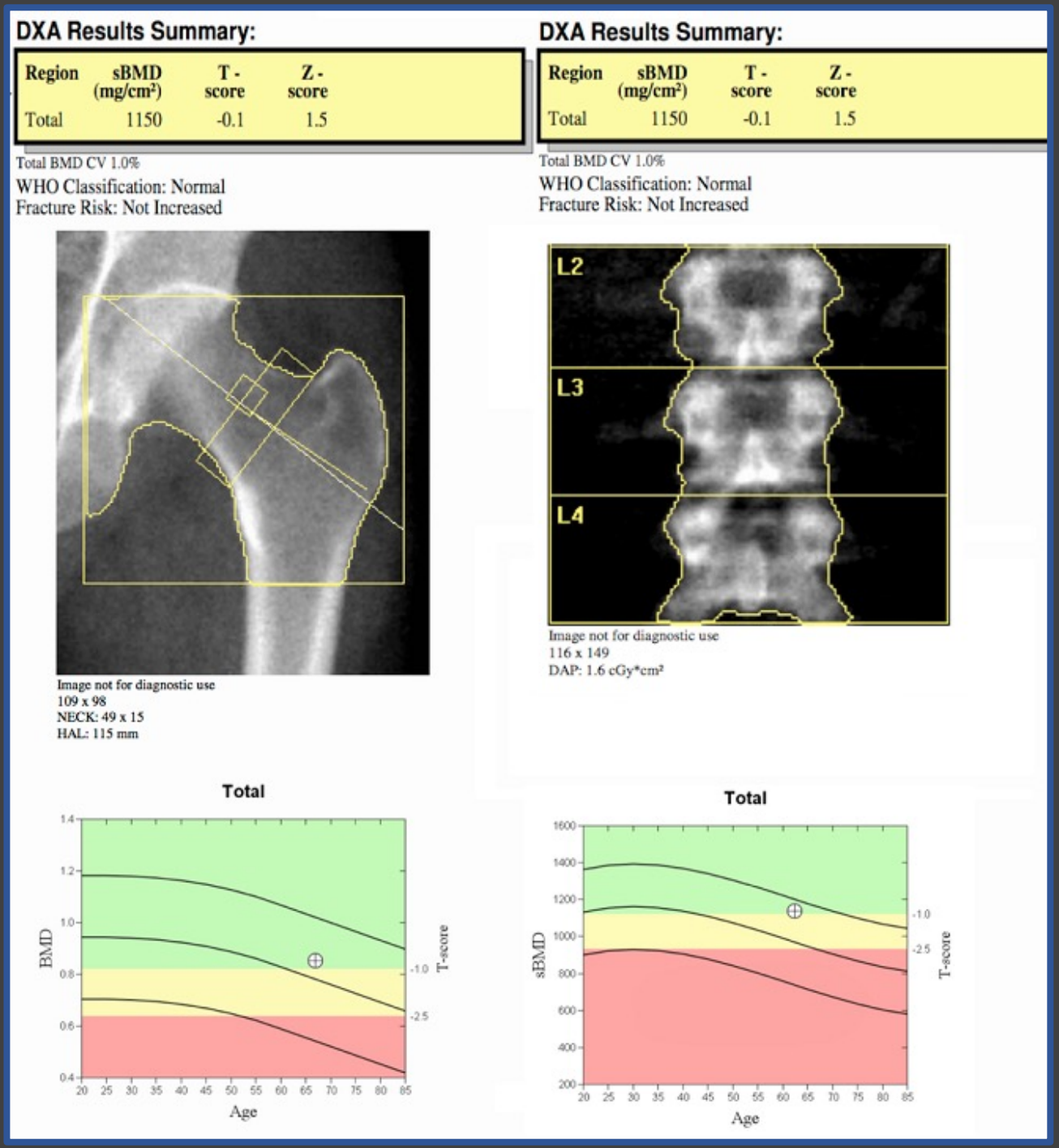
T-SCORE

Z-SCORE

BMD (g/cm²)

+/- FRAX

+/- TBS



Journal of Clinical Densitometry: Assessment & Management of Musculoskeletal Health, vol. ■, no. ■, 1–12, 2017

1094-6950/■:1–12/$36.00
http://dx.doi.org/10.1016/j.jocd.2017.06.019

Original Article

Use of Trabecular Bone Score (TBS) as a Complementary Approach to Dual-energy X-ray Absorptiometry (DXA) for Fracture Risk Assessment in Clinical Practice

Enisa Shevroja,[1,2] Olivier Lamy,[1] Lynn Kohlmeier,[3] Fjorda Koromani,[2] Fernando Rivadeneira,[2] and Didier Hans[,1]*

[1]*Center of Bone Diseases, Bone & Joint Department, Lausanne University Hospital, Lausanne, Switzerland;*
[2]*Musculoskeletal Genomics, Departments of Internal Medicine and Epidemiology, Rotterdam, The Netherlands; and*
[3]*Endocrinology and Metabolic Bone, Spokane Osteoporosis, Spokane, WA, USA*

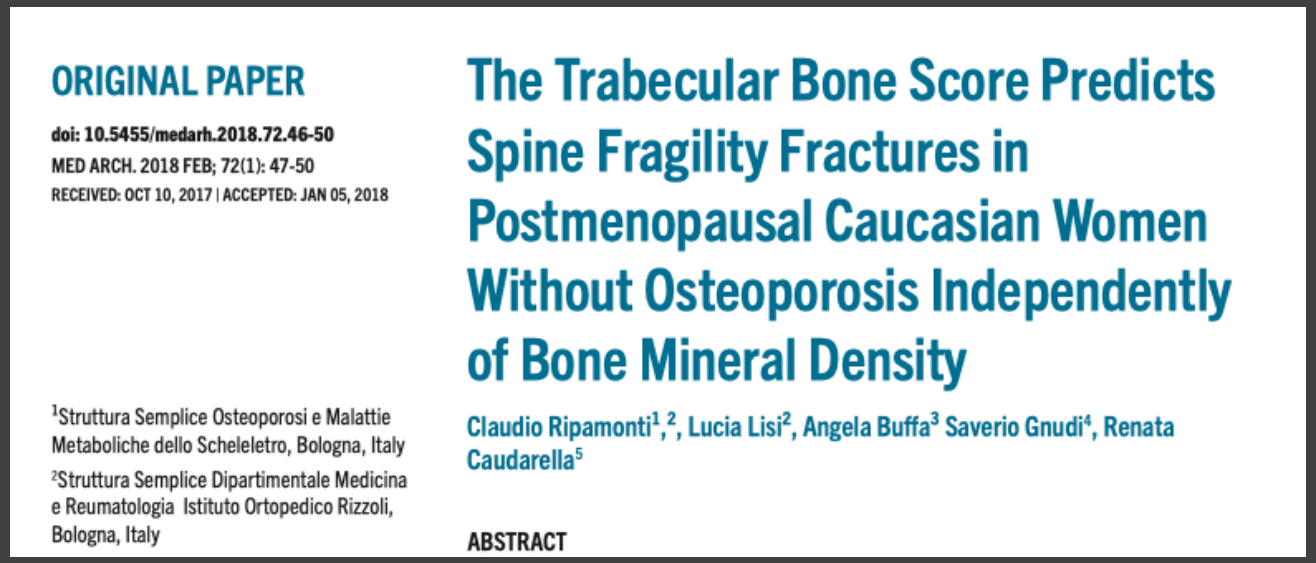
Low lumbar spine TBS is associated with a history of fracture and the incidence of new fractures

The effect is largely independent of BMD

The TBS effect is independent of FRAX, with likely greatest utility for those individuals whose BMD levels lie close to an intervention threshold

The clinical and scientific evidence supporting the use of TBS, makes TBS an attractive and useful clinical tool for physicians to improve patient management in osteoporosis

Take home message: TBS i.e. bone quality should be an everyday part of bone health assessment and is likely to be very important for those women with T scores between -2.0 and -3.0 as it can guide management



ORIGINAL PAPER

doi: 10.5455/medarh.2018.72.46-50
MED ARCH. 2018 FEB; 72(1): 47-50
RECEIVED: OCT 10, 2017 | ACCEPTED: JAN 05, 2018

The Trabecular Bone Score Predicts Spine Fragility Fractures in Postmenopausal Caucasian Women Without Osteoporosis Independently of Bone Mineral Density

[1]Struttura Semplice Osteoporosi e Malattie Metaboliche dello Scheleletro, Bologna, Italy
[2]Struttura Semplice Dipartimentale Medicina e Reumatologia Istituto Ortopedico Rizzoli, Bologna, Italy

Claudio Ripamonti[1,2], Lucia Lisi[2], Angela Buffa[3] Saverio Gnudi[4], Renata Caudarella[5]

ABSTRACT

699 post menopausal women had spine BMD and TBS measured by DEXA

253 had osteoporosis
446 not osteoporotic

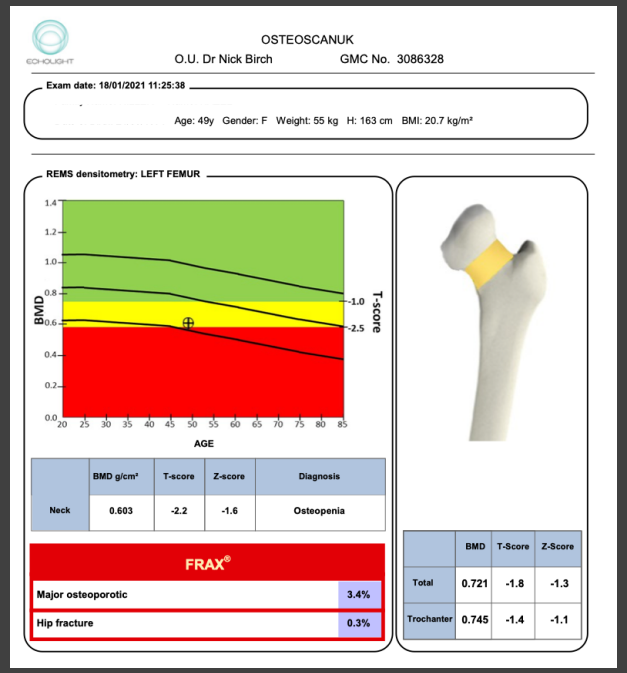
62 sustained spine fragility fractures

BMD and TBS were almost equally good at predicting fragility fractures across the entire cohort

TBS but not BMD predicted fractures in the non-osteoporotic group

Take home message: DEXA derived BMD is only predictive of fractures if the T score is < -2.5 Otherwise the TBS is required to understand the propensity to fracture

REMS Output



OSTEOSCANUK
O.U. Dr Nick Birch GMC No. 3086328

Exam date: 18/01/2021 11:25:38

Age: 49y Gender: F Weight: 55 kg H: 163 cm BMI: 20.7 kg/m²

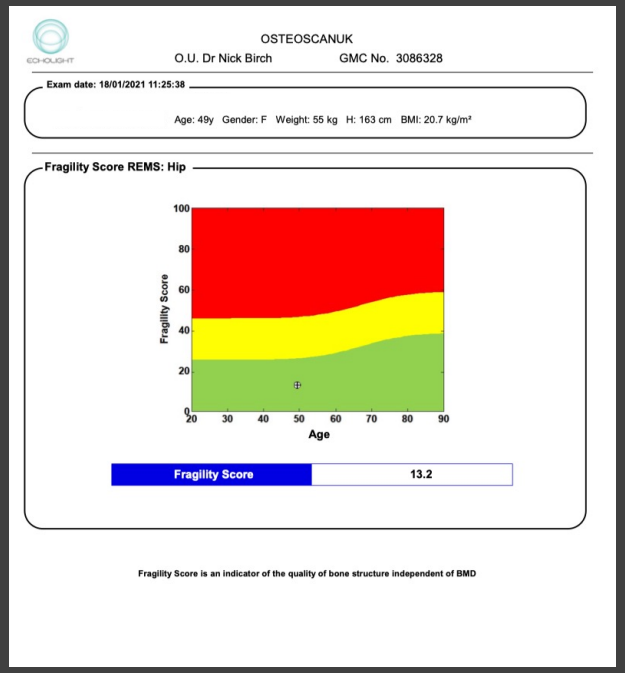
REMS densitometry: LEFT FEMUR

	BMD g/cm²	T-score	Z-score	Diagnosis
Neck	0.603	-2.2	-1.6	Osteopenia

	BMD	T-Score	Z-Score
Total	0.721	-1.8	-1.3
Trochanter	0.745	-1.4	-1.1

FRAX®

Major osteoporotic	3.4%
Hip fracture	0.3%



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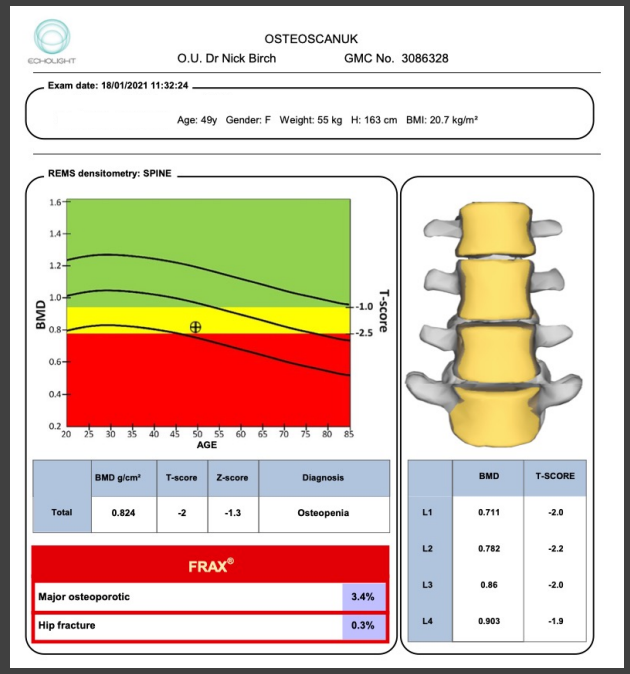
Fragility Score REMS: Hip

Fragility Score	13.2

Fragility Score is an indicator of the quality of bone structure independent of BMD



OSTEOSCANUK
O.U. Dr Nick Birch GMC No. 3086328

Exam date: 18/01/2021 11:32:24

Age: 49y Gender: F Weight: 55 kg H: 163 cm BMI: 20.7 kg/m²

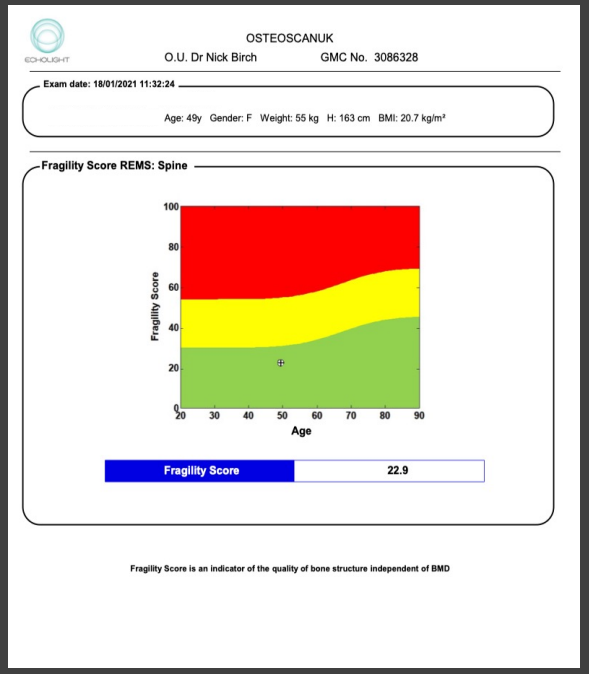
REMS densitometry: SPINE

	BMD g/cm²	T-score	Z-score	Diagnosis
Total	0.824	-2	-1.3	Osteopenia

	BMD	T-SCORE
L1	0.711	-2.0
L2	0.782	-2.2
L3	0.86	-2.0
L4	0.903	-1.9

FRAX®

Major osteoporotic	3.4%
Hip fracture	0.3%



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Exam date: 18/01/2021 11:32:24

Age: 49y Gender: F Weight: 55 kg H: 163 cm BMI: 20.7 kg/m²

Fragility Score REMS: Spine

Fragility Score	22.9

Fragility Score is an indicator of the quality of bone structure independent of BMD

BMI T-SCORE Z-SCORE BMD (g/cm²) FRAX® (> 40 years) FRAGILITY SCORE

Aging Clinical and Experimental Research
https://doi.org/10.1007/s40520-019-01294-4

REVIEW

Radiofrequency echographic multi-spectrometry for the in-vivo assessment of bone strength: state of the art—outcomes of an expert consensus meeting organized by the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO)

Adolfo Diez-Perez[1] · Maria Luisa Brandi[2,3] · Nasser Al-Daghri[4] · Jaime C. Branco[5] · Olivier Bruyère[6] · Loredana Cavalli[2,3] · Cyrus Cooper[7] · Bernard Cortet[8] · Bess Dawson-Hughes[9] · Hans Peter Dimai[10] · Stefano Gonnelli[11] · Peyman Hadji[12] · Philippe Halbout[13] · Jean-Marc Kaufman[14] · Andreas Kurth[15,16] · Medea Locquet[17] · Stefania Maggi[18] · Radmila Matijevic[19,20] · Jean-Yves Reginster[4,6] · René Rizzoli[21] · Thomas Thierry[22,23]

Received: 17 June 2019 / Accepted: 24 July 2019

REMS represents the first clinically available method for direct non-ionizing measurement of lumbar and femoral BMD

REMS-estimated BMD is an accurate diagnostic parameter, predicting incident clinical fracture risk in a representative sample of female subjects

REMS has shown a further potential in the assessment of skeletal fragility based on bone structure quality through the Fragility Score parameter, which is independent from the densitometric evaluation

Take home message: REMS is equivalent to DEXA for BMD and TBS assessment

T-Score Discordance

Concordance (/kənˈkɔːd(ə)ns/)
Noun agreement or consistency.

"the concordance between the teams' research results"

Discordance (/dɪˈskɔːd(ə)ns)/
Noun lack of agreement or consistency.

"the discordance between sales and forecasts should be a focus"

Osteoporosis (WHO definition)

A *systemic* condition characterised by low bone mineral density (BMD) in the osteoporosis range measured by bone densitometry (T score < -2.5)

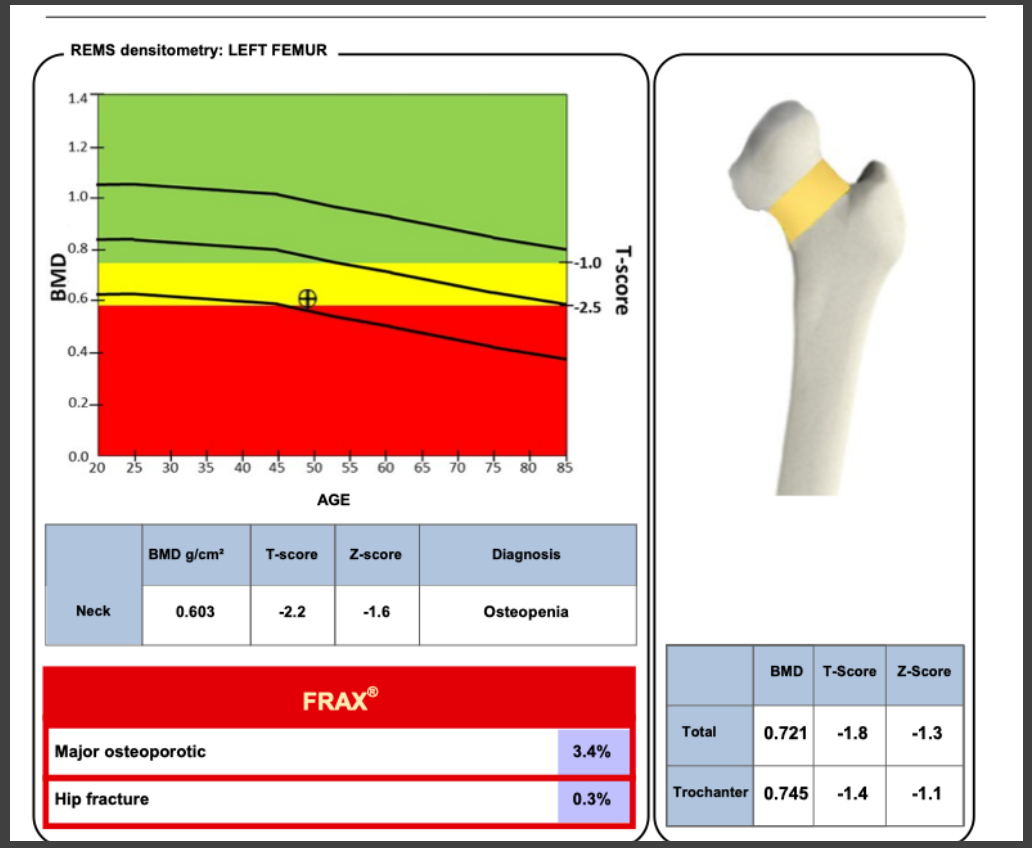
In premenopausal women BMD at the hip and spine should be of the same order of magnitude

In postmenopausal women there can be more variation

There may be a specific reason for a large difference (e.g. paralysis)

Levels of Discordance

Hip	Spine	Level of Discordance
Normal	Normal	None
Normal	Osteopenia	Minor
Normal	Osteoporosis	Major
Osteopenia	Normal	Minor
Osteopenia	Osteopenia	None
Osteopenia	Osteoporosis	Minor
Osteoporosis	Normal	Major
Osteoporosis	Osteopenia	Minor
Osteoporosis	Osteoporosis	None



If T-scores at the hip and in the spine put a woman's bone density into the same WHO diagnostic category, large differences between T-scores e.g. -2.5 at the hip and -4.7 in the spine need to be explained if there is no clear clinical reason why such a difference exists

DEXA Discordant Results

Patient Information:

Name:	[redacted]
Patient ID:	1160660
Identifier 2:	
Postal Code:	
Sex:	Female
Ethnicity:	White
Height:	165.6 cm
Weight:	67.4 kg
DOB:	10.07.1961
Age:	57
Menopause Age:	
Referring Physician:	[redacted]

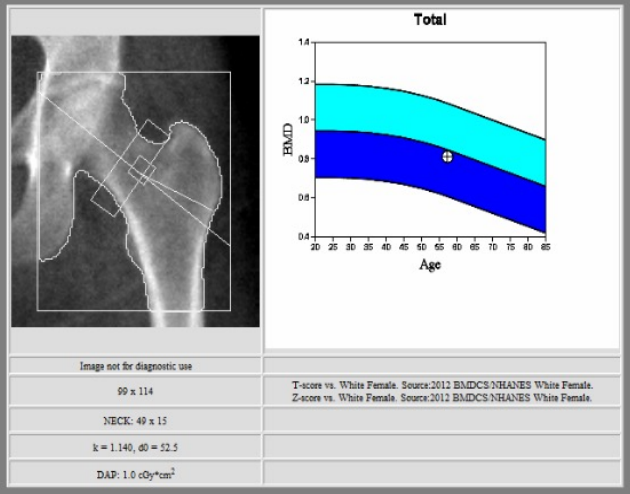


Image not for diagnostic use	
99 x 114	T-score vs. White Female. Source:2012 BMDCS/NHANES White Female. Z-score vs. White Female. Source:2012 BMDCS/NHANES White Female.
NECK: 49 x 15	
k = 1.140, d0 = 52.5	
DAP: 1.0 cGy*cm²	

Scan Information:

Scan Date:	16 November 2018 - A11161811
Scan Type:	x Left Hip
Analysis Date:	16.11.2018 15:26
Analysis Protocol:	Hip
Report Date:	16.11.2018 15:31
Institution:	[redacted]
Operator:	GH
Model:	Horizon W (S/N300212M)
Comment:	
Software version:	13.6.0.5

Results Summary:

Region	Area[cm²]	BMC[(g)]	BMD[g/cm²]	T-score	PR (Peak Reference)	Z-score	AM (Age Matched)
Neck	4.88	3.09	0.634	-1.9	75	-0.8	88
Total	**36.73**	**29.73**	**0.809**	**-1.1**	**86**	**-0.3**	**96**

Total BMD CV 1.0%, ACF = 1.038, BCF = 0.999, TH = 6.301

FRAX® WHO Fracture Risk Assessment Tool

10-year Fracture Risk[1]	
Major Osteoporotic Fracture	12%
Hip Fracture	2.1%
Reported Risk Factors: UK, Neck BMD=0.634, BMI=24.6, previous fracture	

[1] FRAX® Version 3.08. Fracture probability calculated for an untreated patient. Fracture probability may be lower if the patient has received treatment.

Comment:

All treatment decisions require clinical judgment and consideration of individual patient factors, including patient preferences, comorbidities, previous drug use and risk factors not captured in the FRAX model (e.g. frailty, falls, vitamin D deficiency, increased bone turnover, interval significant decline in BMD).

Patient Information:

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Patient ID:	1160660
Identifier 2:	
Postal Code:	
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Ethnicity:	White
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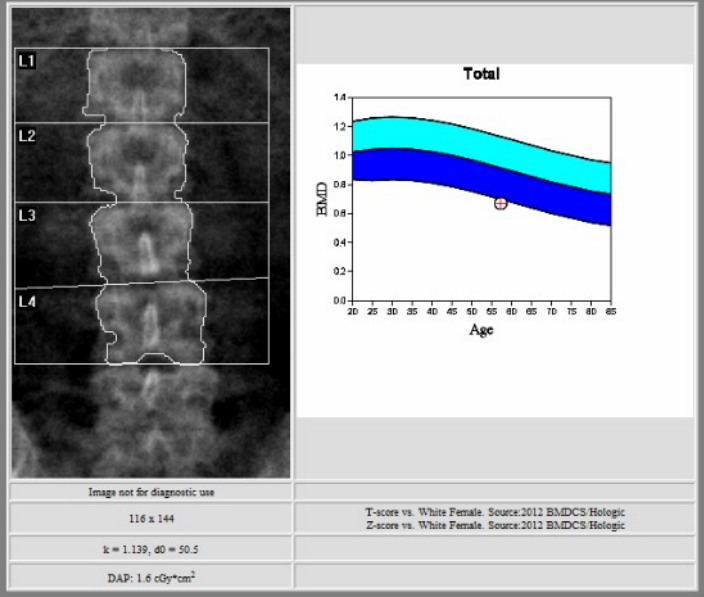

Image not for diagnostic use	
116 x 144	T-score vs. White Female. Source:2012 BMDCS/Hologic Z-score vs. White Female. Source:2012 BMDCS/Hologic
k = 1.139, d0 = 50.5	
DAP: 1.6 cGy*cm²	

Scan Information:

Scan Date:	16 November 2018 - A11161810
Scan Type:	x Lumbar Spine
Analysis Date:	16.11.2018 15:23
Analysis Protocol:	Spine
Report Date:	16.11.2018 15:31
Institution:	[redacted]
Operator:	GH
Model:	Horizon W (S/N300212M)
Comment:	
Software version:	13.6.0.5

Results Summary:

Region	Area[cm²]	BMC[(g)]	BMD[g/cm²]	T-score	PR (Peak Reference)	Z-score	AM (Age Matched)
L1	14.60	9.90	0.678	-2.8	68	-1.8	78
L2	14.70	9.88	0.672	-3.2	65	-2.0	75
L3	15.64	10.65	0.681	-3.7	63	-2.4	72
L4	16.35	10.55	0.645	-3.8	61	-2.5	70
Total	**61.29**	**40.97**	**0.669**	**-3.4**	**64**	**-2.2**	**73**

Total BMD CV 1.0%, ACF = 1.038, BCF = 0.999, TH = 6.739

Comment:

HOLOGIC®

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Total BMD CV 1.0%, ACF = 1.038, BCF = 0.999, TH = 6.739

Minor discordance according to WHO diagnostic category but significant discordance according to T score difference

Causes of Discordance

Physiological	The skeleton's adaptive reaction to mechanical strain (not test related)
Pathophysiological	A disease state affecting the skeleton (not test related)
Anatomical	Differences between sites in content of cortical and trabecular bone and/or rate of bone loss (e.g. spinal degeneration)
Artefactual	The presence of man-made items within the region of interest of the test (spinal implants)
Technical	Faulty device hardware or software or the technologist's method of acquiring or analysing the test (machine failure, post-processing errors) *Prevalence and type of errors in dual energy x-ray absorptiometry (DEXA)* *European Radiology; May 2015, Volume 25, Issue 5, pp 1504–1511* *Messina et al.* *2476 patients having DEXA; More than 90 % of DXA presented at least one error, mainly of data analysis; International Society for Clinical Densitometry guidelines are very poorly followed*

Rates of Discordance with DEXA

Author	Year	Patient numbers	Minor	Major
El Maghraoui	2007	3015	41.5%	4.3%
Woodson	2000	5627	44%	5%
Moayyeri	2006	4188	38.9%	2.7%
Mounach	2009	3479	42%	4%
Derakshan	2012	3039	40.0%	1.8%
Younes	2014	1780	45.7%	4.8%
Ayaz	2017	944	42.4%	2.5%
		Mean	42.1%	3.6%

Rates of Discordance with REMS OsteoscanUK 2018 – 2021 data

	Female	Male	All
Patients	523	86	609
Total Minor Discordance (WHO diagnostic category)	64 (12.1%)	2 (2.3%)	66 (10.8%)
Total Major Discordance (WHO diagnostic category)	0	0	0
Femur Osteopenia / Spine OP	18 (3.4%)	0	18 (3.0%)
Femur OP / Spine Osteopenia	19 (3.6%)	0	19 (3.1%)
Femur normal / Spine Osteopenia	19 (3.6%)	0	19 (3.1%)
Femur Osteopenia / Spine Normal	8 (1.5%)	2 (2.3%)	10 (1.6%)

	DEXA	REMS
Major	3.6%	0%
Minor	42.1%	10.8%
Total	45.7%	10.8%

Recommendation

If a woman has a DEXA scan showing a major discordance, or a T-score discrepancy between hip and spine of more than 1.5 and she has no obvious reasons for such a result, she should query the DEXA result

If a reasonable answer is not forthcoming, asking for a second opinion with a bone density scan performed either on a different DEXA machine or with alternative technology e.g. REMS, is entirely reasonable and appropriate

Therapeutics:

Reversing Bone Loss, Curing Osteoporosis

Therapeutic Options for Treating Osteoporosis

Antiresorptive agents:

Bisphosphonates (Alendronate, Zoledronate, Pamidronate, Ibandronate)
RANK Ligand antibody (Denosumab)
Strontium Ranelate
Calcitonin
Oestrogen
Raloxifene (post-menopausal oestrogen mimic)

Anabolic agents:

Parathyroid hormone analogues (Teriparatide, Abaloparatide)
Sclerostin inhibitors (Romosozumab)

Antiresorptive therapy reduces bone turnover rate and ratio of resorption to formation, leading to:

Increased BMD and mean mineralization density

Preserved microarchitecture (connectivity, trabecular number and thickness, cortical porosity) at best but antiresorptive agents do not restore microstructural deterioration existing at the time of starting treatment

These effects lead to increased bone strength and quality compared to age matched controls not on treatment and as a result decreased fracture risk

But….unknown or uncertain roles of antiresorptive therapy on microcracks and overall bone geometry

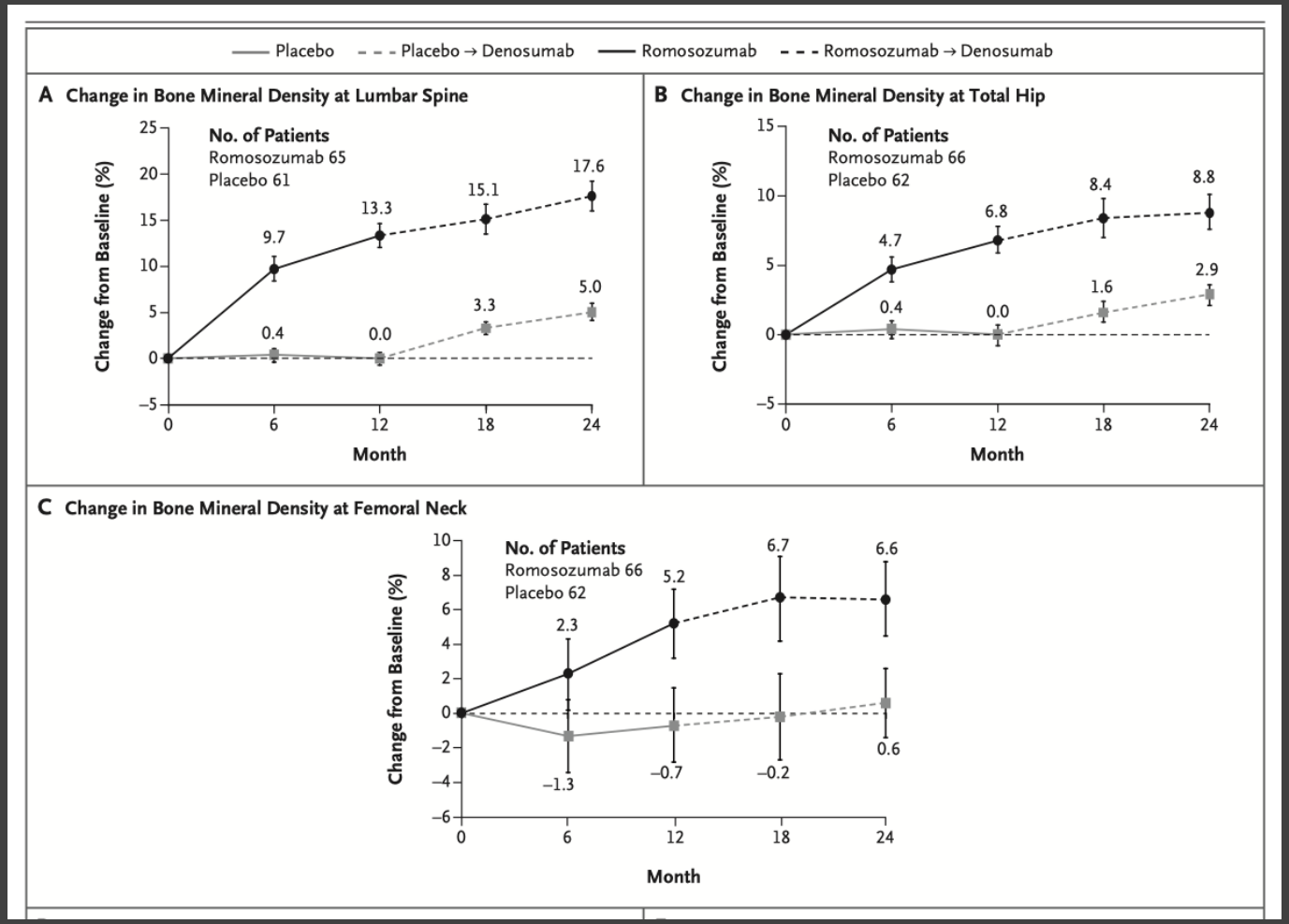
Sclerostin

Sclerostin: a protein produced almost exclusively from osteocytes inhibiting bone formation by both osteoblasts and osteocytes

Romosozumab, a monoclonal antibody that binds sclerostin, increases bone formation and decreases bone resorption

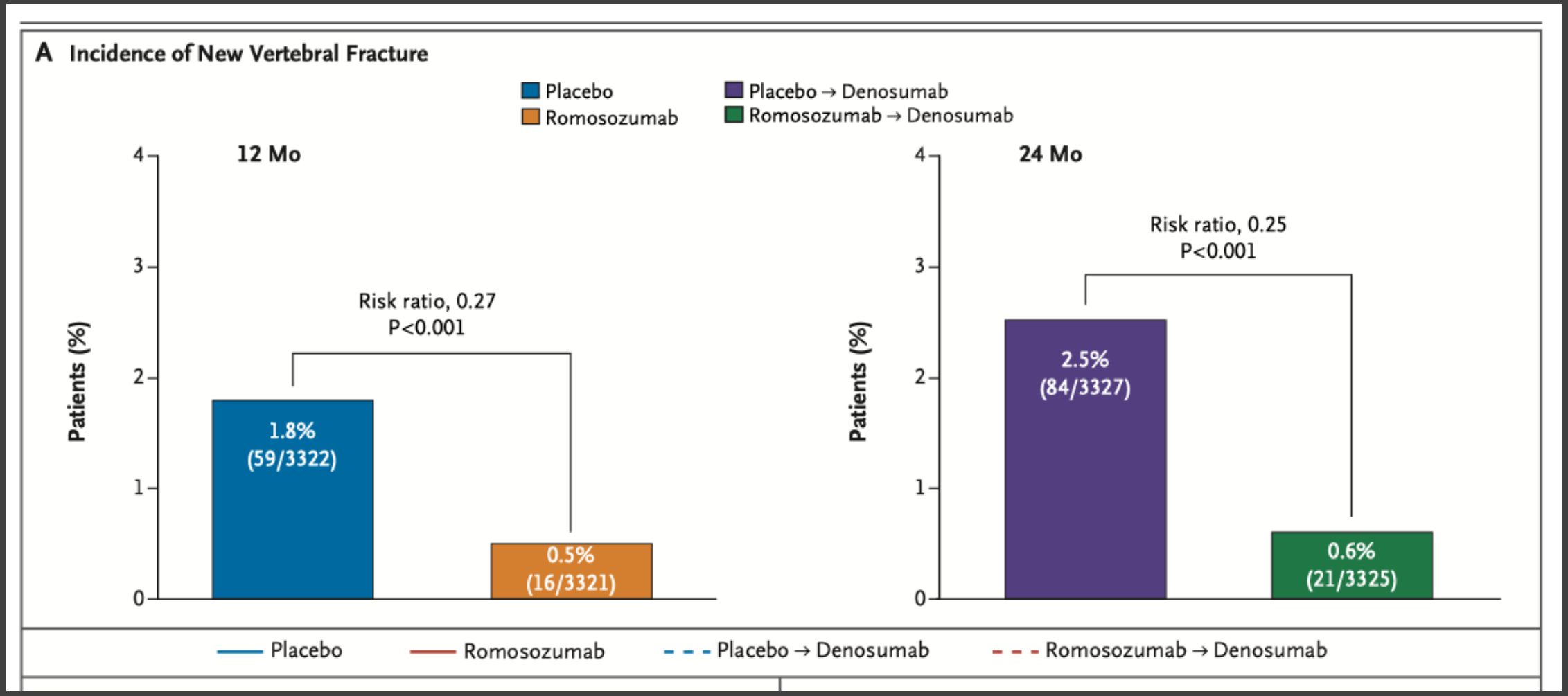
One year of romosozumab treatment in postmenopausal women with osteoporosis resulted in a lower risk of vertebral and clinical fractures than the risk with placebo

Substantial gains in bone mineral density at the spine and hip with romosozumab provided a foundation for an ongoing reduction in the risk of fracture during sequential treatment with denosumab.



Romosozumab Treatment in Postmenopausal Women with Osteoporosis

Cosman et al. N Engl J Med 2016;375:1532-43.


A Incidence of New Vertebral Fracture
Placebo
Romosozumab
Placebo → Denosumab
Romosozumab → Denosumab
12 Mo
24 Mo
Patients (%)
Risk ratio, 0.27
P<0.001
1.8%
(59/3322)
0.5%
(16/3321)
Risk ratio, 0.25
P<0.001
2.5%
(84/3327)
0.6%
(21/3325)
0
1
2
3
4
Placebo
Romosozumab
Placebo → Denosumab
Romosozumab → Denosumab

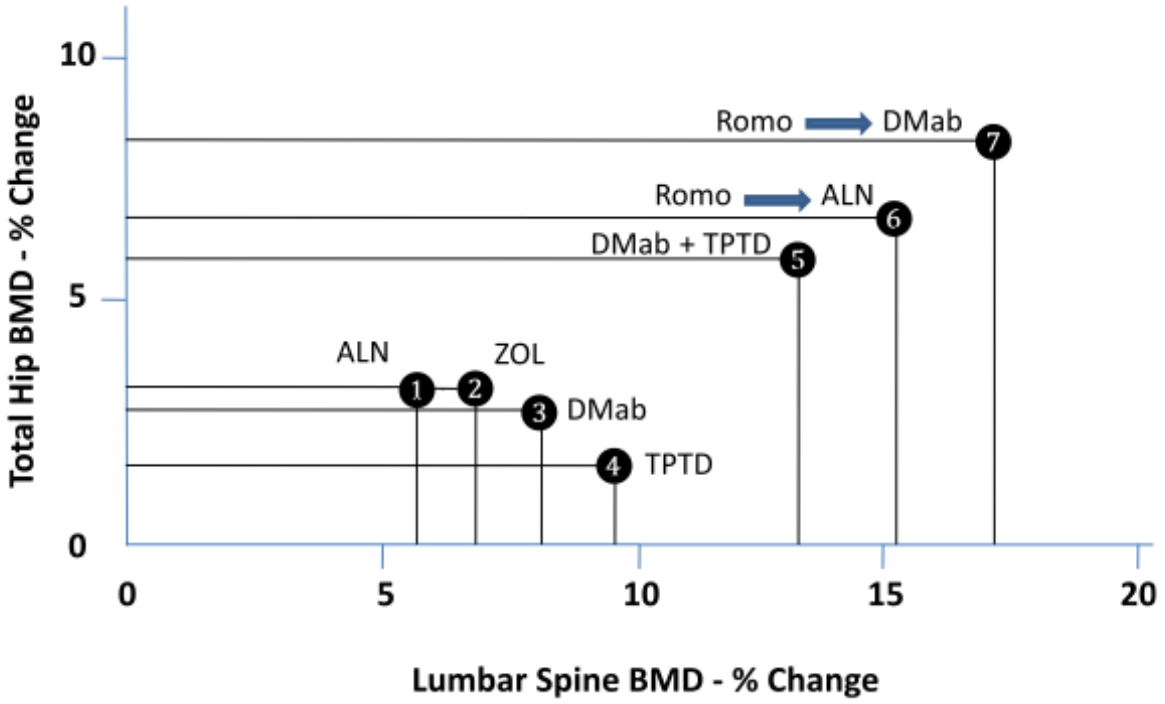
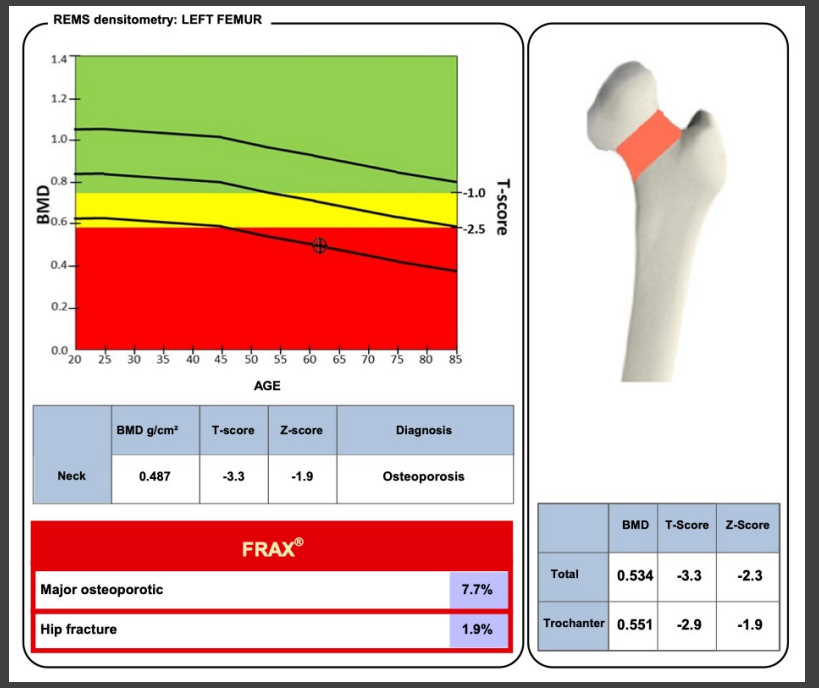
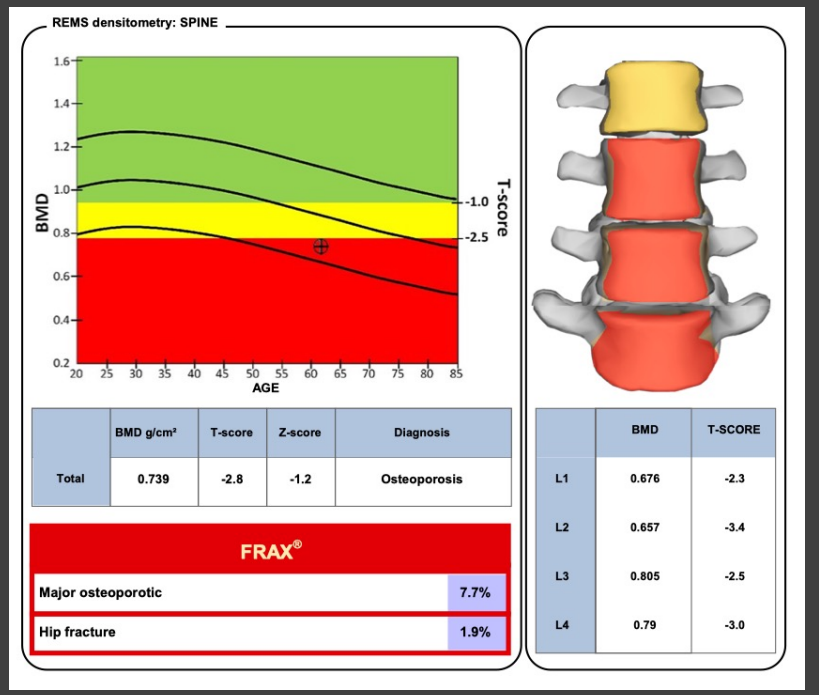


Fig. 1. Percent changes from baseline at 24 months (M) in bone mineral density (BMD) of the lumbar spine and total hip in postmenopausal women with osteoporosis with various treatment regimens. *1*, alendronate (ALN) [16]; *2*, zoledronic acid (ZOL) [24]; *3*, denosumab (DMab) [25]; *4*, teriparatide (TPTD) [25]; *5*, denosumab plus teriparatide [25]; 6, romosozumab 12 M and alendronate 12 M [16]; *7*, romosozumab 12 M and denosumab 12 M [15].





62-year-old post-menopausal woman
BMI 19 kg/m^2
No additional clinical risk factors
Osteoporosis hip and spine

	T score after treatment	
Rx	**Hip**	**Spine**
ALN	-3.2	-2.6
ZOL	-3.2	-2.6
DMab	-3.2	-2.6
TPTD	-3.2	-2.5
Dmab + TPTD	-3.1	-2.4
Romo + ALN	-3.1	-2.4
Romo + DMab	-3.0	-2.3

Dietetics:

Meat-free diet and Bone Health

High Content Calcium Foods (and supplements)

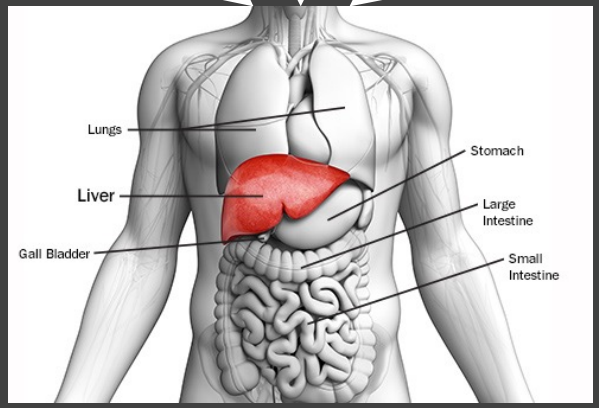
Dairy products

Supplements

Sunlight creates inactive Vit D through tanning

Diet especially oily fish

Supplements



Vitamin D activated in the liver

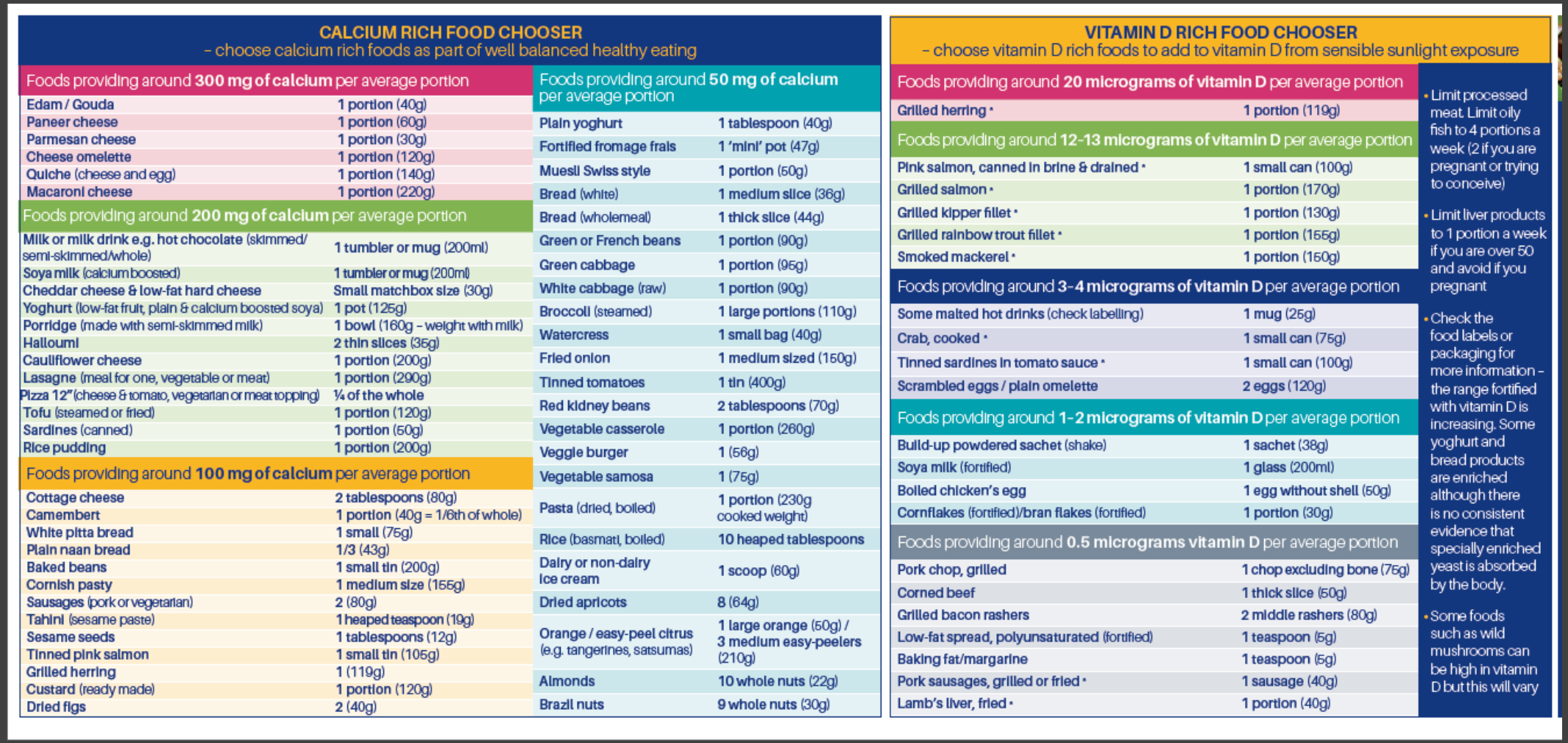
Calcium and Vitamin D calculator

Breakfast:
Yoghurt
Fruit / muesli
250 mg Ca^{2+}
< 1 µg D3

Lunch:
Sardines in pitta
300 mg Ca^{2+}
2 µg D3

Dinner:
Spaghetti bolognaise with parmesan cheese broccoli
400 mg Ca^{2+}
< 1 µg D3

= 950 mg Ca^{2+}
< 4 µg D3 (160 i.u.)



CALCIUM RICH FOOD CHOOSER
– choose calcium rich foods as part of well balanced healthy eating

Foods providing around **300 mg of calcium** per average portion	
Edam / Gouda	1 portion (40g)
Paneer cheese	1 portion (60g)
Parmesan cheese	1 portion (30g)
Cheese omelette	1 portion (120g)
Quiche (cheese and egg)	1 portion (140g)
Macaroni cheese	1 portion (220g)

Foods providing around **200 mg of calcium** per average portion	
Milk or milk drink e.g. hot chocolate (skimmed/ semi-skimmed/whole)	1 tumbler or mug (200ml)
Soya milk (calcium boosted)	1 tumbler or mug (200ml)
Cheddar cheese & low-fat hard cheese	Small matchbox size (30g)
Yoghurt (low-fat fruit, plain & calcium boosted soya)	1 pot (125g)
Porridge (made with semi-skimmed milk)	1 bowl (160g – weight with milk)
Halloumi	2 thin slices (35g)
Cauliflower cheese	1 portion (200g)
Lasagne (meal for one, vegetable or meat)	1 portion (290g)
Pizza 12" (cheese & tomato, vegetarian or meat topping)	¼ of the whole
Tofu (steamed or fried)	1 portion (120g)
Sardines (canned)	1 portion (50g)
Rice pudding	1 portion (200g)

Foods providing around **100 mg of calcium** per average portion	
Cottage cheese	2 tablespoons (80g)
Camembert	1 portion (40g = 1/6th of whole)
White pitta bread	1 small (75g)
Plain naan bread	1/3 (43g)
Baked beans	1 small tin (200g)
Cornish pasty	1 medium size (155g)
Sausages (pork or vegetarian)	2 (80g)
Tahini (sesame paste)	1 heaped teaspoon (19g)
Sesame seeds	1 tablespoons (12g)
Tinned pink salmon	1 small tin (105g)
Grilled herring	1 (119g)
Custard (ready made)	1 portion (120g)
Dried figs	2 (40g)

Foods providing around **50 mg of calcium** per average portion	
Plain yoghurt	1 tablespoon (40g)
Fortified fromage frais	1 'mini' pot (47g)
Muesli Swiss style	1 portion (50g)
Bread (white)	1 medium slice (36g)
Bread (wholemeal)	1 thick slice (44g)
Green or French beans	1 portion (90g)
Green cabbage	1 portion (95g)
White cabbage (raw)	1 portion (90g)
Broccoli (steamed)	1 large portions (110g)
Watercress	1 small bag (40g)
Fried onion	1 medium sized (150g)
Tinned tomatoes	1 tin (400g)
Red kidney beans	2 tablespoons (70g)
Vegetable casserole	1 portion (260g)
Veggie burger	1 (56g)
Vegetable samosa	1 (75g)
Pasta (dried, boiled)	1 portion (230g cooked weight)
Rice (basmati, boiled)	10 heaped tablespoons
Dairy or non-dairy ice cream	1 scoop (60g)
Dried apricots	8 (64g)
Orange / easy-peel citrus (e.g. tangerines, satsumas)	1 large orange (50g) / 3 medium easy-peelers (210g)
Almonds	10 whole nuts (22g)
Brazil nuts	9 whole nuts (30g)

VITAMIN D RICH FOOD CHOOSER
– choose vitamin D rich foods to add to vitamin D from sensible sunlight exposure

Foods providing around **20 micrograms of vitamin D** per average portion	
Grilled herring •	1 portion (119g)

Foods providing around **12–13 micrograms of vitamin D** per average portion	
Pink salmon, canned in brine & drained •	1 small can (100g)
Grilled salmon •	1 portion (170g)
Grilled kipper fillet •	1 portion (130g)
Grilled rainbow trout fillet •	1 portion (155g)
Smoked mackerel •	1 portion (150g)

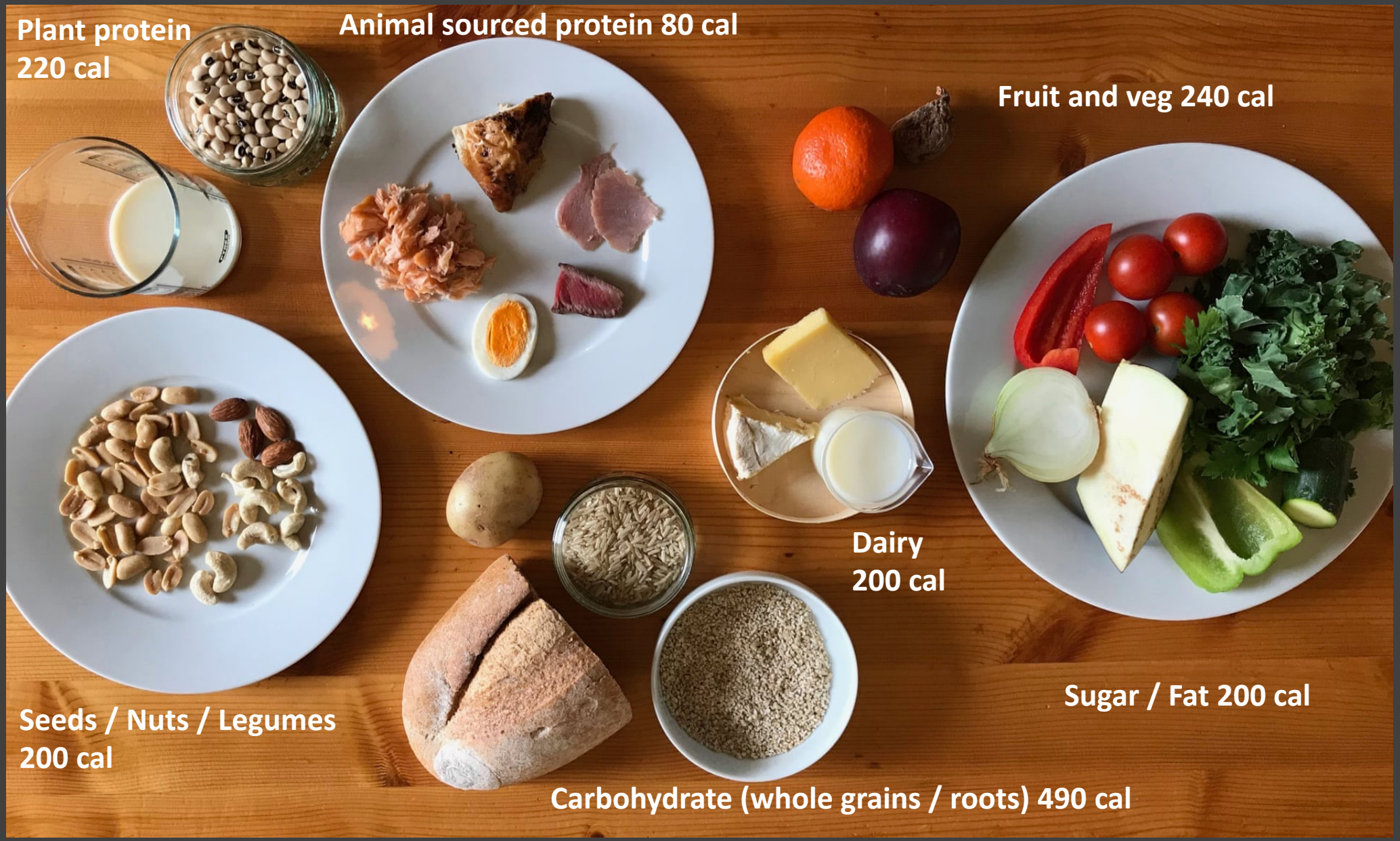
Foods providing around **3–4 micrograms of vitamin D** per average portion	
Some malted hot drinks (check labelling)	1 mug (25g)
Crab, cooked •	1 small can (75g)
Tinned sardines in tomato sauce •	1 small can (100g)
Scrambled eggs / plain omelette	2 eggs (120g)

Foods providing around **1–2 micrograms of vitamin D** per average portion	
Build-up powdered sachet (shake)	1 sachet (38g)
Soya milk (fortified)	1 glass (200ml)
Boiled chicken's egg	1 egg without shell (50g)
Cornflakes (fortified)/bran flakes (fortified)	1 portion (30g)

Foods providing around **0.5 micrograms vitamin D** per average portion	
Pork chop, grilled	1 chop excluding bone (75g)
Corned beef	1 thick slice (50g)
Grilled bacon rashers	2 middle rashers (80g)
Low-fat spread, polyunsaturated (fortified)	1 teaspoon (5g)
Baking fat/margarine	1 teaspoon (5g)
Pork sausages, grilled or fried •	1 sausage (40g)
Lamb's liver, fried •	1 portion (40g)

- Limit processed meat. Limit oily fish to 4 portions a week (2 if you are pregnant or trying to conceive)
- Limit liver products to 1 portion a week if you are over 50 and avoid if you pregnant
- Check the food labels or packaging for more information – the range fortified with vitamin D is increasing. Some yoghurt and bread products are enriched although there is no consistent evidence that specially enriched yeast is absorbed by the body.
- Some foods such as wild mushrooms can be high in vitamin D but this will vary

Flexitarian Diet



Total energy intake
1630 cal

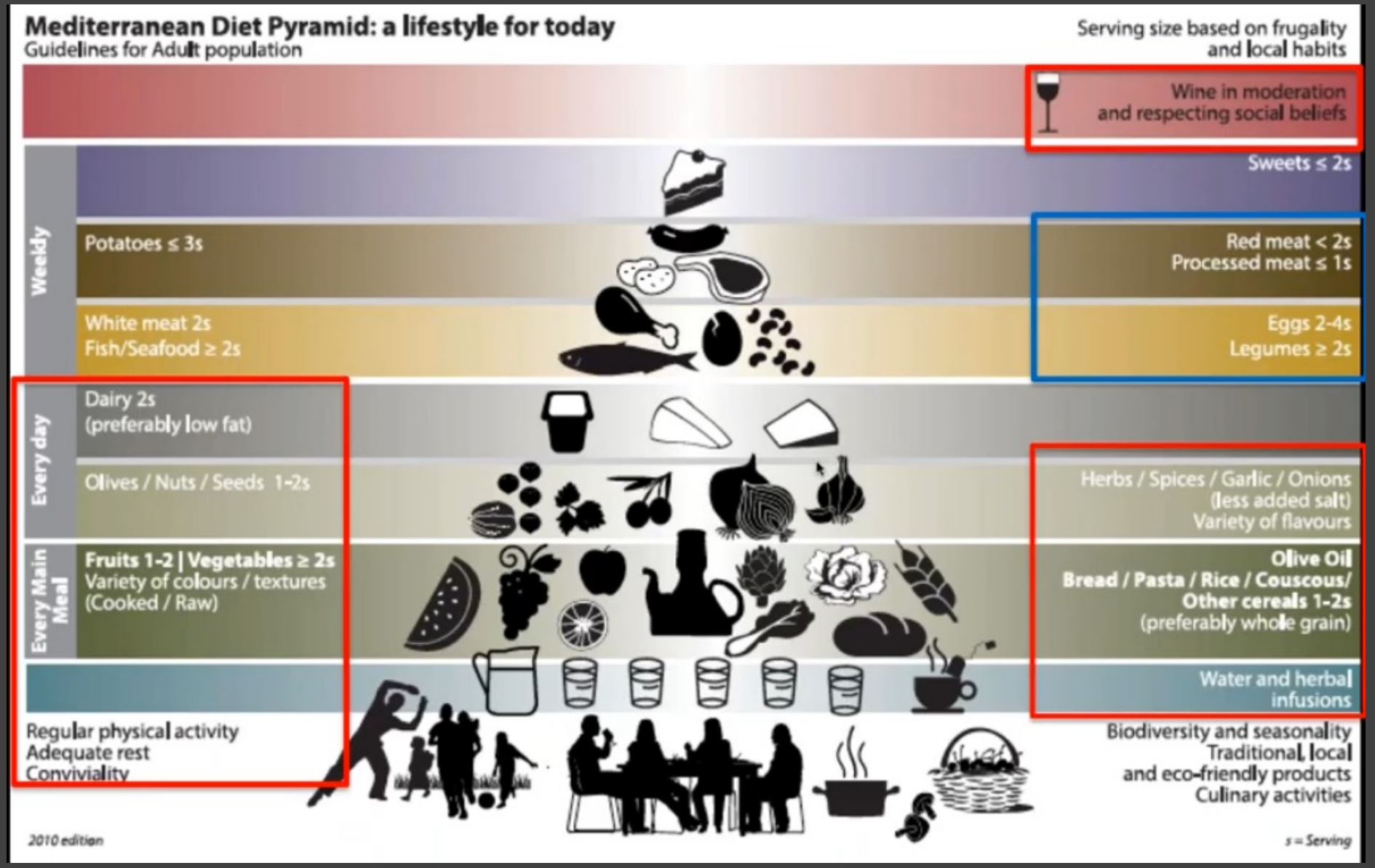
Total Ca^{2+}
800 mg

Total Vit D
< 2 µg (80 i.u)

Vegetarian Food Pyramid

Vegan Food Chart

Mediterranean Diet Pyramid



Veganism, vegetarianism, bone mineral density, and fracture risk: a systematic review and meta-analysis

Isabel Iguacel et al. ***Nutrition Reviews 2018; Vol. 77(1):1–18***

Vegetarian and vegan diets should be planned to avoid negative consequences on bone health

Differences in Bone Mineral Density between Adult Vegetarians and Non-vegetarians Become Marginal when Accounting for Differences in Anthropometric Factors

Nena Karavasiloglou et al. ***J Nutr 2020;00:1–6.***

Lower BMD among adult vegetarians is in larger parts explained by lower BMI and waist circumference

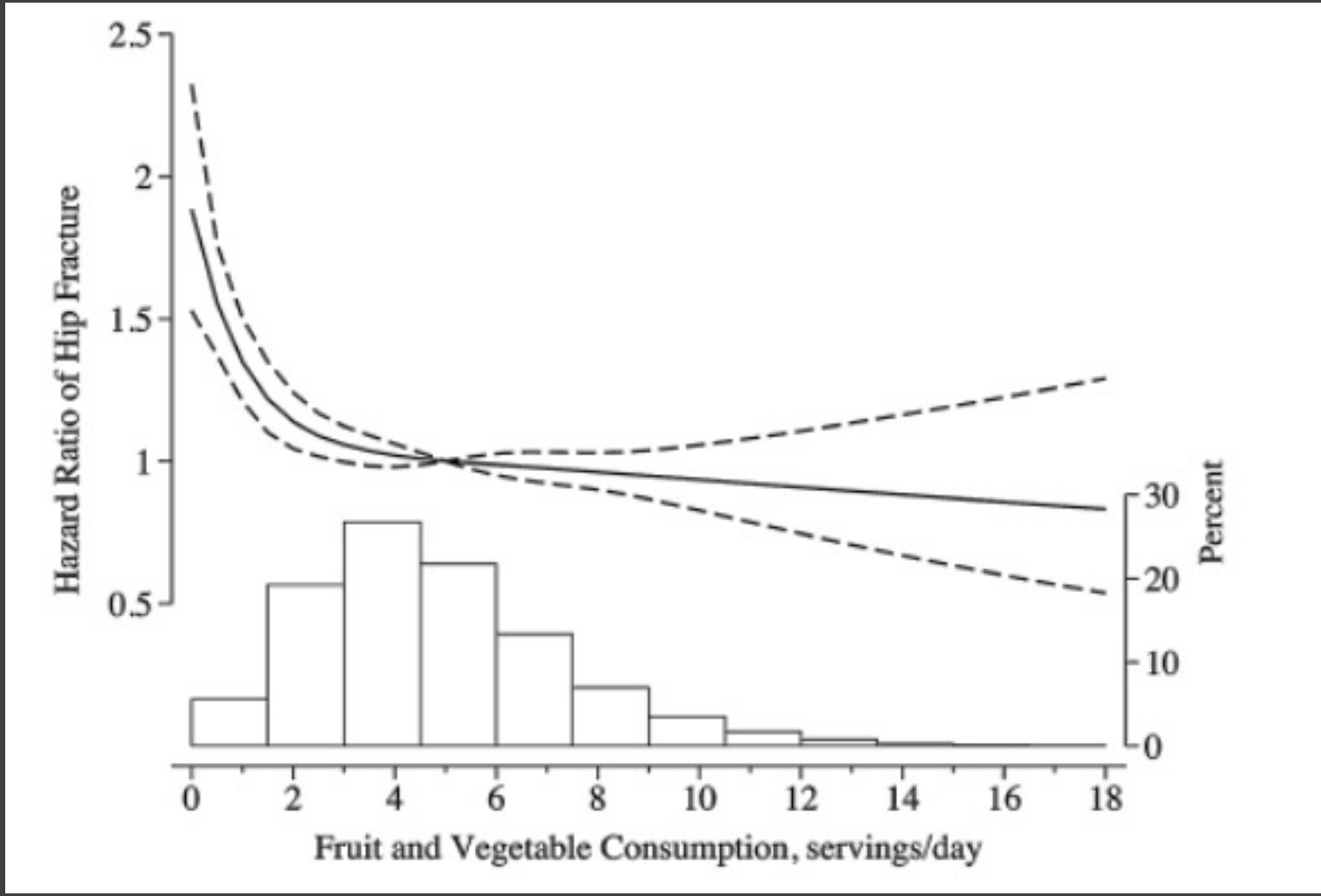
Vegetarian and vegan diets and risks of total and site-specific fractures: results from the prospective EPIC-Oxford study

Tammy Y. N. Tong et al. ***BMC Medicine (2020) 18:353***

Non-meat eaters, especially vegans, had higher risks of either all and some site-specific fractures, particularly hip fractures

Prospective study of dietary Non-Enzymatic Antioxidant Capacity on the risk of hip fracture in the elderly

Essi Hantikainen et al. *Bone 90 (2016) 31–36*



Take Home Messages

Diet is vital to bone health

Omnivores should consider moderation of animal protein intake and increase of plant-based foods to reduce secondary health risks

Vegetarians and vegans should analyse their dietary intake to ensure they have sufficient energy and nutrient intake to reach RDA

Everyone should engage in at least 30 min impact exercise daily to maintain bone density and toughness

Exercise:

Vibration Therapy and Bone Health

Year	First author	Study type:	Particpants	Number of participants / Arms	WBV schedule: Force Frequency Program	Study length	Change in bone health	
2004	**Rubin**	RCT	Postmenopausal women	70 / 2 WBV + Controls	0.2g / 30 Hz / 20 min daily	12 months	Relative improvement of hip BMD if highly compliant with treatment Relative Improvement of spine BMD especially in < 65 kg women	
2004	**Verscheueren**	RCT	Postmenopausal women	70 / 3 WBV + Exercise + Controls	2.3 g – 5.1 g / 35-40 Hz / 30 minutes x 3 / week	6 months	Hip BMD increased in WBV group; reduced in exercise and controls	
2011	**Slatkovska**	RCT	Postmenopausal women	202 / 2 WBV + Controls (Ca/Vit D supp)	0.3g / 30 Hz & 90 Hz / 20 minutes / day	12 months	No benefit	No benefit
2011	**Wysocki**	Narrative review	Postmenopausal women	Number of studies	Range of protocols	Variety	Concludes WBV has not been shown to provide benefit or reduce fracture risk	
2011	**Lau**	Systematic review and meta-analysis	Postmenopausal women	Number of studies	Range of protocols	Variety	Concludes WBV not shown to improve BMD in older women	

JOURNAL OF BONE AND MINERAL RESEARCH
Volume 19, Number 3, 2004
Published online on December 22, 2003; doi: 10.1359/JBMR.0301251

Prevention of Postmenopausal Bone Loss by a Low-Magnitude, High-Frequency Mechanical Stimuli: A Clinical Trial Assessing Compliance, Efficacy, and Safety

Clinton Rubin,[1] Robert Recker,[2] Diane Cullen,[2] John Ryaby,[3] Joan McCabe,[3] and Kenneth McLeod[4]

JOURNAL OF BONE AND MINERAL RESEARCH
Volume 19, Number 3, 2004
Published online on December 22, 2003; doi: 10.1359/JBMR.0301245

Effect of 6-Month Whole Body Vibration Training on Hip Density, Muscle Strength, and Postural Control in Postmenopausal Women: A Randomized Controlled Pilot Study

Sabine MP Verschueren,[1] Machteld Roelants,[2] Christophe Delecluse,[2] Stephan Swinnen,[1] Dirk Vanderschueren,[3] and Steven Boonen[4]

ORIGINAL RESEARCH | Annals of Internal Medicine

Effect of 12 Months of Whole-Body Vibration Therapy on Bone Density and Structure in Postmenopausal Women

A Randomized Trial

Lubomira Slatkovska, PhD; Shabbir M.H. Alibhai, MD, MSc; Joseph Beyene, PhD; Hanxian Hu, MPH; Alice Demaras, MSc; and Angela M. Cheung, MD, PhD

Ann Intern Med. 2011;155:668-679.

REVIEW | Annals of Internal Medicine

Whole-Body Vibration Therapy for Osteoporosis: State of the Science

Andrea Wysocki, MPP; Mary Butler, MBA, PhD; Tatyana Shamliyan, MD, MS; and Robert L. Kane, MD

Ann Intern Med. 2011;155:680-686.

Article

CLINICAL REHABILITATION

Clinical Rehabilitation
25(11) 975–988
! The Author(s) 2011
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DOI: 10.1177/0269215511405078
cre.sagepub.com

SAGE

The effects of whole body vibration therapy on bone mineral density and leg muscle strength in older adults: a systematic review and meta-analysis

Ricky WK Lau[1], Lin-Rong Liao[1,2], Felix Yu[1], Tilda Teo[1,3], Raymond CK Chung[1] and Marco YC Pang[1]

Effects of whole body vibration on bone mineral density in postmenopausal women: a systematic review and meta-analysis

Osteoporosis International

October 2016, Volume 27, Issue 10, pp 2913–2933 | Cite as

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- D. A. A. Pires-Oliveira (1)

Year	First author	Study type:	Particpants	Number of participants / Arms	WBV schedule: Force Frequency Program	Study length	Change in bone health
2013	**Stolzenberg**	RCT	Postmenopausal women	28 / 2 WBV v Exercise	3.9 g – 10.9 g / 22 – 26 Hz/ 4 minutes x 2 / week	9 months	Statistically significant improvement in trabecular and total bone density in the lower tibia and forearm in both groups
2013	**Lai**	RCT	Postmenopausal women	28 / 2 WBV v Controls	3.2g / 30 Hz / 5 minutes x 3 / week	6 months	The relative treatment benefit (increased spinal BMD) was 2.078% in favour of WBV (p=0.016)
2014	**Leung**	RCT	Postmenopausal women	710 / 2 WBV v Controls	0.3g / 35 Hz / 20 minutes x 5 / week	18 months	WBV yielded beneficial effects on fall and fracture rates with a trend towards improvement in the spinal BMD
2014	**Zaki**	RCT	Postmenopausal women	80 /2 WBV v Exercise	2.5 g / 16 Hz/ 20 minutes x 3 / week	8 months	WBV and resistance training associated with higher BMD and lower BMI in obese postmenopausal women
2015	**Liphardt**	RCT	Women with osteopenia	42 / 2 WBV v Controls	6.0 g / 20 Hz / 10 minutes x 11 sessions / month	12 months	No difference BMD or bone architecture tibia between groups; no difference BMD spine and hip
2016	**Oliveira**	Systematic review and meta-analysis	This systematic review and meta-analysis of randomized controlled trials (RCTs) identified significant effects of WBV on BMD of the lumbar spine, femoral neck, and trochanter in postmenopausal women				

J Musculoskelet Neuronal Interact 2013; 13(1):66-76

Original Article

Hylonome

Bone strength and density via pQCT in post-menopausal osteopenic women after 9 months resistive exercise with whole body vibration or proprioceptive exercise

N. Stolzenberg[1], D.L. Belavý[1], G. Beller[1], G. Armbrecht[1], J. Semler[2], D. Felsenberg[1]

[1]Centre for Muscle and Bone Research, Charité Universitätsmedizin Berlin, Hindenburgdamm 30, 12203 Berlin, Germany;
[2]Centre for Osteology and Metabolic Diseases, Immanuel Krankenhaus, Königstrasse 63, 14109 Berlin, Germany

Hindawi Publishing Corporation
Journal of Osteoporosis
Volume 2014, Article ID 702589, 6 pages
http://dx.doi.org/10.1155/2014/702589

Hindawi

Research Article

Effects of Whole Body Vibration and Resistance Training on Bone Mineral Density and Anthropometry in Obese Postmenopausal Women

Moushira Erfan Zaki

Medical Research Division, Biological Anthropology Department, National Research Centre, El-Buhouth Street, Dokki, Giza, Egypt

Clinical Interventions in Aging

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Effect of 6 months of whole body vibration on lumbar spine bone density in postmenopausal women: a randomized controlled trial

Clinical Interventions in Aging 2013:8 1603–1609

Osteoporos Int
DOI 10.1007/s00198-014-2995-8

ORIGINAL ARTICLE

Bone quality in osteopenic postmenopausal women is not improved after 12 months of whole-body vibration training

A. M. Liphardt · J. Schipilow · D. A. Hanley · S. K. Boyd

Original Article | Published: 28 March 2014

Effects of 18-month low-magnitude high-frequency vibration on fall rate and fracture risks in 710 community elderly—a cluster-randomized controlled trial

K. S. Leung, C. Y. Li, Y. K. Tse, T. K. Choy, P. C. Leung, V. W. Y. Hung, S. Y. Chan, A. H. C. Leung & W. H. Cheung ✉

Osteoporosis International **25**, 1785–1795(2014) | Cite this article

Summary of the Evidence

Up to 2011 limited evidence that WBV had a positive effect on BMD with equal number of studies suggesting no effect

From 2011 to 2016 increasing evidence for positive effect of WBV at least on spine BMD and also falls prevention with a lesser effect on femoral BMD

Higher magnitude WBV at high frequency appears better than low magnitude high frequency WBV

The “dose” of WBV appears to have an effect on outcomes

No studies have reported adverse effects of WBV

Q & A