Optimising Bone Health in Sportswomen and men – Point of Care Bone Health Assessment of Athletes Using EchoS from Echolight

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Bone Health Assessment: The Options

Impaired Bone Health and Fracture Risk

Female Athletes: Risk Factors for Impaired Bone Health

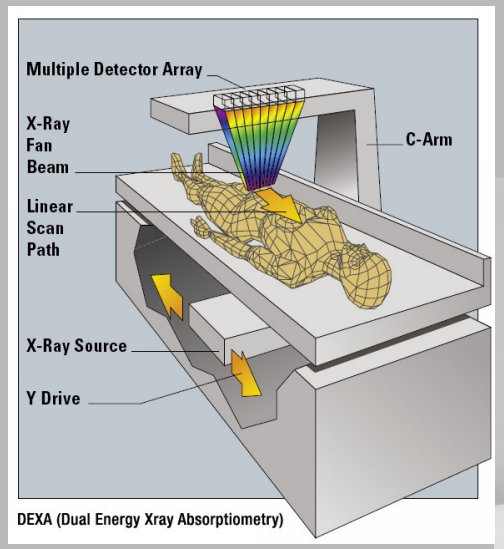
Male Athletes: Bone Stress Injuries - the Influence of Bone Health and Impact

EchoS Point of Care REMS Assessment: Helping to Manage Sportspeople’s Bone Health

Bone Health Assessment: Options

Measurement Technology

Modality	BMD (bone mineral density)	Bone toughness (TBS / FS)	Bone stiffness
DEXA (dual energy x-ray absorptiometry)	+	+/-	-
REMS (radiofrequency echographic multispectrometry)	+	+	-
QpCT (quantitative peripheral computerized axial tomography)	+	-	-
QUS (quantitative ultrasound)	+/-	-	+

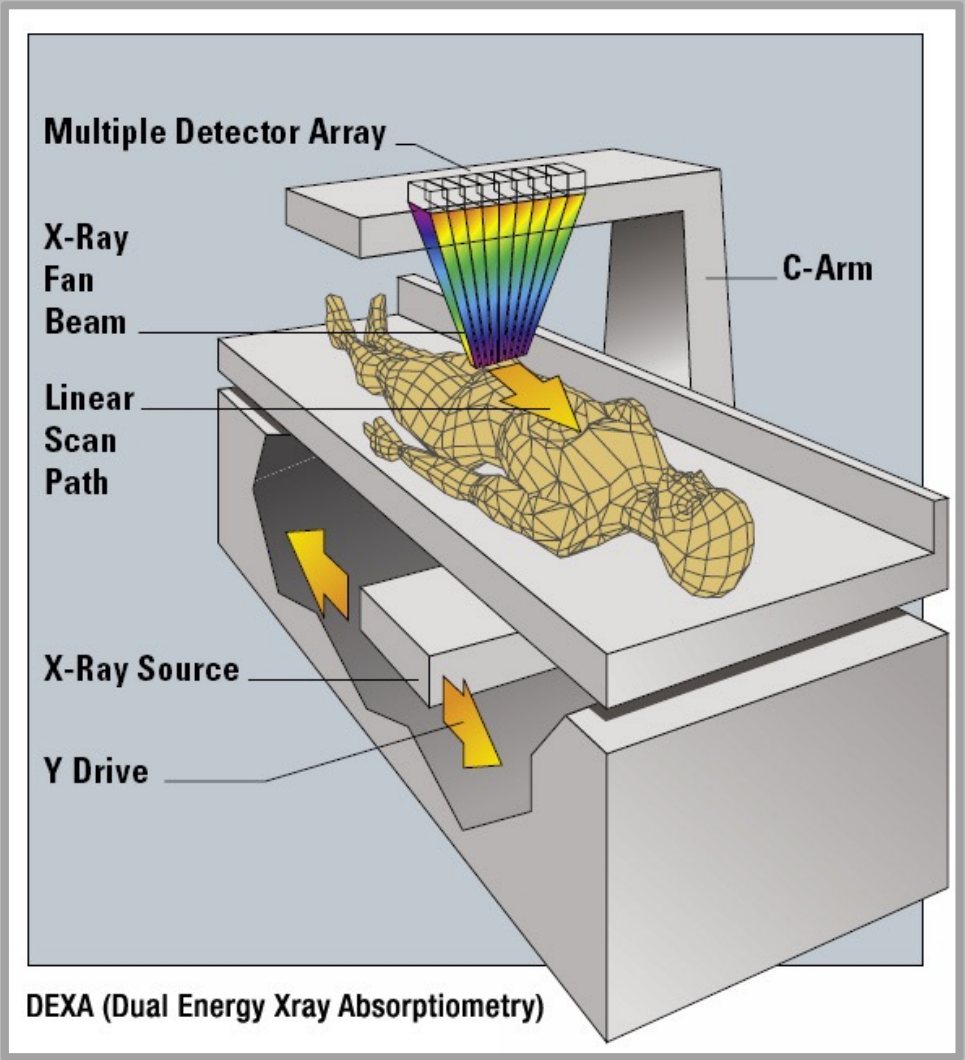


DEXA (Dual Energy Xray Absorptiometry)

Prevention strategies: Early Assessment of Bone Health

Modality	Non-ionising	Portable	High sensitivity / specificity	Reproducible
DEXA	-	-	+	+
REMS	+	+	+	+
QpCT	-	-	+	+
QUS	+	+	-	+

DEXA: Dual Energy X-ray Absorptiometry



DEXA (Dual Energy Xray Absorptiometry)

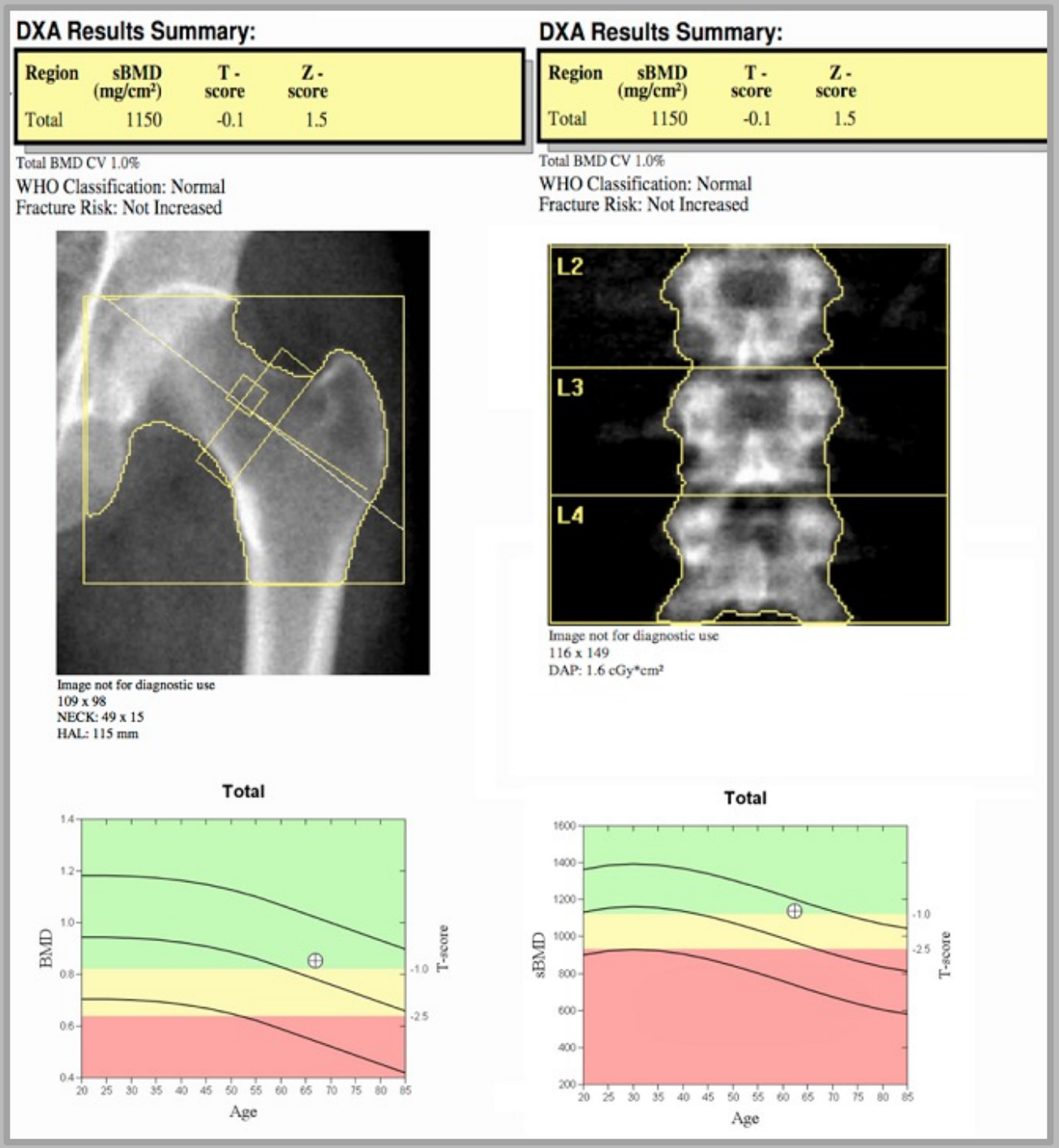
DEXA Output:
The Gold Standard

T-SCORE
Z-SCORE
BMD (g/cm²)
Trabecular bone score*

Correct placement of Regions Of Interest (ROI) boxes

Exclusion of areas of abnormal bone density

If software installed on machine



Strengths and Weaknesses of DEXA

Strengths

Simple, fast, low dose x-ray

Fast data collection

Most standardised BMD measurement method

Precision across a platform

Body composition assessment

Weaknesses

Fixed site

Operator dependent – position on scanner

Limited value when spinal deformity present or previous spinal surgery

Post-processing variability

Variation of machine sensitivity (Lunar v Hologic v Norland)

BMD alone cannot predict fracture risk

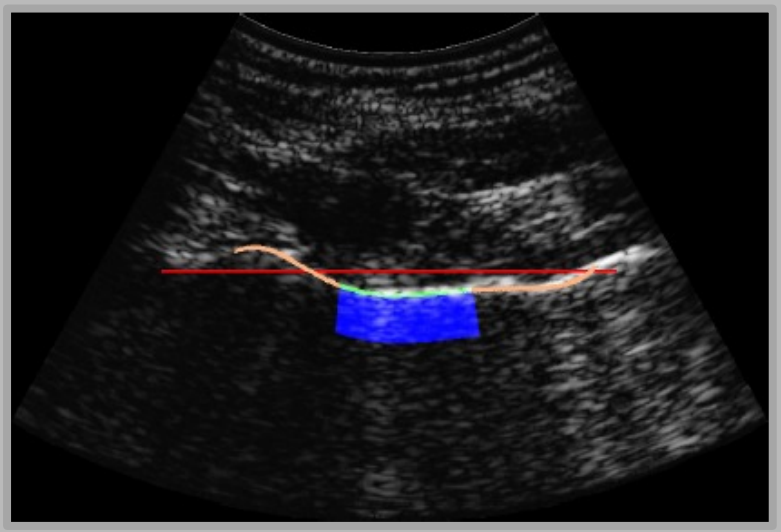
Reproducibility across time too low (5-6%) to accurately monitor treatment in < 3 - 4 years

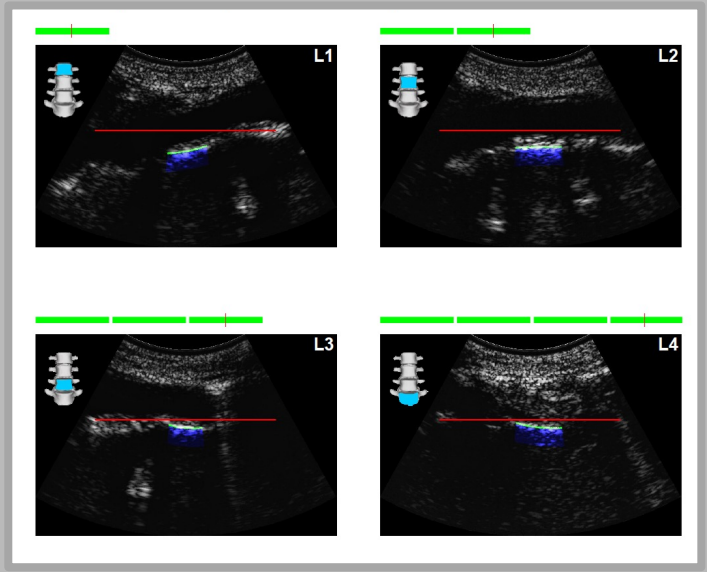
BMD measured on different machines non-comparable

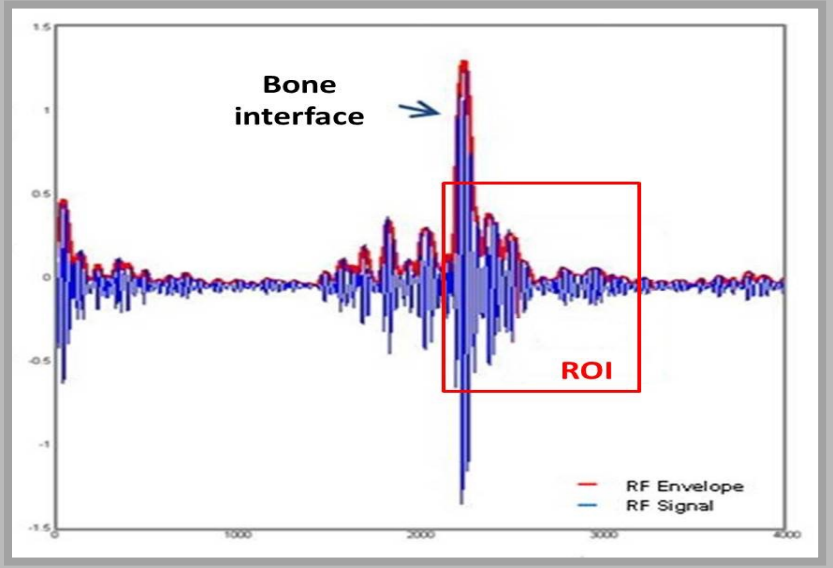
EchoS REMS Scan
(Radiofrequency Echographic Multispectrometry)

1. ULTRASOUND ACQUISITION

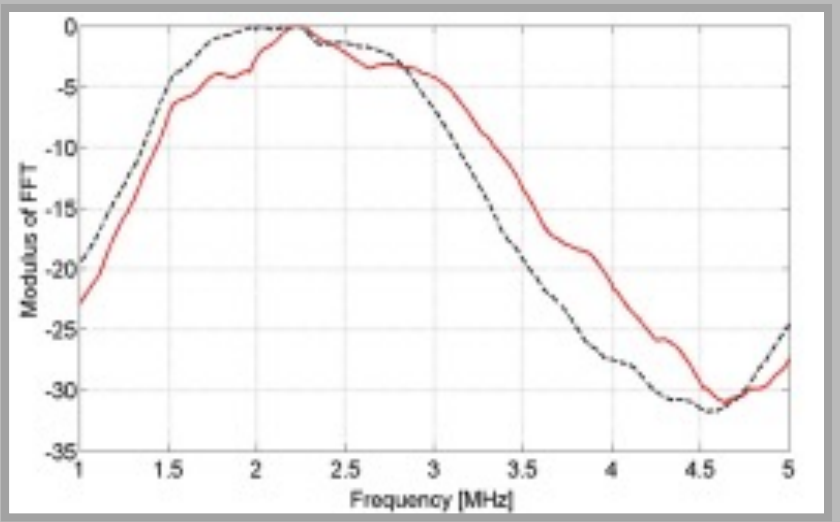
SIGNALS ANALYSIS







SPECTRAL COMPARISON WITH BMD DATABASE

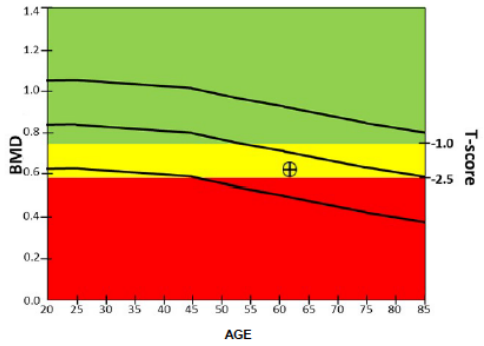


EchoS REMS Output

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

Exam date: 20/07/2020 15:39:10
Family Name: MENOPAUSE AGE: 50
Date of Birth: 29/09/1957 Age: 62y Gender: F Weight: 68 kg H: 162 cm BMI: 25.91 kg/m²

REMS densitometry: LEFT FEMUR



	BMD g/cm²	T-score	Z-score	Diagnosis
Neck	0.615	-2.1	-0.7	Osteopenia

	BMD	T-Score	Z-Score
Total	0.761	-1.5	-0.4
Trochanter	0.786	-1.1	-0.2

FRAX®

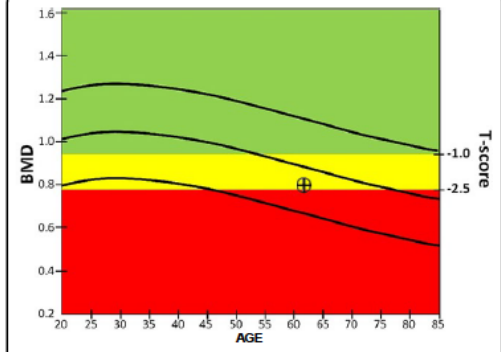
Major osteoporotic	31.9%
Hip fracture	5.5%

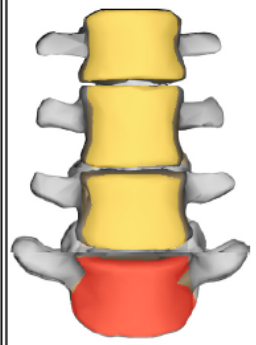
NOTES / DIAGNOSTIC RESULT

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

Exam date: 20/07/2020 16:14:02
Family Name : MENOPAUSE AGE: 50
Date of Birth: 29/09/1957 Age: 62y Gender: F Weight: 68 kg H: 162 cm BMI: 25.91 kg/m²

REMS densitometry: SPINE





	BMD g/cm²	T-score	Z-score	Diagnosis
Total	0.791	-2.3	-0.7	Osteopenia

	BMD	T-SCORE
L1	0.676	-2.3
L2	0.82	-1.9
L3	0.827	-2.3
L4	0.806	-2.8

FRAX®

Major osteoporotic	31.9%
Hip fracture	5.5%

NOTES / DIAGNOSTIC RESULT

OSTEOSCANUK
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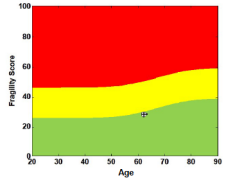
Exam date: 20/07/2020 15:39:10
Family Name: (MENOPAUSE AGE: 50
Date of Birth: 29/09/1957 Age: 62y Gender: F Weight: 68 kg H: 162 cm BMI: 25.91 kg/m²

Fragility Score REMS: Hip



Fragility Score	27.7

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: 28/07/2020 16:44:58
Family Name: MENOPAUSE AGE: 45
Date of Birth: 07/12/1958 Age: 61y Gender: F Weight: 61 kg H: 163 cm BMI: 22.96 kg/m²

REMS Total Risk for Major Osteoporosis Fractures

Combining Matrix of REMS BMD and Fragility Score

REMS FRAGILITY SCORE \ REMS T-SCORE classification	NORMAL	OSTEOPENIA	OSTEOPOROSIS
NORMAL	R1	R3	R5
DECREASED	R2	R4	R6
LOW	R3	R5	R7

Total Fracture Risk at 5 years (‰)

Risk class	Risk of major osteoporotic fracture per 1000 subjects per 5 years
R1	≤ 5
R2	[5-10]
R3	[10-20]
R4	[20-35]
R5	[35-60]
R6	[60-100]
R7	> 100

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

Strengths and Weaknesses of REMS

Strengths

Mobile

Simple, fast, radiation-free

Operator independent and no post-processing errors

Spinal deformity or previous surgery has no or limited effect

Immediate results

Precision across platform

Reproducible results (intra-observer variation 1 – 3%) suitable for treatment monitoring

Fragility score predicts fracture risk

Weaknesses

Limited independent verification studies comparing to DEXA

REMS compared to DEXA

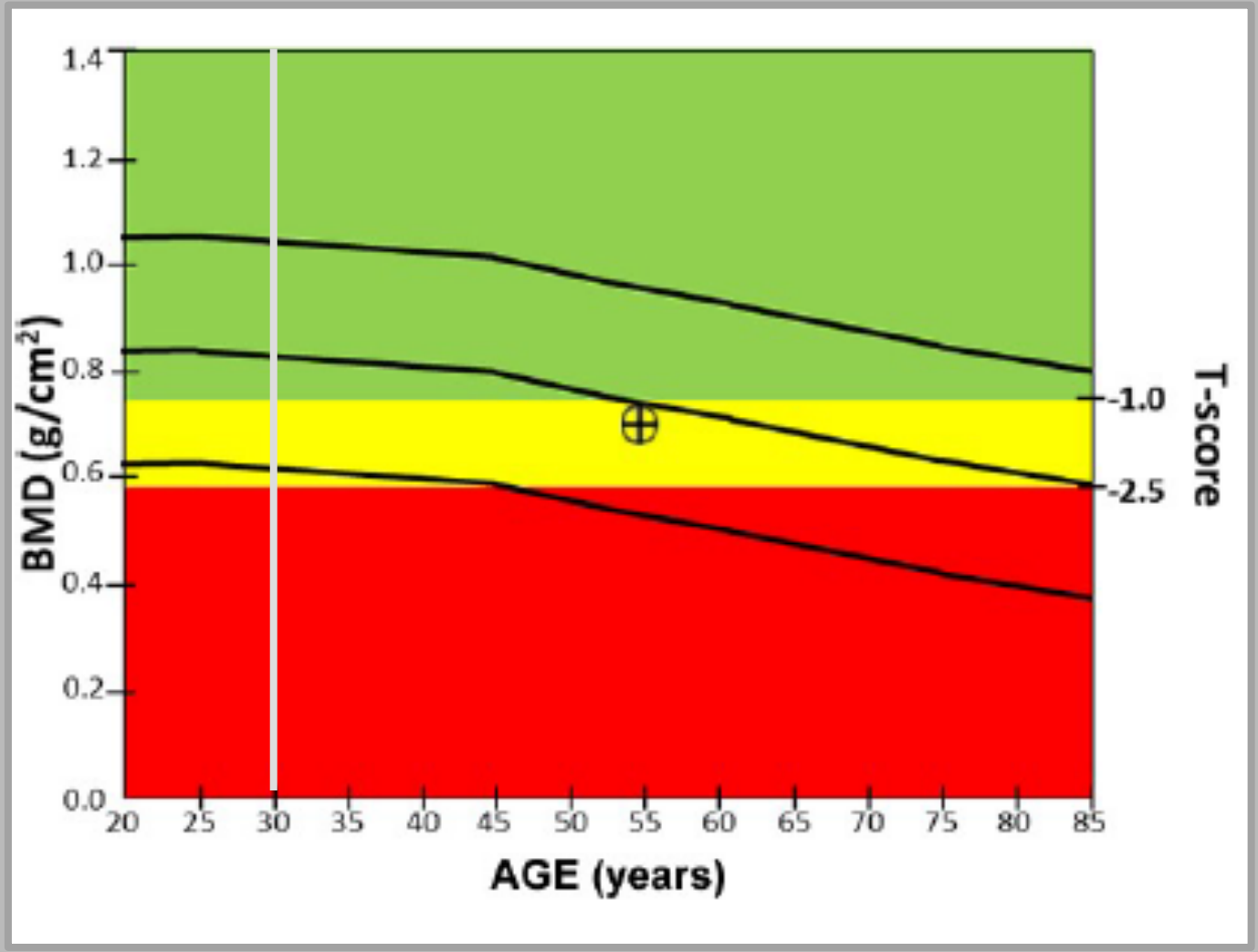
Radiofrequency echographic multispectrometry compared with dual X-ray absorptiometry for osteoporosis diagnosis on lumbar spine and femoral neck
Di Paola, M., Gatti, D., Viapiana, O. et al. *Osteoporos Int (2018).*

Measure	Sensitivity	Specificity	T Score Correlation
Femur	91.5%*	91.8%*	93%
Spine	91.7%*	92%*	94%

* Results are above the thresholds recommended by the Royal Osteoporosis Society for establishing the diagnosis of osteoporosis using ultrasound-based technology.

Impaired Bone Health and Fracture Risk

Bone Mineral Density Change With Age - NHANES III Database
Comparison with healthy 30-year-olds: T scores
Age matched: Z scores

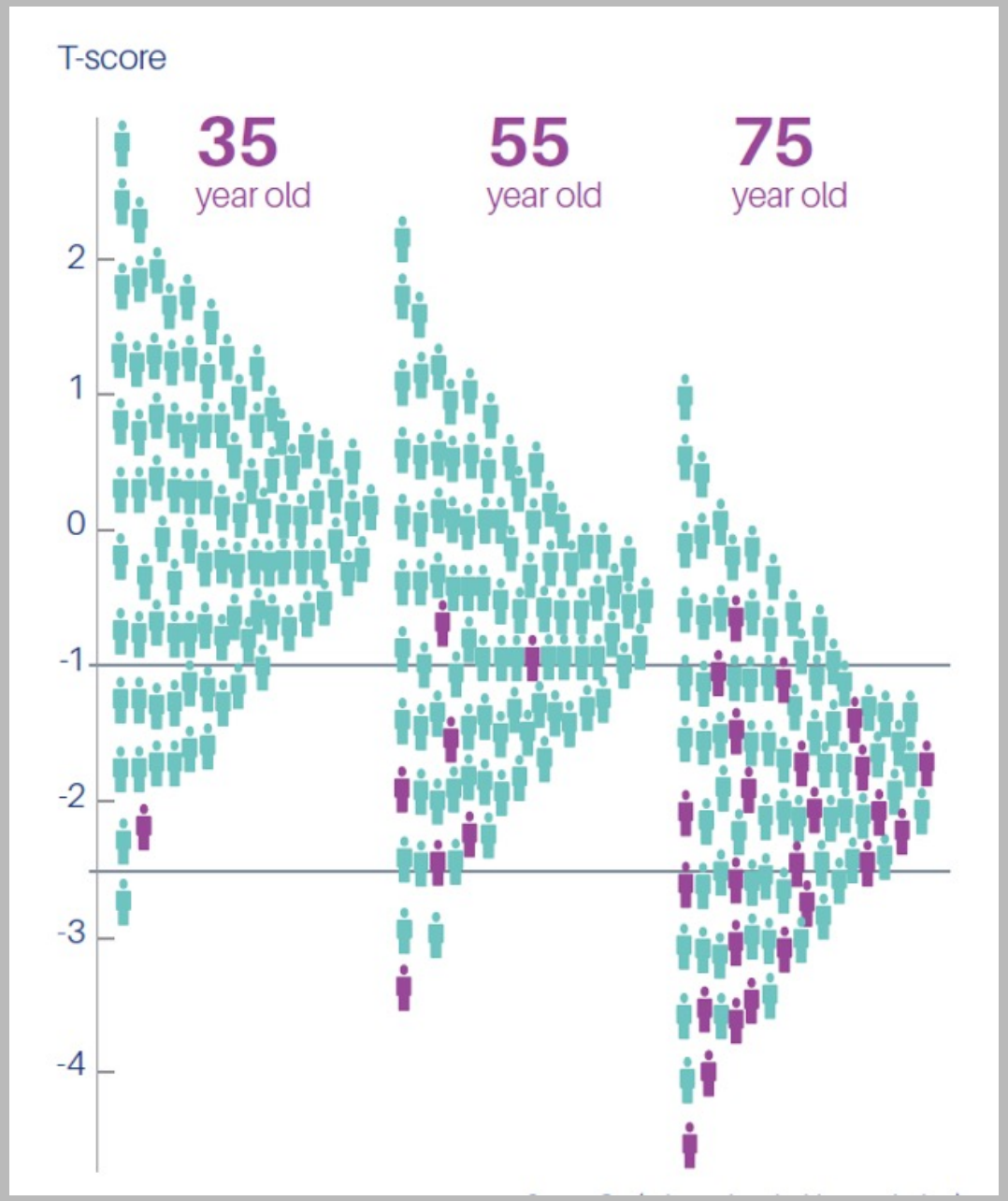


The "Traffic Light" system represents the T score showing the bone mineral density of an individual compared to a healthy 30 year old

Green = Normal Bone Density
Yellow = Osteopenia – transition from normal to osteoporotic bone
Red = Osteoporosis

The middle black line represents the modal Z score with the upper and lower black lines showing the range in which 95% of the age-matched population lie (2 standard deviations above and below the mean)

Risk of Fragility Fractures in Women According to Age

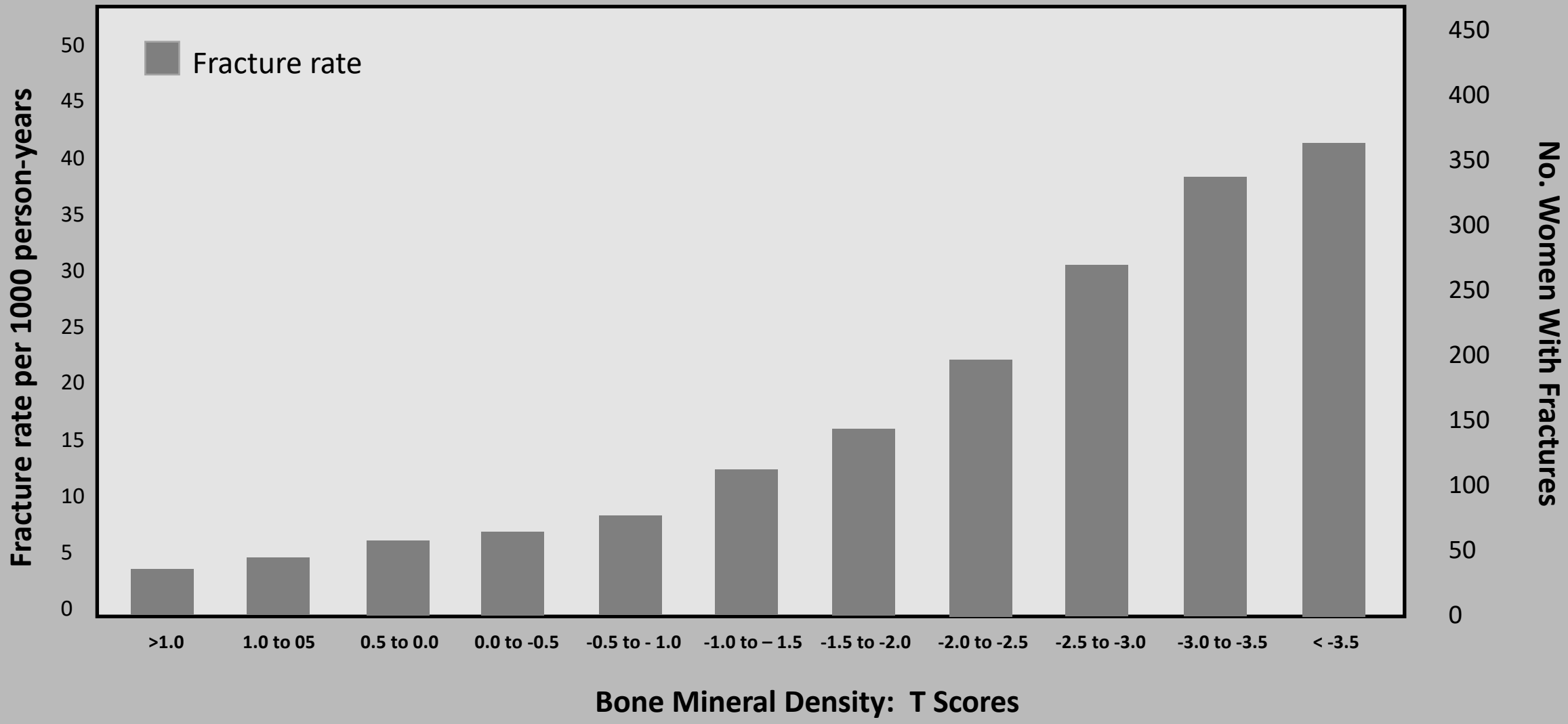


Age 35: 1 in 100

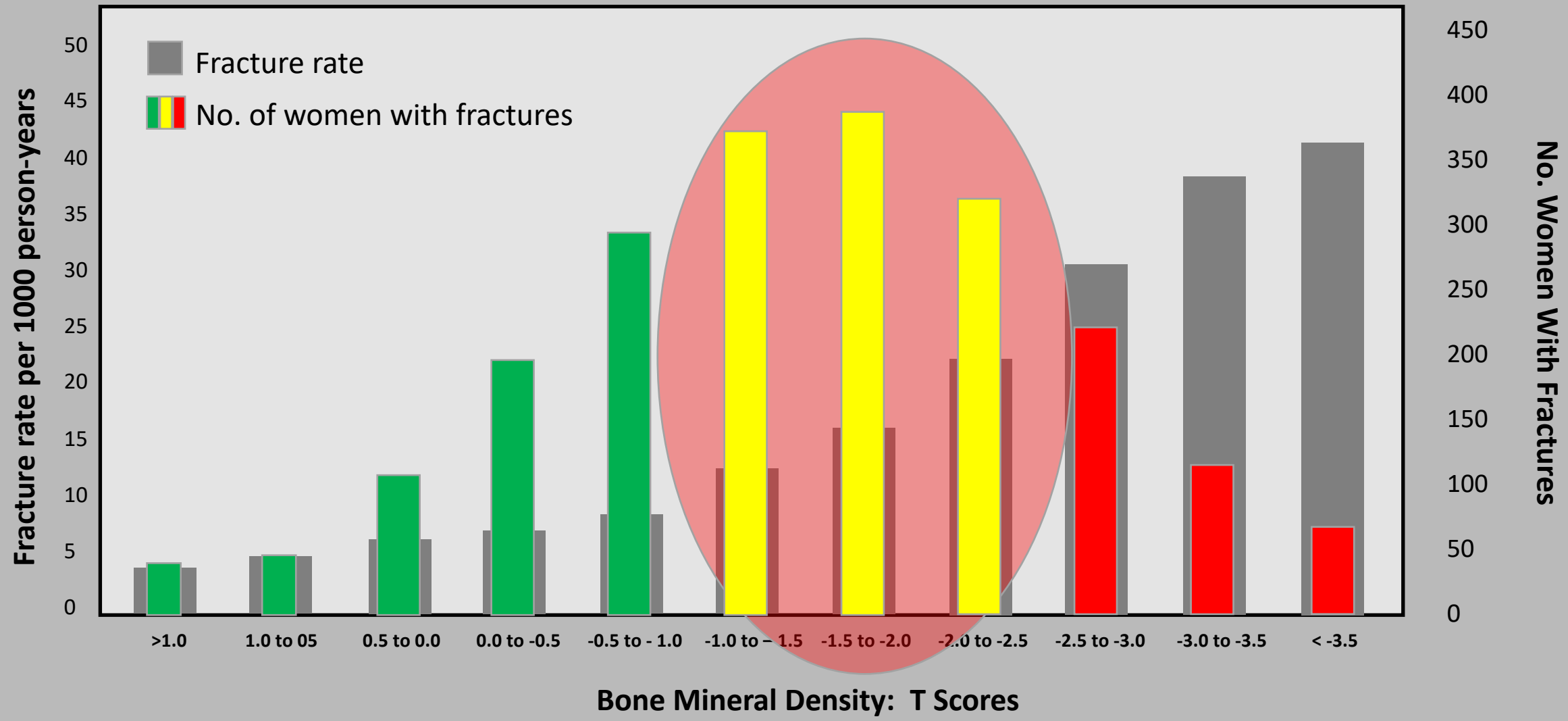
Age 55: 7 in 100

Age 75: 24 in 100

Rate of Fractures in Women According to Bone Mineral Density



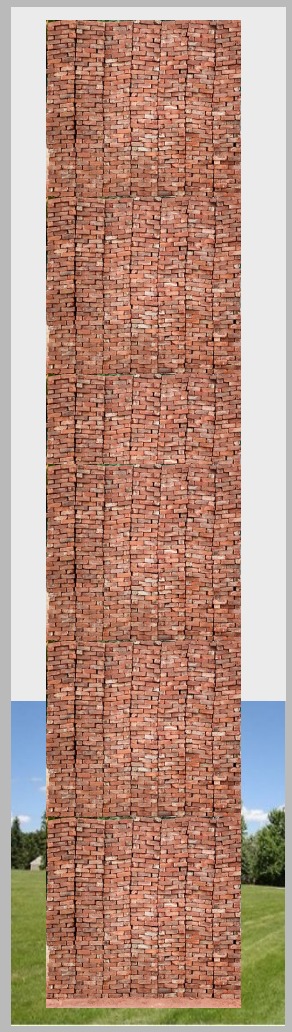
Rate and Number of Fractures in Women According to Bone Mineral Density



Reducing fracture risk when the T score is -1.0 to – 2.5

BMD + Trabecular Bone Score = quality of bone or “toughness” i.e. Fragility Score

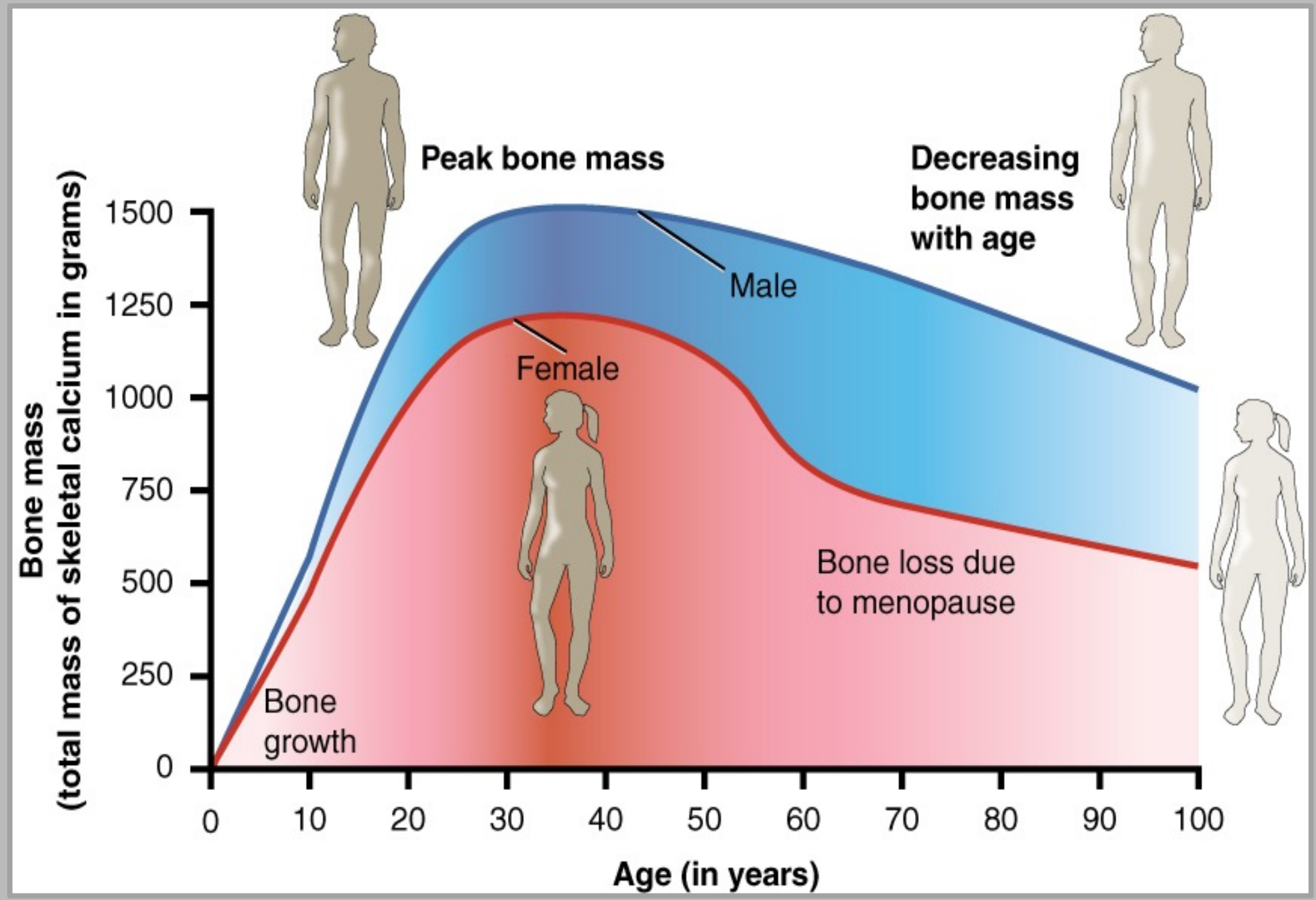
Light-weight
Well-built



Massive but no
structural integrity

Female Athletes:
Risk Factors for Impaired Bone Health

Peak Bone Mass



Factors under her control

Nutrition:

Calcium

Vitamin D

Calorific intake

Regularity of periods

Exercise:

Impact – varied load and frequency

Avoidance of harm:

Cigarettes

Excess alcohol

Harmful drugs

Factors not under her control

Hormonal:

Menarche

Menopause

Genetics:

Family history of osteoporosis

Ethnicity

Small frame

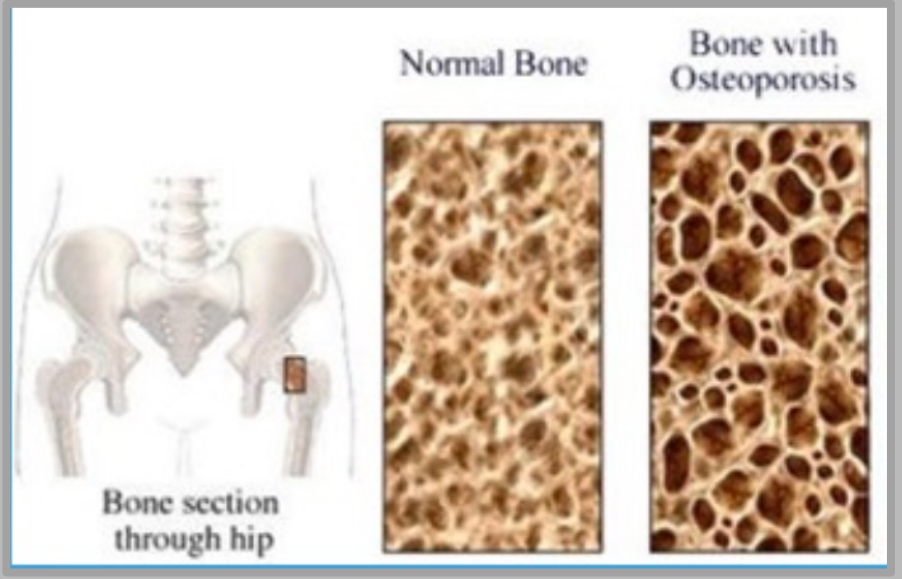
Medical conditions:

Conditions requiring steroids (colitis, coeliac, arthritis)

Thyroid disease

Treatment for epilepsy

Treatment for peptic ulcers



Risks for Impaired Bone Health and Specific Risks for Women Athletes

Being female	*Being female*
Over 65 years old	Over 65 years old
A fracture after 50 years of age	A fracture after 50 years of age
Parent(s) with a hip fracture	*Parent(s) with a hip fracture*
Early menopause - before the age of 45	*Early menopause - before the age of 45*
Cigarette smoking	*Cigarette smoking*
Taking steroid medication	*Taking steroid medication*
Rheumatoid Arthritis	*Rheumatoid Arthritis*
Heavy drinking	*Heavy drinking*
Thyroid disease	*Thyroid disease*
Chronic liver disease	*Chronic liver disease*
Chronic kidney disease	*Chronic kidney disease*
Diabetes	*Diabetes*
Malabsorption of food	*Malabsorption of food*
(Crohn's disease / Ulcerative colitis /Coeliac disease)	*(Crohn's disease / Ulcerative colitis /Coeliac disease)*
Sedentary lifestyle	Sedentary lifestyle
Low body weight or small stature	*Low body weight or small stature*
No periods for more than 6 months	*No periods for more than 6 months*
Some medications e.g. proton pump inhibitors	*Some medications e.g. proton pump inhibitors*

Healthy Athletes

Anorexia

Toxic Habits

Specific Risk Factors for Stress Fractures in Ballet Dancers (Erika Mayall, 2017)

Sex

Race

Nutrition (caloric insufficiency, calcium and vitamin D levels)

Hormonal status

Low bone mineral density

BMI < 19

Muscle mass/strength

Neuromuscular function

Abnormal bony alignment

Training surfaces

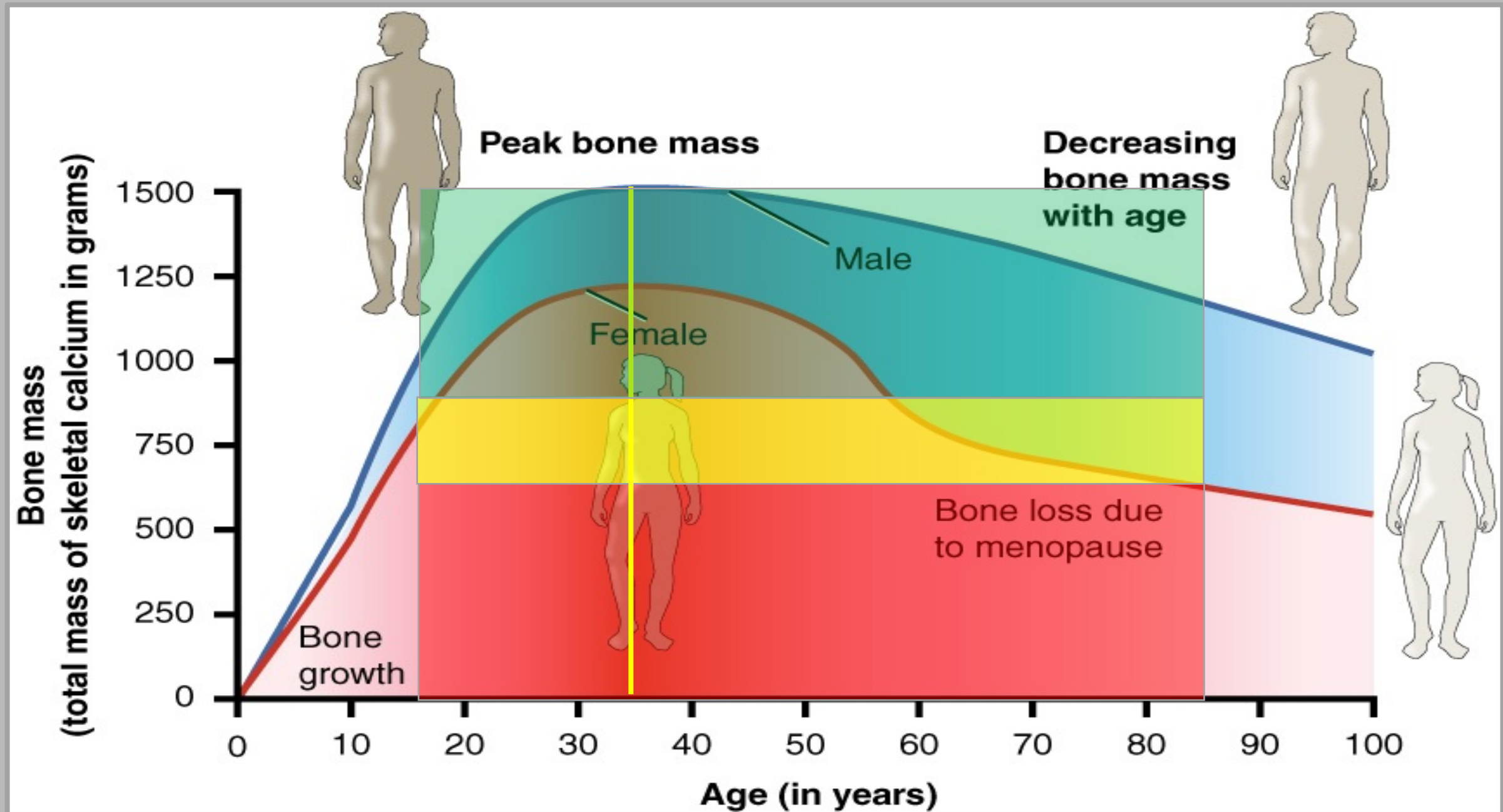
Improper technique/biomechanics

Changes in training intensity and/or volume

Overall training load

Dancers training >5hrs/day increase their risk of a stress fracture 16 times versus training <5hrs/day, regardless of other risk factors

Implication of low Peak Bone Mass?

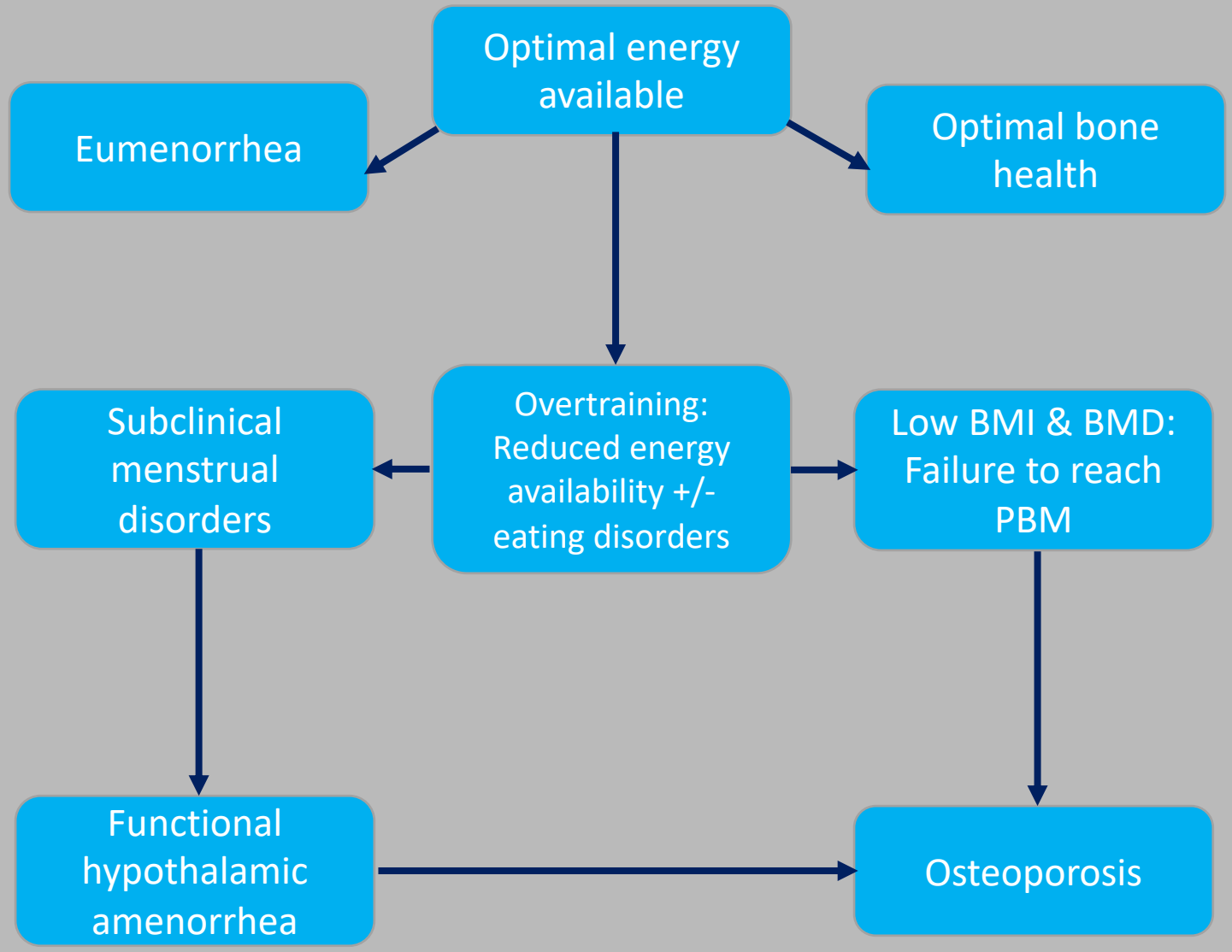


Functional Effects of The Female Triad on Bone Health

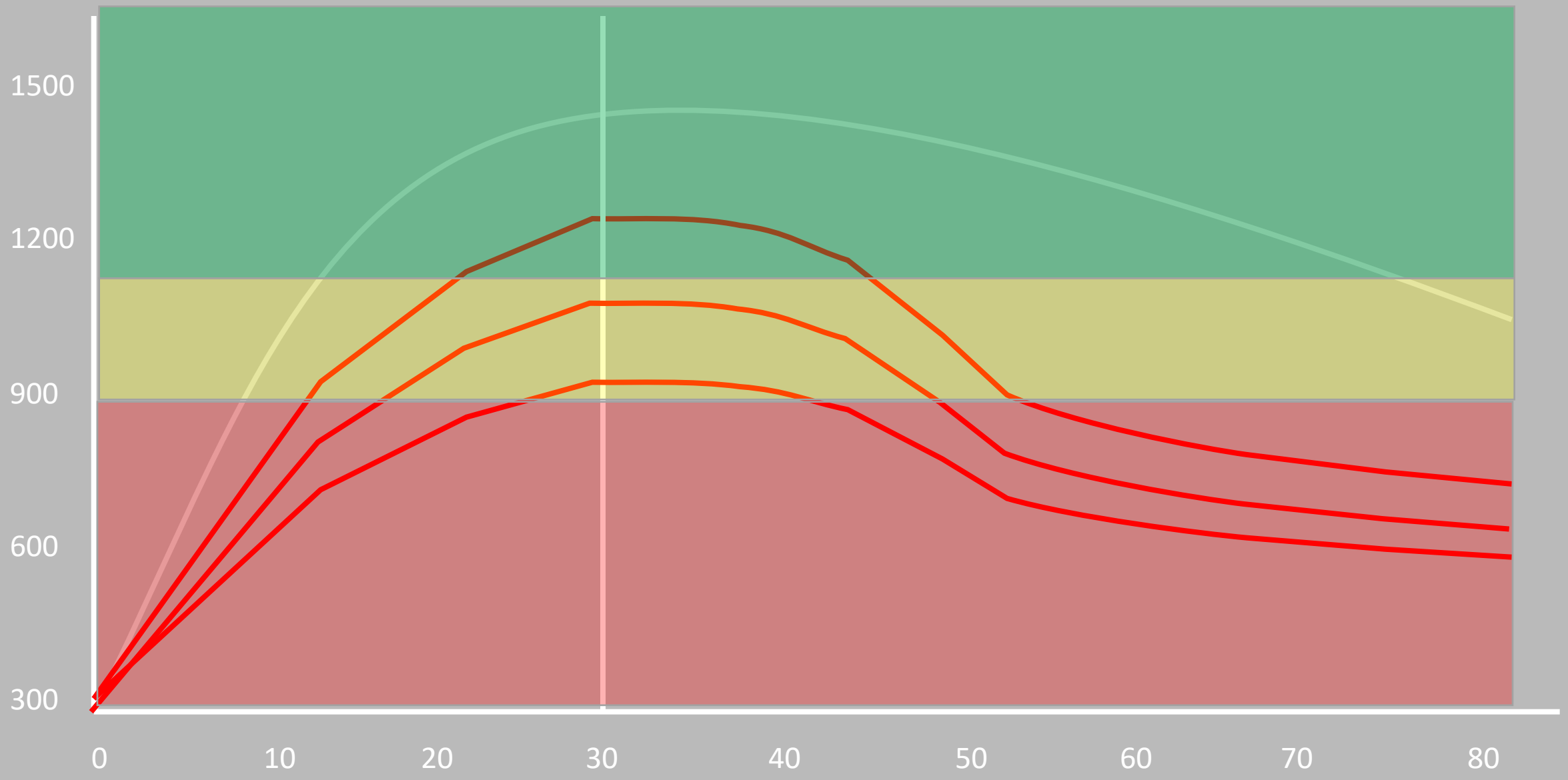
J Clin Endocrinol Metab. 2014 Nov;99(11):4037-50. doi: 10.1210/jc.2013-3030. Epub 2014 Mar 6.

Endocrine disorders in adolescent and young female athletes: impact on growth, menstrual cycles, and bone mass acquisition.

Maïmoun L, Georgopoulos NA, Sultan C.



If She Doesn't Reach Peak Bone Mass?



Real Life Case: REMS Reports

OSTEOSCANUK

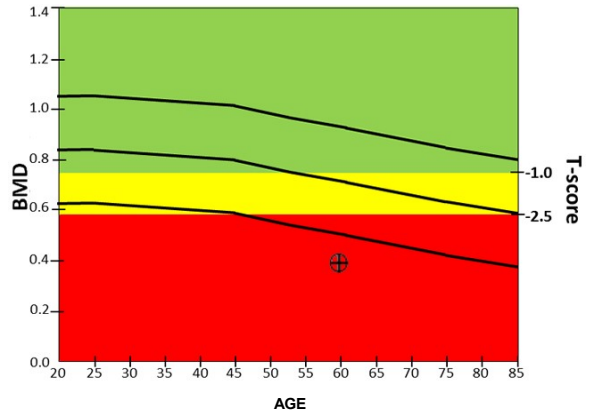
O.U. Dr Nick Birch GMC No. 3086328

Exam date: 28/09/2020 16:04:56

Family Name . MENOPAUSE AGE: 52

Date of Birth: 28/08/1960 Age: 60y Gender: F Weight: 40 kg H: 157 cm BMI: 16.23 kg/m²

REMS densitometry: LEFT FEMUR



	BMD g/cm²	T-score	Z-score	Diagnosis
Neck	0.382	-4.2	-2.9	Osteoporosis

	BMD	T-Score	Z-Score
Total	0.476	-3.8	-2.8
Trochanter	0.491	-3.3	-2.5

FRAX®

Major osteoporotic	12.5%
Hip fracture	2.7%

NOTES / DIAGNOSTIC RESULT

OSTEOSCANUK

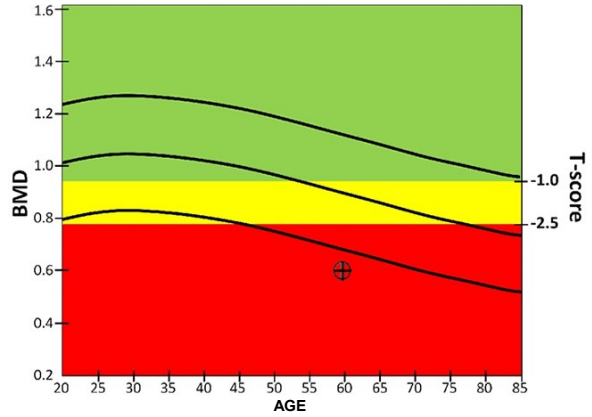
O.U. Dr Nick Birch GMC No. 3086328

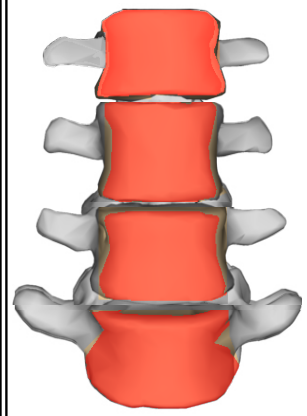
Exam date: 28/09/2020 16:12:17

Family Name: MENOPAUSE AGE: 52

Date of Birth: 28/08/1960 Age: 60y Gender: F Weight: 40 kg H: 157 cm BMI: 16.23 kg/m²

REMS densitometry: SPINE





	BMD g/cm²	T-score	Z-score	Diagnosis
Total	0.618	-3.9	-2.5	Osteoporosis

	BMD	T-SCORE
L1	0.515	-3.7
L2	0.58	-4.1
L3	0.679	-3.7
L4	0.667	-4.1

FRAX®

Major osteoporotic	12.5%
Hip fracture	2.7%

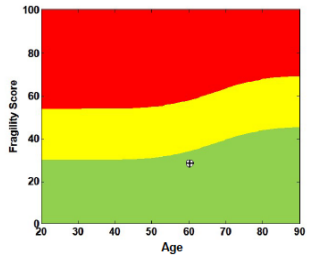
NOTES / DIAGNOSTIC RESULT

Fragility Scores

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

Exam date: 28/09/2020 16:12:17
Family Name: MENOPAUSE AGE: 52
Date of Birth: 28/08/1960 Age: 60y Gender: F Weight: 40 kg H: 157 cm BMI: 16.23 kg/m²

Fragility Score REMS: Spine



Fragility Score	28.4

OSTEOSCANUK
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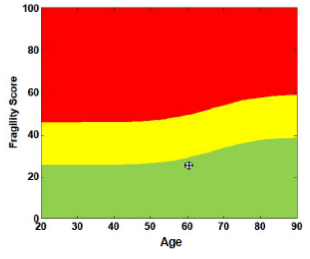
Exam date: 28/09/2020 16:04:56
Family Name: MENOPAUSE AGE: 52
Date of Birth: 28/08/1960 Age: 60y Gender: F Weight: 40 kg H: 157 cm BMI: 16.23 kg/m²

Fragility Score REMS: Hip



Fragility Score	25.3

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

Exam date: 28/09/2020 16:12:17
Family Name: LOCKWOOD Name: LINDA MENOPAUSE AGE: 52
Date of Birth: 28/08/1960 Age: 60y Gender: F Weight: 40 kg H: 157 cm BMI: 16.23 kg/m²

REMS Total Risk for Major Osteoporosis Fractures

Combining Matrix of REMS BMD and Fragility Score

REMS FRAGILITY SCORE Classification	REMS T-SCORE classification: NORMAL	OSTEOPENIA	OSTEOPOROSIS
NORMAL	R1	R3	R5
DECREASED	R2	R4	R6
LOW	R3	R5	R7

Total Fracture Risk at 5 years (‰)

Risk class	Risk of major osteoporotic fracture per 1000 subjects per 5 years
R1	≤ 5
R2	[5-10]
R3	[10-20]
R4	[20-35]
R5	[35-60]
R6	[60-100]
R7	> 100

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

Exam date: 28/09/2020 16:04:56
Family Name: LOCKWOOD Name: LINDA MENOPAUSE AGE: 52
Date of Birth: 28/08/1960 Age: 60y Gender: F Weight: 40 kg H: 157 cm BMI: 16.23 kg/m²

REMS Total Risk for Hip Fracture

Combining Matrix of REMS BMD and Fragility Score

REMS FRAGILITY SCORE Classification	REMS T-SCORE classification: NORMAL	OSTEOPENIA	OSTEOPOROSIS
NORMAL	R1	R3	R5
DECREASED	R2	R4	R6
LOW	R3	R5	R7

Total Fracture Risk at 5 years (‰)

Risk class	Risk of hip fracture per 1000 subjects per 5 years
R1	≤ 1
R2	[1-4]
R3	[4-8]
R4	[8-15]
R5	[15-30]
R6	[30-50]
R7	> 50

Body Mass Index (BMI), Peak Bone Mass (PBM) and Bone Health in Later Life

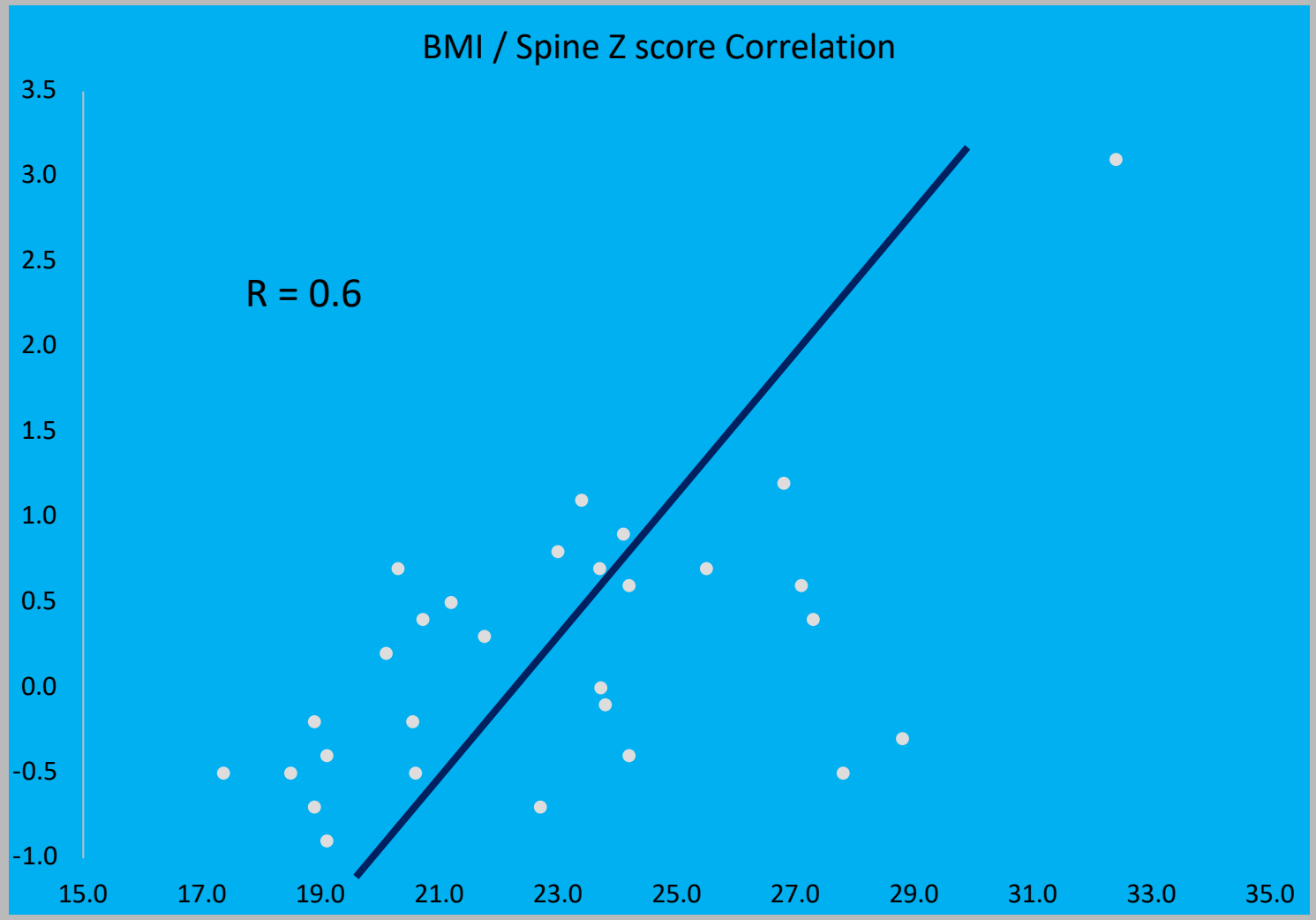
BMI is strongly predictive of BMD

Lower BMD recognised as risk factor for bone stress injuries and failure to reach PBM

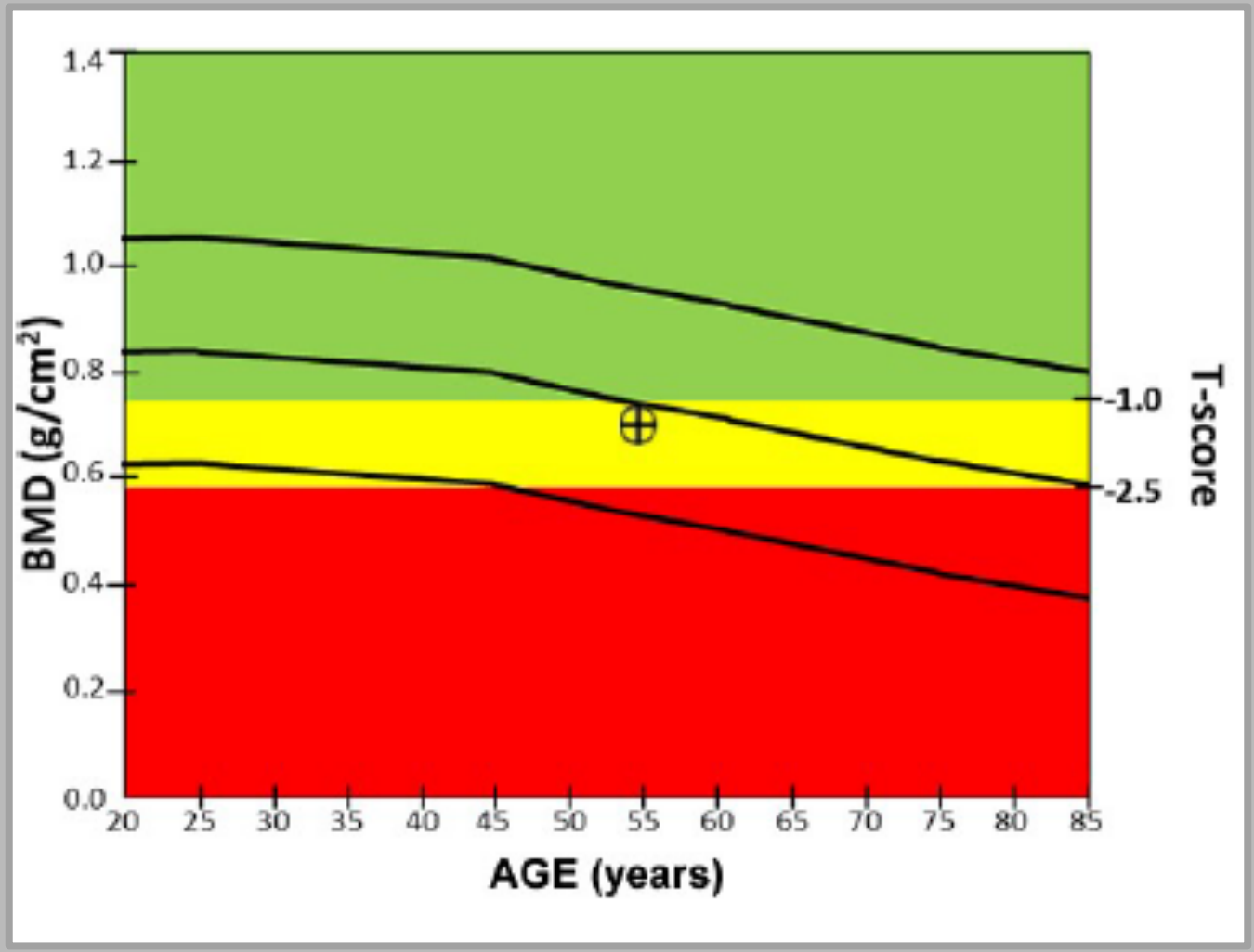
Identification of risk at the earliest stage will assist reaching PBM

PBM + 10% with appropriate menopause management could significantly reduce the incidence and prevalence of osteoporosis

BMI / Spine Z Score Correlation Young Women 2018 - 20



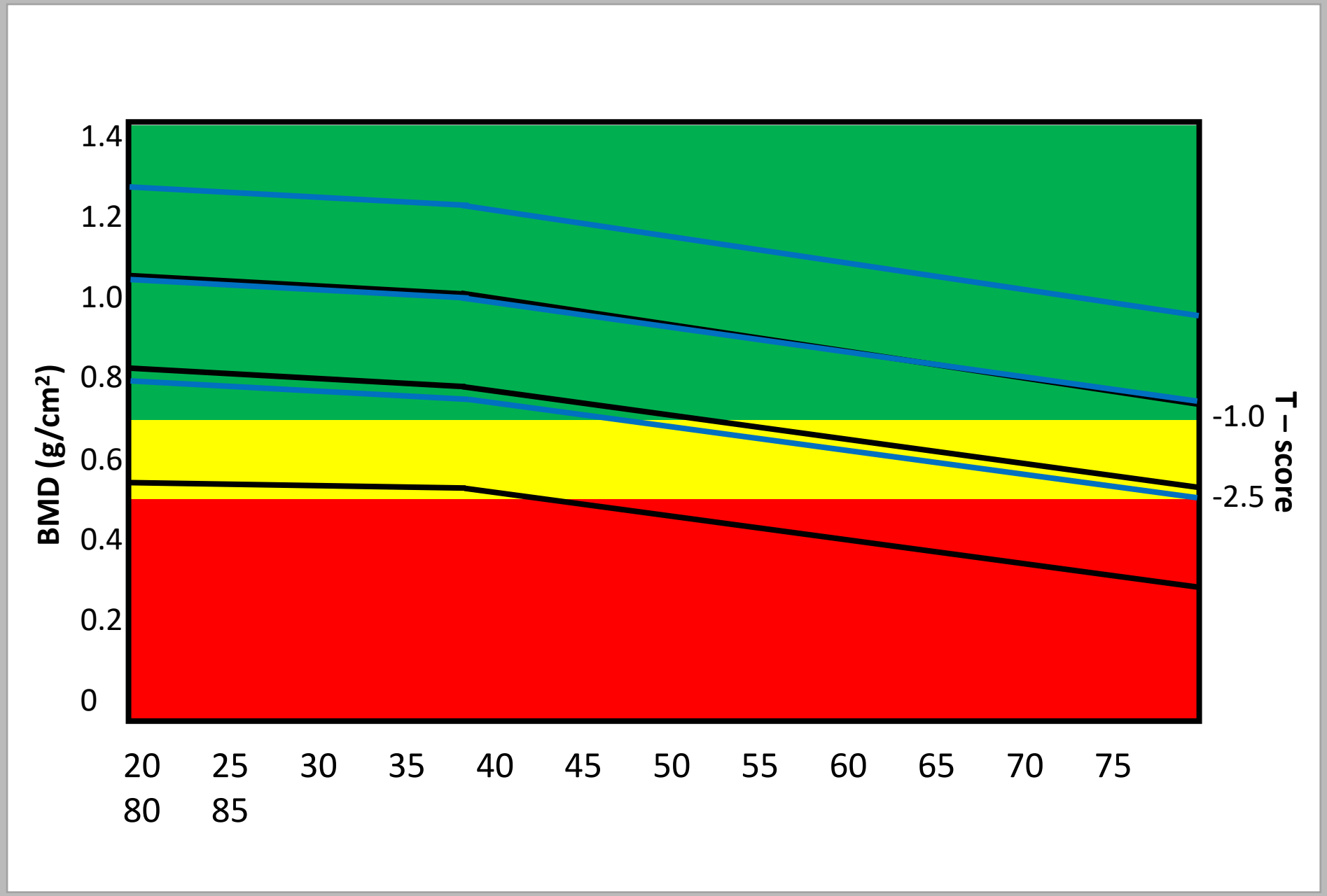
Bone Mineral Density Change With Age: NHANES III Database



Using the current definition of osteoporosis, to prevent 95% of the population having osteoporosis by the age of 85, if the natural history does not change (i.e. the graph shape remains the same), the mean BMD at 30 years would need to increase by 25%

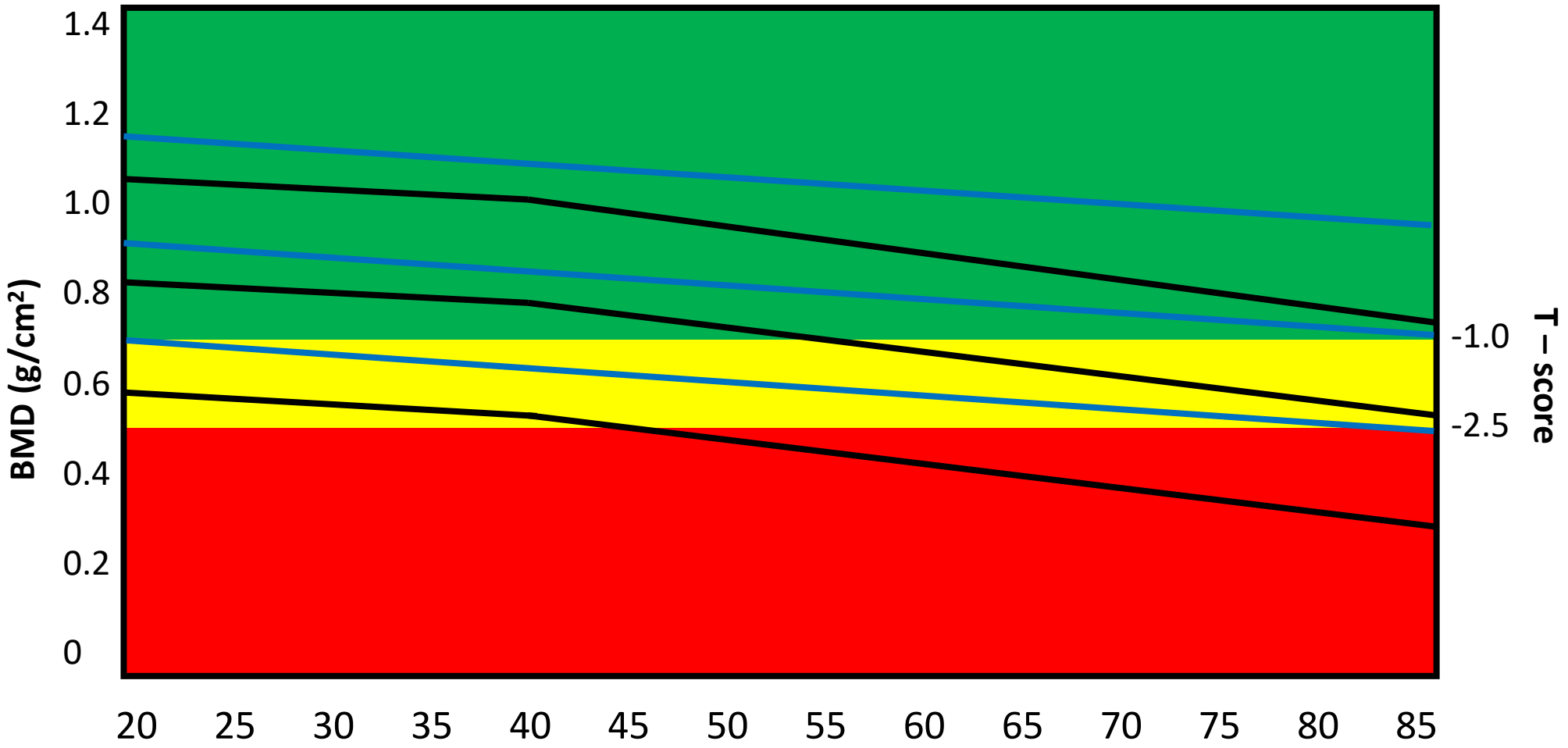
No change in the natural history:

Increase in BMD at 30 years old of 25% to prevent osteoporosis in 95% of the population at age 85



If the natural history is modified

10% increase in PBM at 30 years and 25% reduction in age-related BMD loss especially at time of menopause



Impaired Bone Health in Young Women: Changing Beliefs and Behaviours

Education:

Primary and secondary level teaching re: importance of Bone Health
Broadcast and social media

Diet:

Recommended Dietary Allowance (RDA) of essential nutrients
Intolerances
Dislikes / Body anxiety / Eating disorders
Sunshine exposure

Activity:

Teenage thumbs – obesity – increased fragility risk
BMD loss / failure to reach PBM – increased fragility risk
Reduction in variety of sport – lack of robustness and resilience
Over-training in athletes causing amenorrhea

Impairment of bone health in young women is largely preventable

They need local access to risk-free assessments for early assessment of bone health

Life-long impact exercise and dietary education

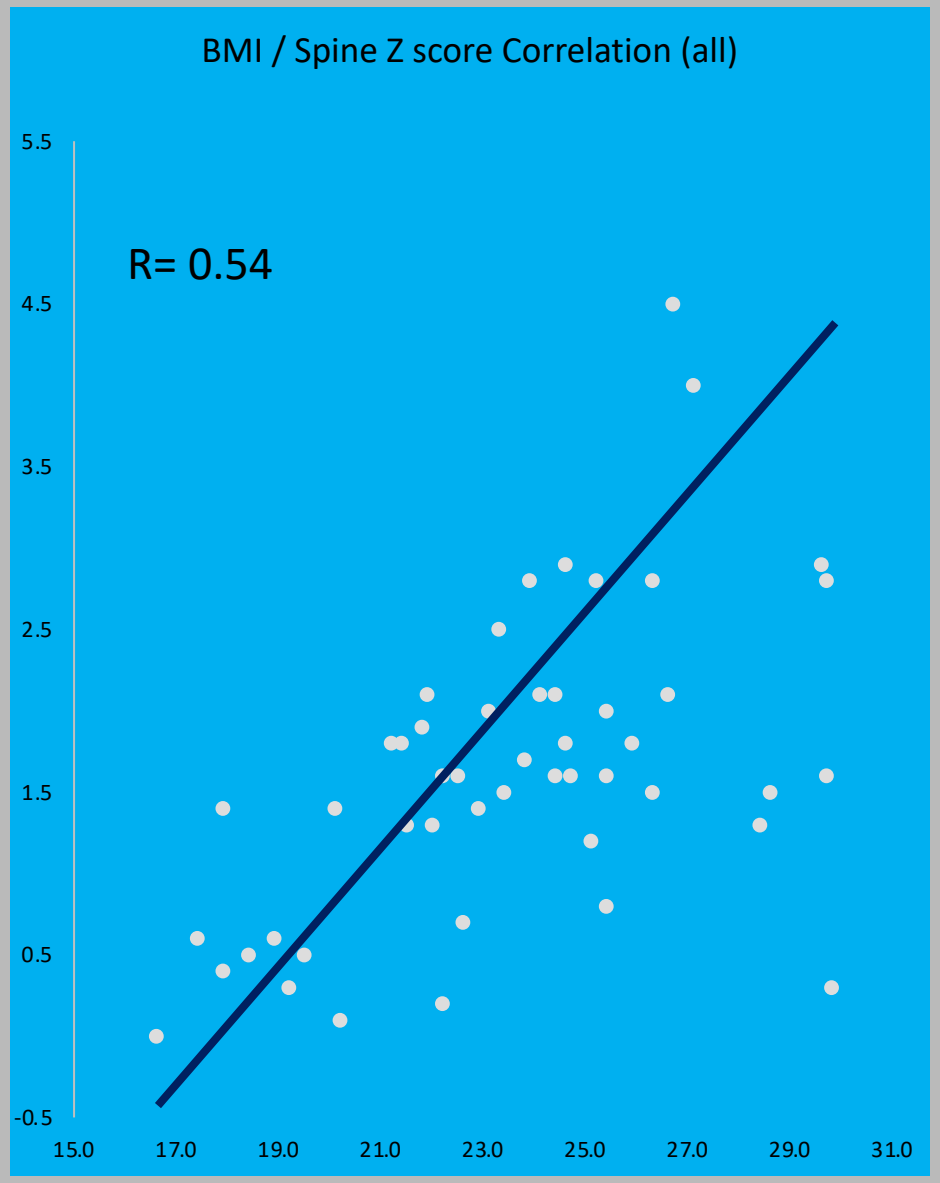
Prevent menopause related bone loss: early anabolic treatment

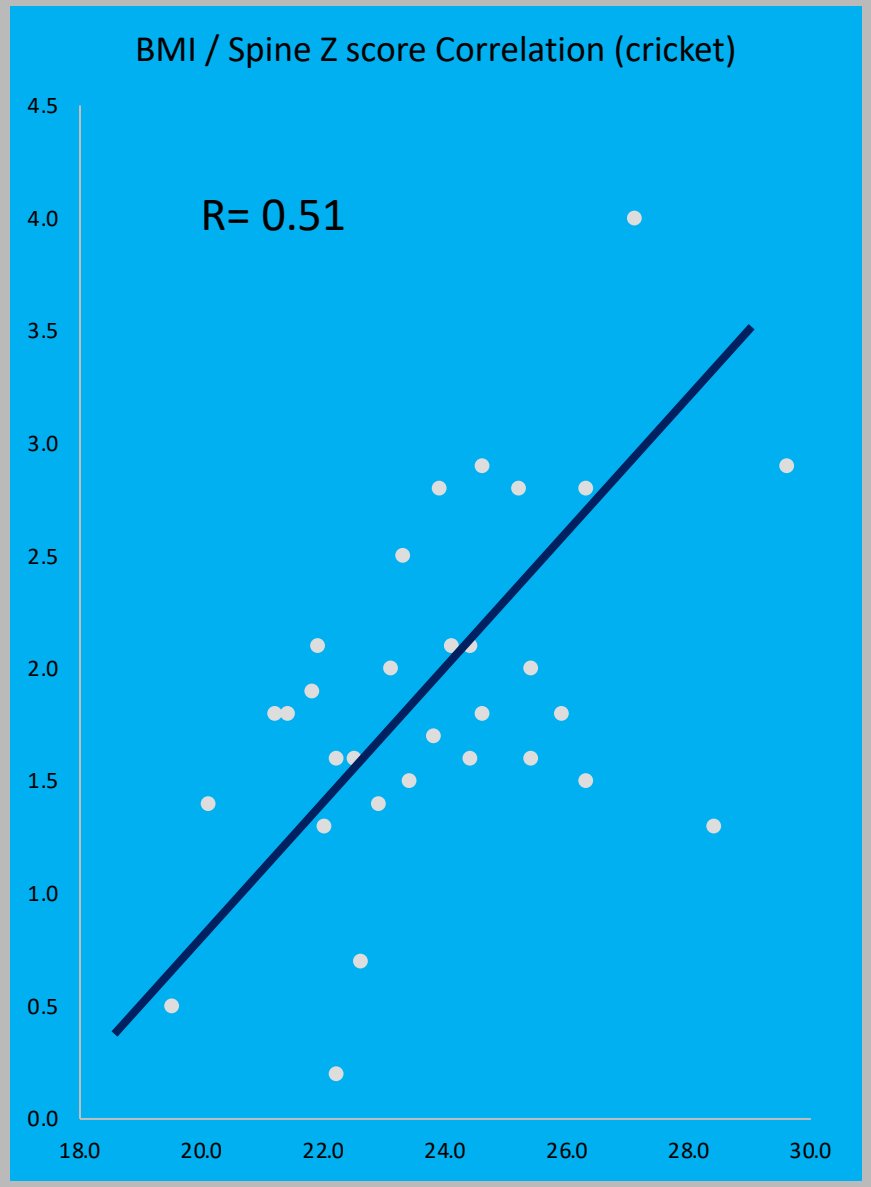
Sportsmen: Bone Stress Injuries – The Influence of Bone Health and Impact

Bone Health in Sportsmen: REMS Scans 2018-20

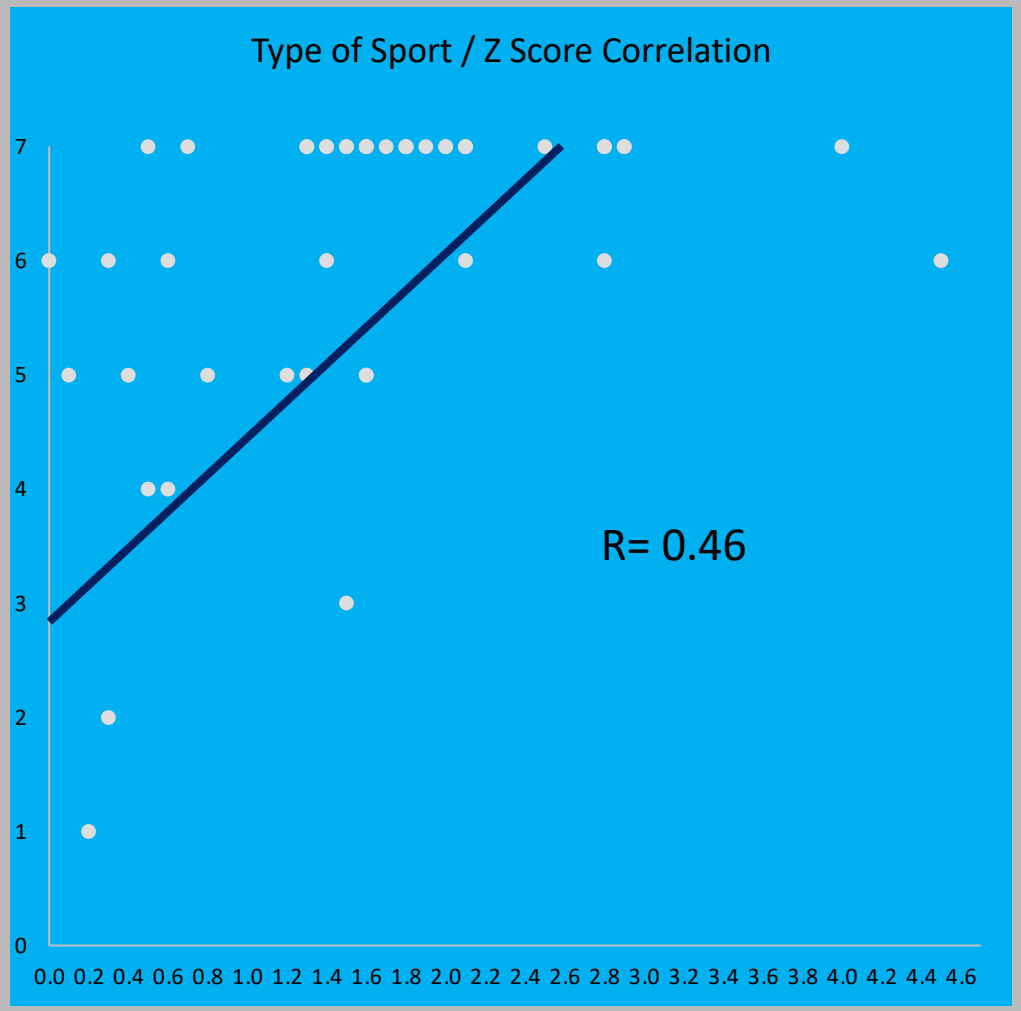
	All	Professional	Semi-professional	Amateur		Fractures associated with RDL / Line lifts / Squats
Cricket	30	26	3	1		8
Rugby	7	2		5		5
Athletics	7	1		6		2
Golf	1			1		1
Soccer	2	1		1		2
MMA	1		1			
Cycling	1			1		
Total	49	30	4	15		18

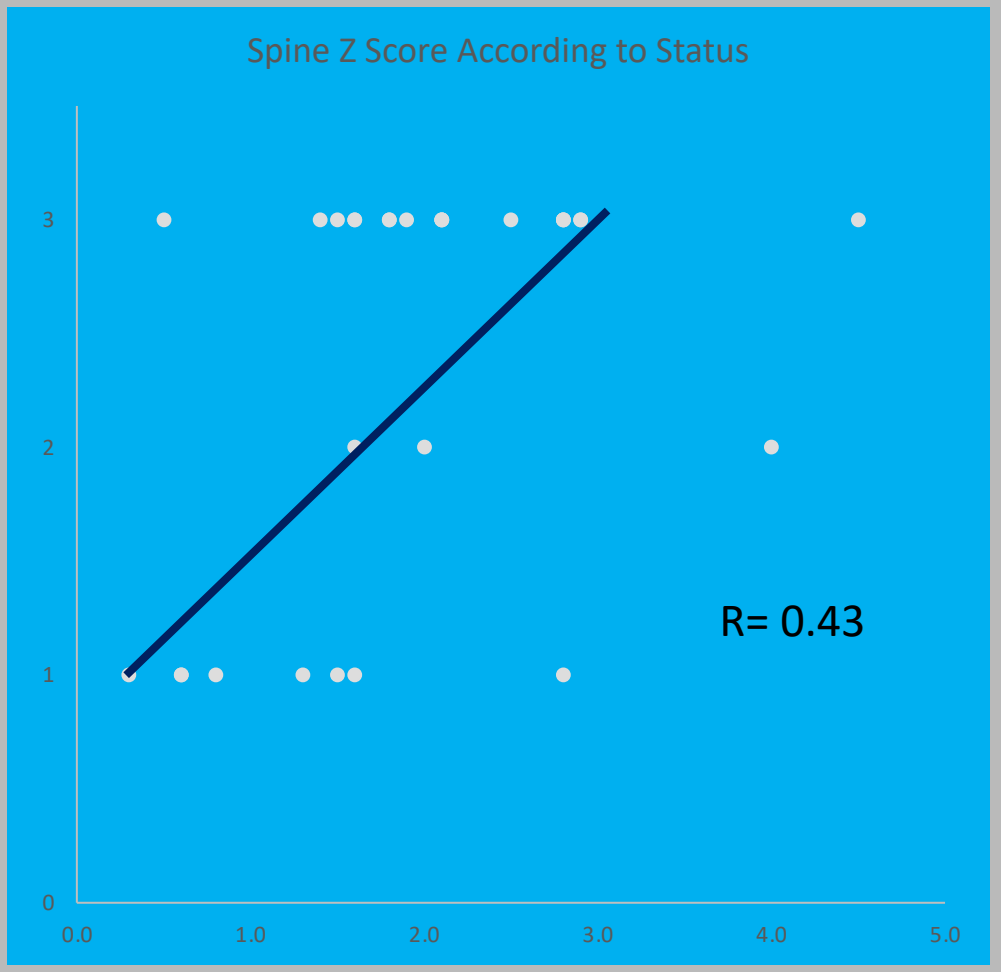
Z Score and BMI Correlation: Sportsmen





Z Score Correlations: Sport and Status (surrogates for intensity of activity)

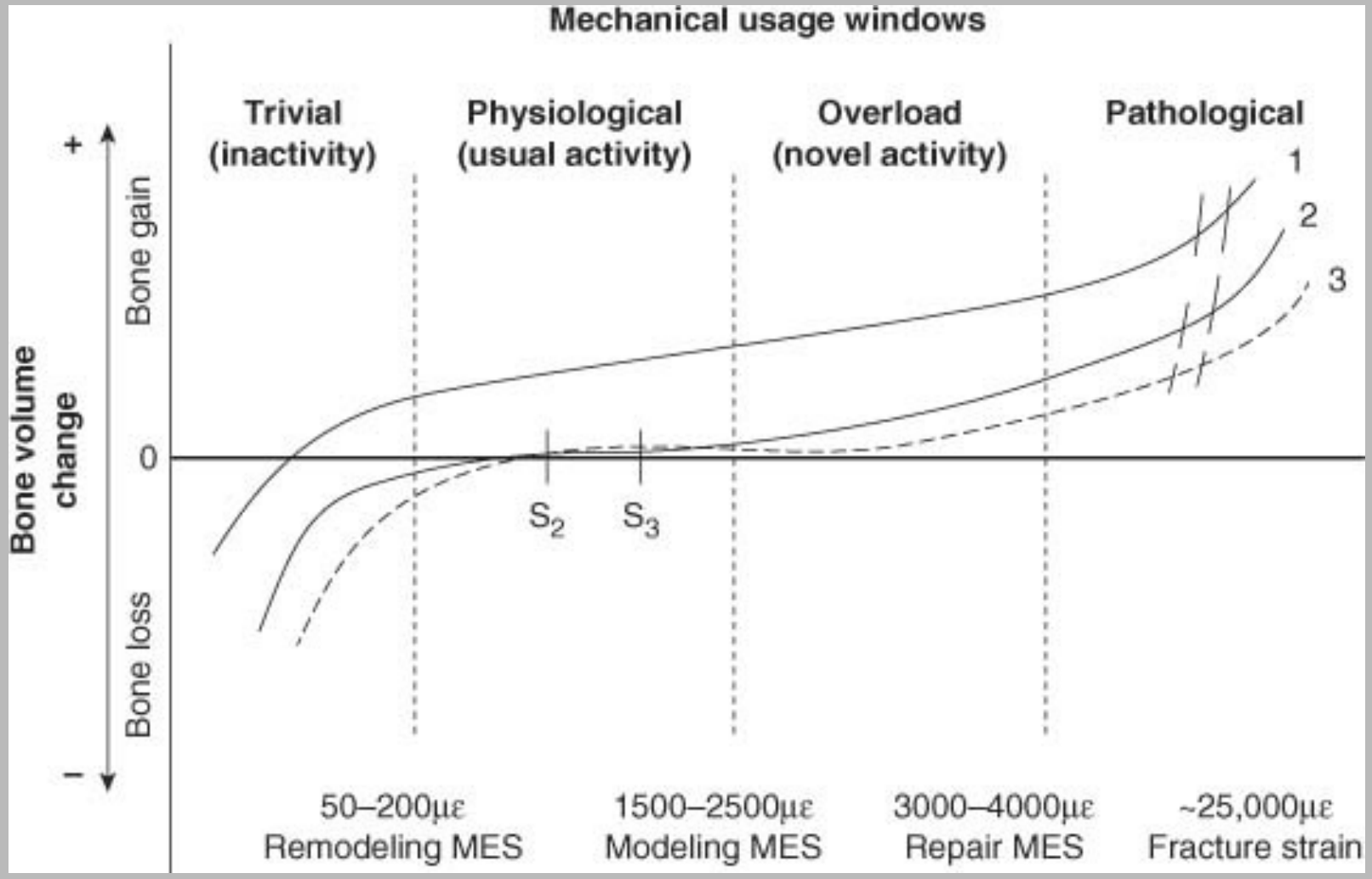




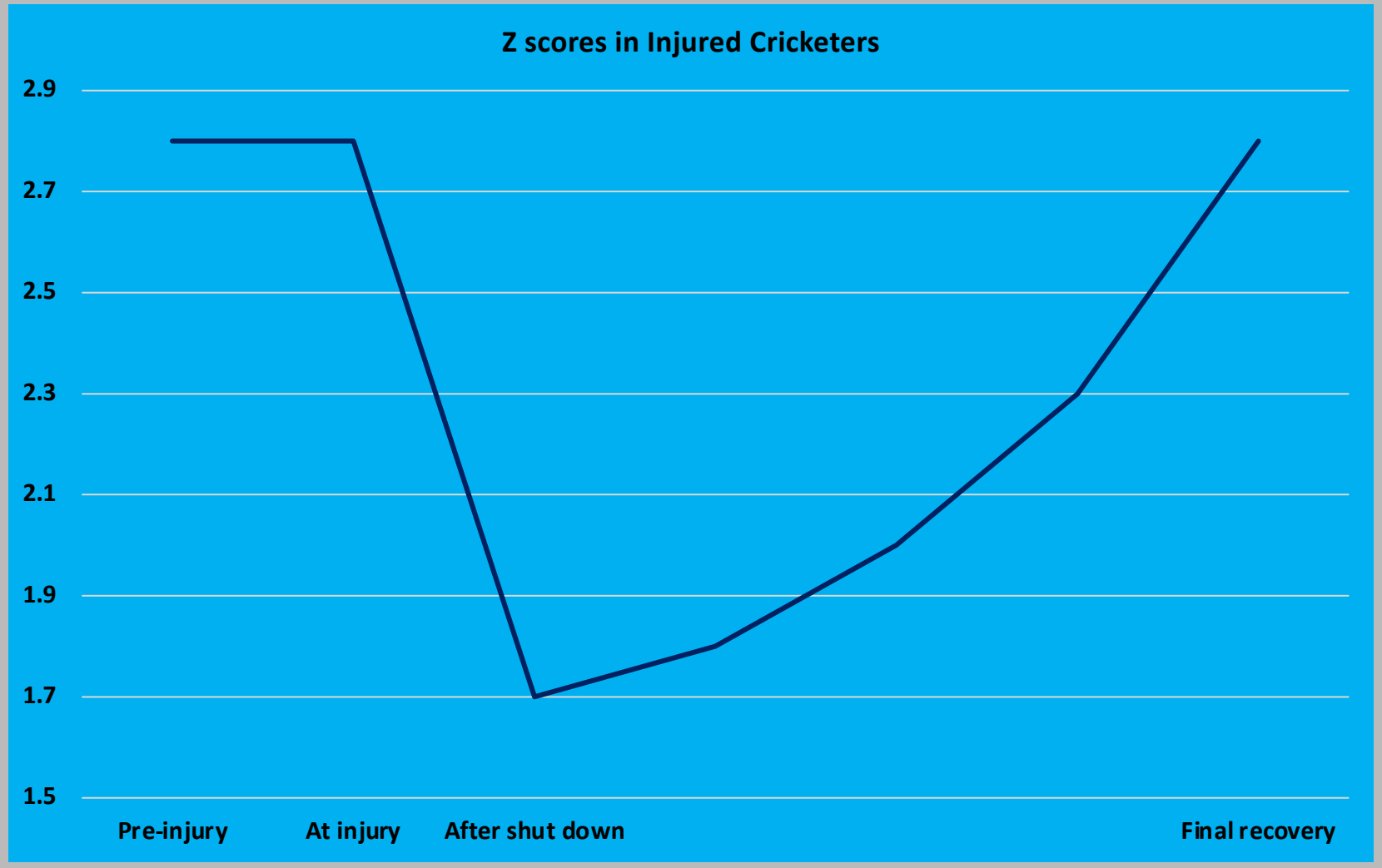
Characteristics of Sportsmen Presenting with and without a BSI

		Bone Stess Injury	No Bone Stress Injury
Age	Range	13 - 28	18 - 39
	Mean	19.9	25.7
Skeletal Maturity (<24 years)		66%	45%
BMI	Range	16.6 - 27.1	19.5 - 29.8
	Mean	21.5	24.8
Spine Z score	Range	0. 4.5	0.2 - 2.9
	Mean	1.3	2.4
Sports	Cricket	44%	71%
	Rugby	28%	6%
	Athletics	11%	16%
	Soccer	11%	0%
	Golf	6%	0%
	MMA	0%	3%
	Cycling	0%	3%
Status	Pro	56%	65%
	Semi-pro	6%	6%
	Amateur	39%	29%

Mechanostat and Injury Recovery



Fast Bowler Bone Health (Alway, Peirce, Brooke-Wavell 2018)



EchoS Point of Care REMS Assessment: Helping to Manage Sportspeople's Bone Health

Acceptability of regular bone health measurement more likely with non-radiation service and screening in high risk players pre-maturity (gymnastics, dance, soccer, cricket, rugby, weight training) is risk-free

Baseline assessment BMD to ensure peak bone mass is achieved is possible on-site at sports clubs, schools etc. i.e. *Localism*

Monitoring BMD change during periods of shut down / recovery “tracking the mechanostat” is realistic and can inform rehab decisions

Regular bone health assessment (REMS, FS, Vit D) throughout sporting career would be a welcome addition to the management of players’ welfare

Q&A

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