

Osteoporosis and falls

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Scope

- Gait instability
- Falls
- Osteoporosis/fracture

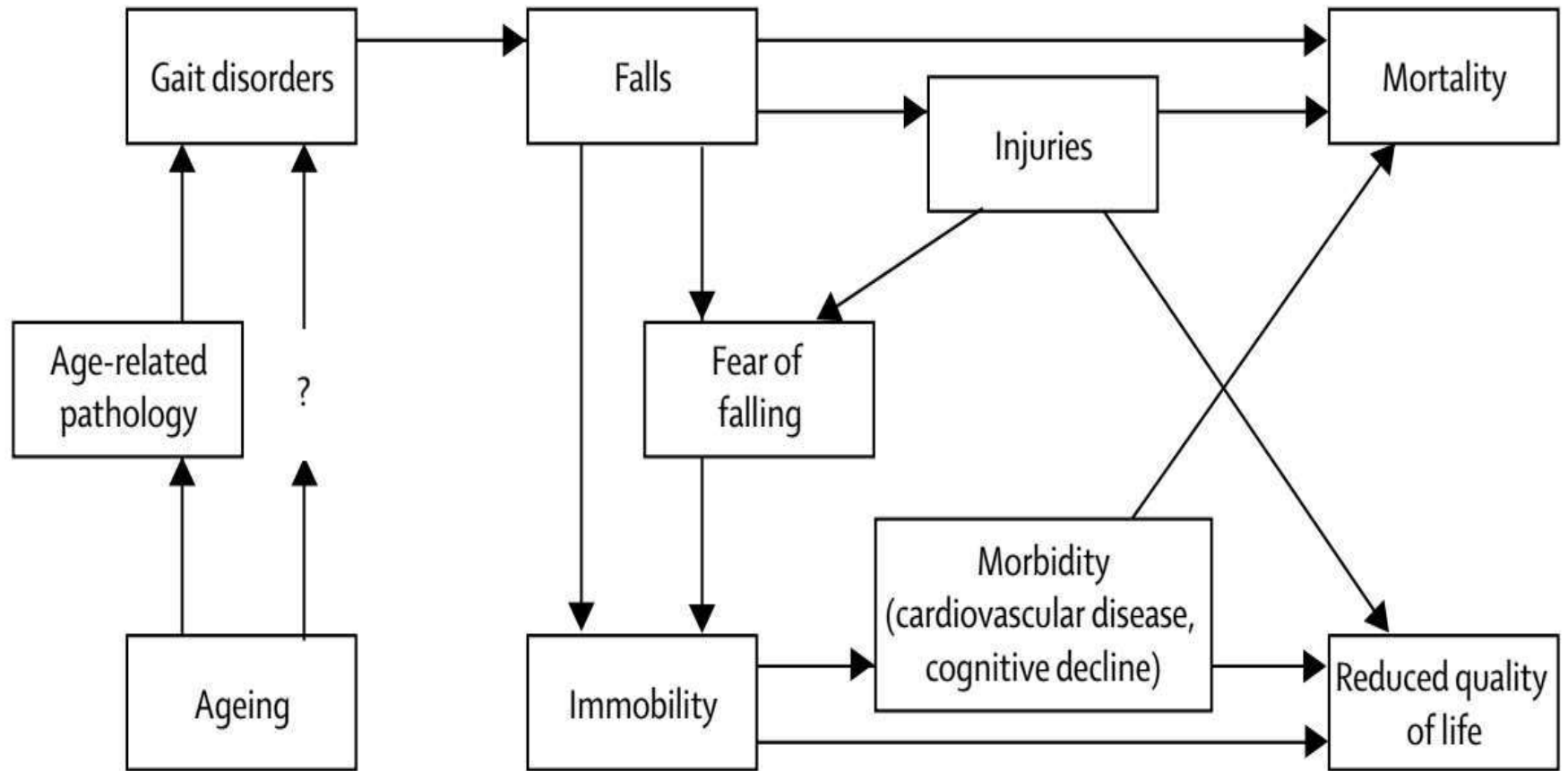


Figure 3: Indirect association between ageing and geriatric gait disorders

This association occurs mainly, if not exclusively, via the intermediate of age-related pathology. Adverse consequences of gait disorders in elderly people include reduced quality of life and, eventually, reduced survival.

Case 1: a 78 year old man

- *Chief complaint:* gait instability and repeated falls for 1 year
- Underlying disease: HT well controlled and good compliance

Gait instability and falls

What to assess?

History and
physical
examination

Normal gait

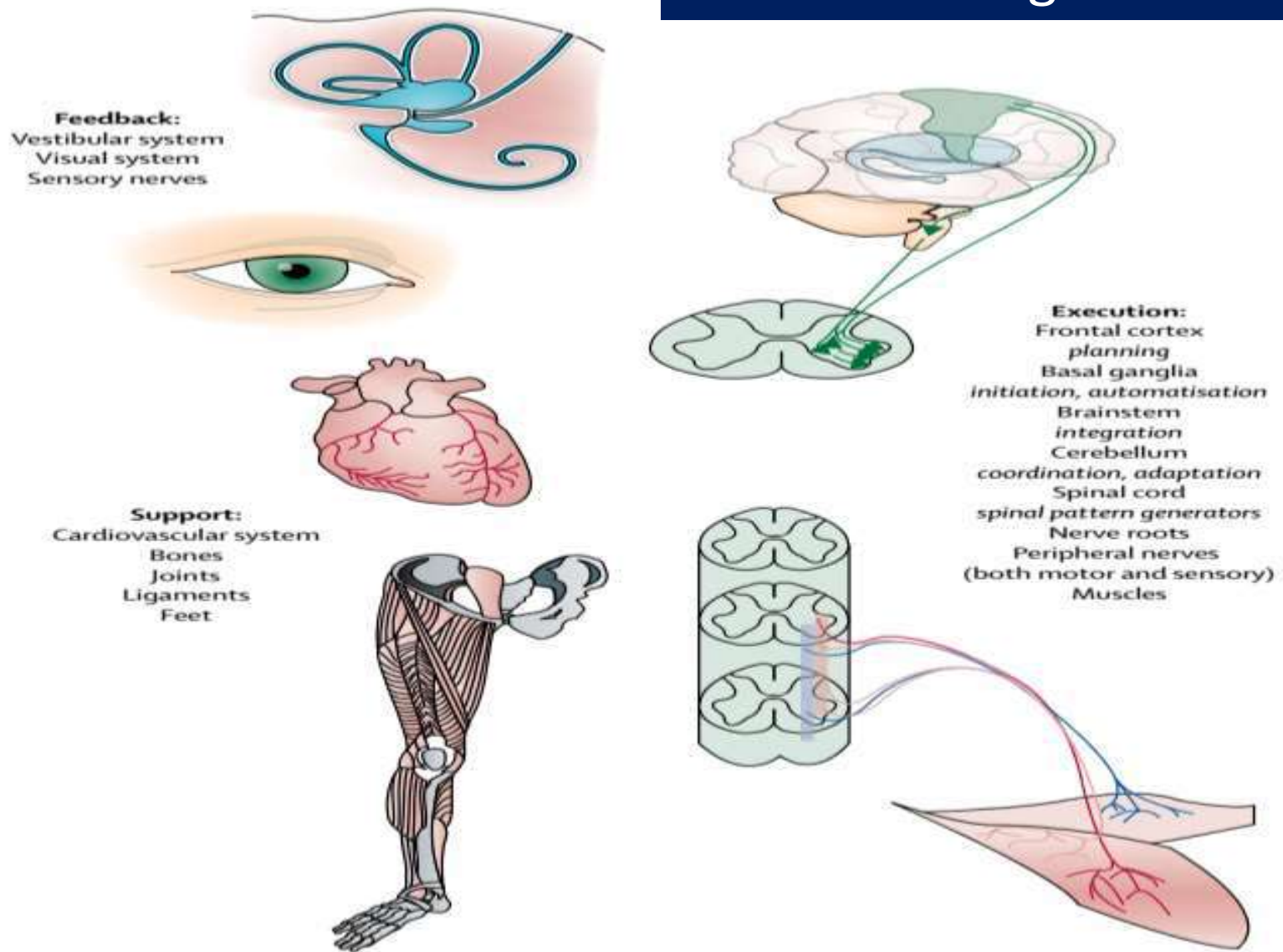


Figure 1: Levels of the central and peripheral nervous system required for normal gait

	Examples	Drawbacks
Hierarchical	Lower level Intermediate level Higher level	Term higher level often abused as basket term for any poorly understood gait disorders Subdivisions of higher level gait disorders difficult to use in clinical practice Overlap in symptoms between middle and higher level gait disorders
Anatomical	Frontal gait Cerebellar gait	Different anatomical lesions may present with similar gait patterns Any given anatomical lesion may present with different gait patterns
Aetiological	Vascular Neurodegenerative	Ancillary studies or post-mortem examination often required to make definitive diagnosis
Phenomenological	See table 1	Pathophysiology not taken into account
Table 4: Drawbacks of currently available gait classification systems		

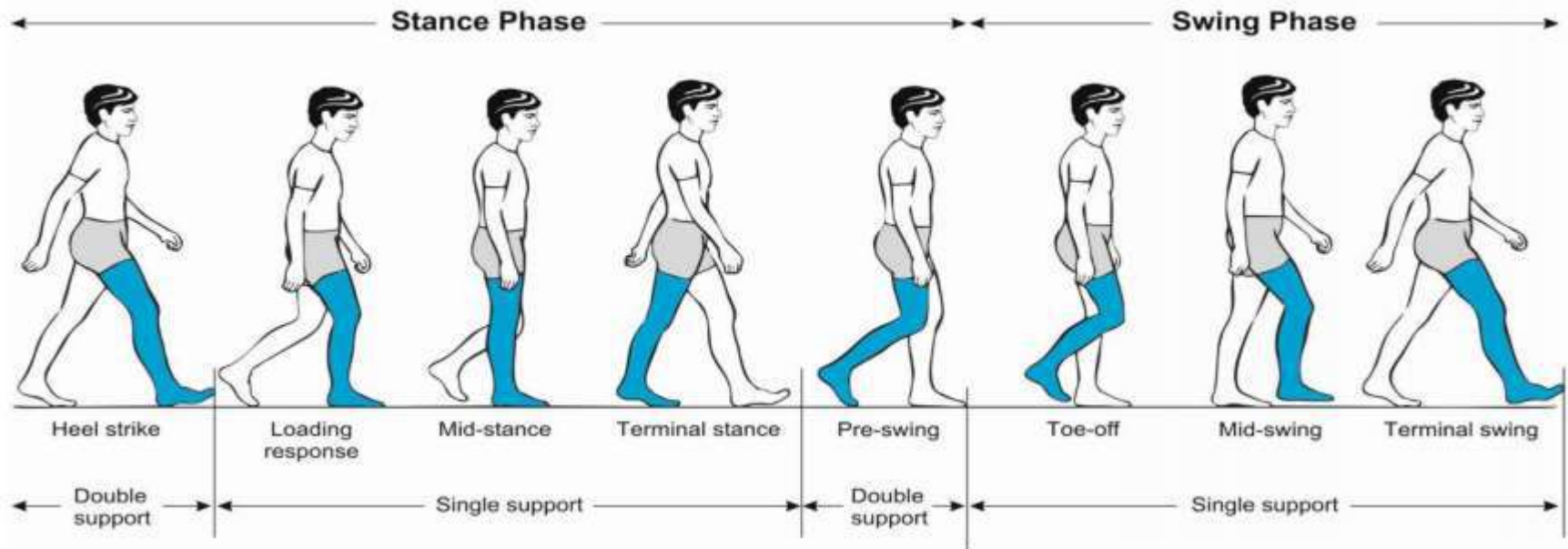


Fig. 1 Phases of the normal gait cycle

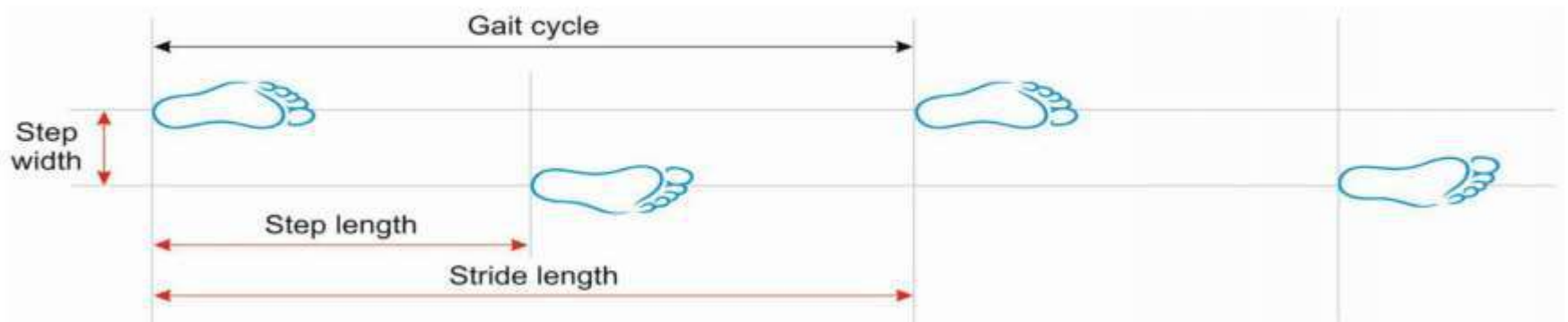


Fig. 2 Basic terminology describing the gait cycle

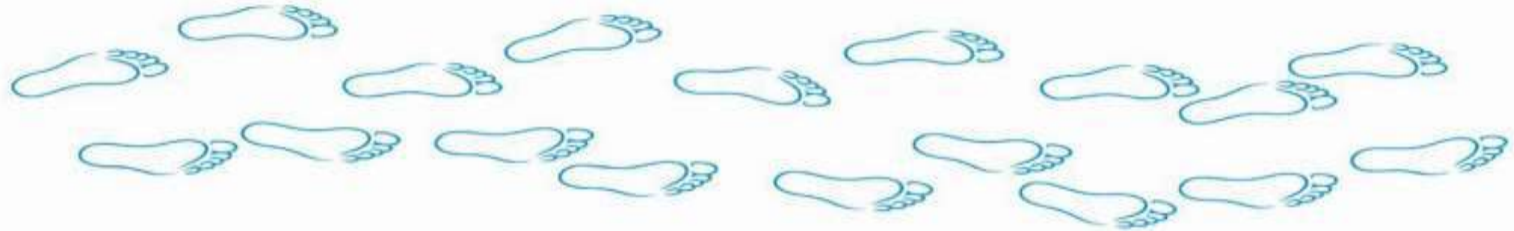
a



b



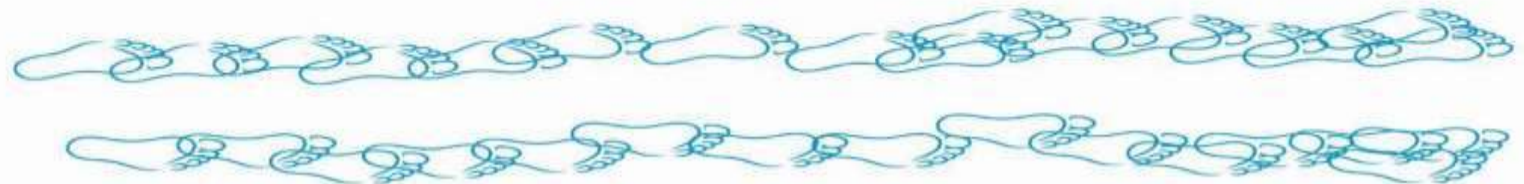
c



d



e



Parameters for the clinical examination of gait

- Sitting unaided
- Standing up from a sitting position (unaided and with/without use of upper limbs)
- Posture (trunk, neck and head, upright, bent or asymmetrical)
- Stance (narrow/wide base)
- Gait initiation (blockage)
- Walking (smooth, stiff, insecure, symmetrical, limping)
- Step length, lifting of feet, contact with ground, wide/narrow base
- Speed
- Arm swing
- Freezing
- Turning
- Postural reflexes (pull or push test)
- Sitting down (“motor recklessness”)

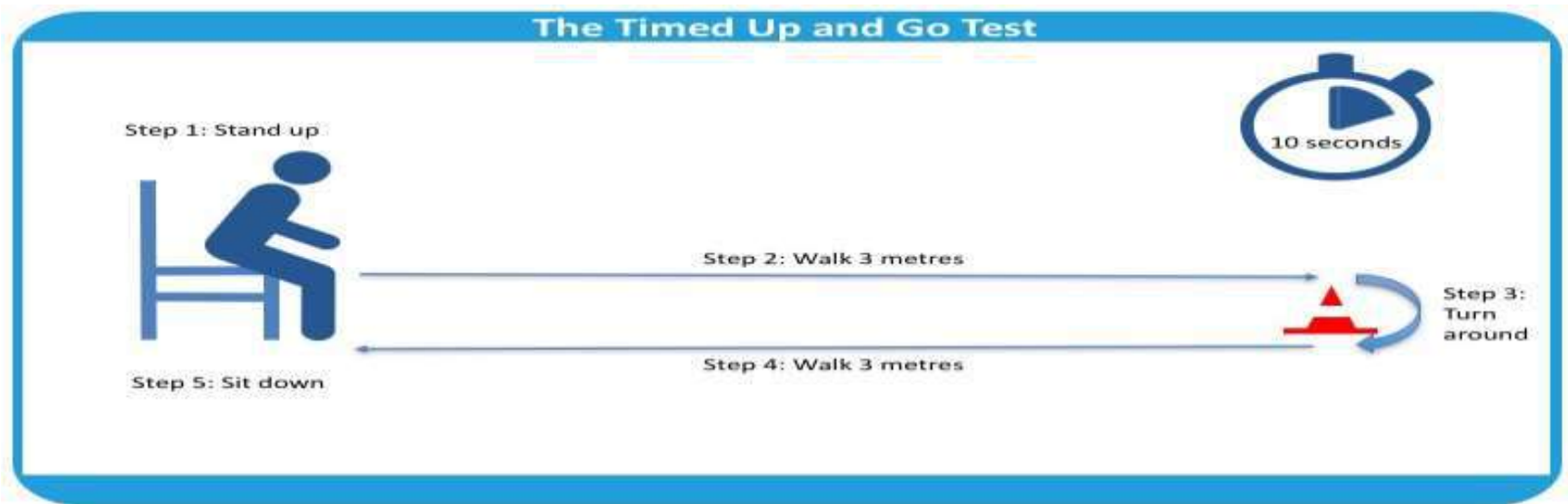
Complex tests of stance and gait

- Tandem stance
- Tandem gait
- Romberg's test (standing with eyes closed and narrow base)
- Blind gait
- Walking backwards
- Walking fast
- Walking slowly (in a deliberate manner)
- Running

- Turning quickly
- Turning on the spot
- Unterberger's test (walking on the spot with eyes closed)
- Standing and walking on heels
- Standing and walking on toes
- Hopping on one foot
- Dual task maneuver (walking while talking or carrying objects)
- Functional reach

Assessment of gait and balance

- **Get Up and Go Test (GUG)**



- **Timed Up and Go Test (TUG)*: time record**

Gait disorder	Characteristics
Hemispastic gait	Unilateral extension and circumduction
Paraspastic gait	Bilateral extension and adduction, stiff
Ataxic gait	Broad base, lack of coordination
Sensory ataxic gait	Cautious, worsening without visual input
Cautious gait	Broad based, cautious, slow, anxious
Freezing gait	Blockage, e. g. on turning
Propulsive gait	Centre of gravity in front of body, festination
Astasia	Primary impairment of stance/balance
Dystonic gait	Abnormal posture of foot/leg
Choreatic gait	Irregular, dance-like, broad-based
Steppage gait	Weakness of foot extensors
Waddling gait	Broad-based, swaying, drop of swinging leg
Antalgic gait	Shortened stance phase on affected side
Vertiginous gait	Insecure, tendency to fall to one side
Psychogenic gait disorder	Bizarre, rarely falls

Clip gait

Gait

Fall risk assessment

- **Ask the patient at least once a year about falls in a previous year**
- **If yes...then ask...**
 - Is the cause of visit because of falls?
 - Falls ≥ 2 time in a previous year
 - Have a problem with gait and balance?

Fall prevention guidelines 2012. Kaiser Foundation Health Plan of Washington.

If any “yes” → fall risk
assessment

FALLS RISK ASSESSMENT TOOL (FRAT)

UR NUMBER

SURNAME

GIVEN NAMES.....

DATE OF BIRTH

Please fill in if no patient/resident label available

(see instructions for completion of FRAT in the FRAT PACK-Falls Resource Manual)

PART 1: FALL RISK STATUS

RISK FACTOR	LEVEL	RISK SCORE
RECENT FALLS <i>(To score this, complete history of falls, overleaf)</i>	none in last 12 months.....	2
	one or more between 3 and 12 months ago.....	4
	one or more in last 3 months.....	6
	one or more in last 3 months whilst inpatient / resident....	8
MEDICATIONS <i>(Sedatives, Anti-Depressants Anti-Parkinson's, Diuretics Anti-hypertensives, hypnotics)</i>	not taking any of these.....	1
	taking one	2
	taking two	3
	taking more than two.....	4
PSYCHOLOGICAL <i>(Anxiety, Depression ↓Cooperation, ↓Insight or ↓Judgement esp. re mobility)</i>	does not appear to have any of these.....	1
	appears mildly affected by one or more.....	2
	appears moderately affected by one or more.....	3
	appears severely affected by one or more.....	4
COGNITIVE STATUS <i>(AMTS: Hodkinson Abbreviated Mental Test Score)</i>	AMTS 9 or 10 / 10 OR intact.....	1
	AMTS 7-8 mildly impaired.....	2
	AMTS 5-6 mod impaired.....	3
	AMTS 4 or less severely impaired	4
(Low Risk: 5-11 Medium: Risk: 12-15 High Risk: 16-20)		RISK SCORE
		/20

PART 2: RISK FACTOR CHECKLIST		Y/N
Vision	Reports / observed difficulty seeing - objects / signs / finding way around	
Mobility	Mobility status unknown or appears unsafe / impulsive / forgets gait aid	
Transfers	Transfer status unknown or appears unsafe ie. over-reaches, impulsive	
Behaviours	Observed or reported agitation, confusion, disorientation	
	Difficulty following instructions or non-compliant (observed or known)	
Activities of Daily Living (A.D.L's)	Observed risk-taking behaviours, or reported from referrer / previous facility	
	Observed unsafe use of equipment	
	Unsafe footwear / inappropriate clothing	
Environment	Difficulties with orientation to environment i.e. areas between bed / bathroom / dining room	
Nutrition	Underweight / low appetite	
Continence	Reported or known urgency / nocturia / accidents	
Other		

History taking

Multifactorial falls risk assessment

- **Fall-related**

- History of falls
- Activity at time of fall(s)
- Prodromal symptoms
- Location and time of fall(s)
- Environment
- Injury from falls

- **Underlying disease eg CVS, HT, Neuro problem**
- **Medication history (new, changed, high-risk meds)**
- **Previous gait instability**
- **Previous function**
- **Bowel and bladder control**
- **Cognitive function**

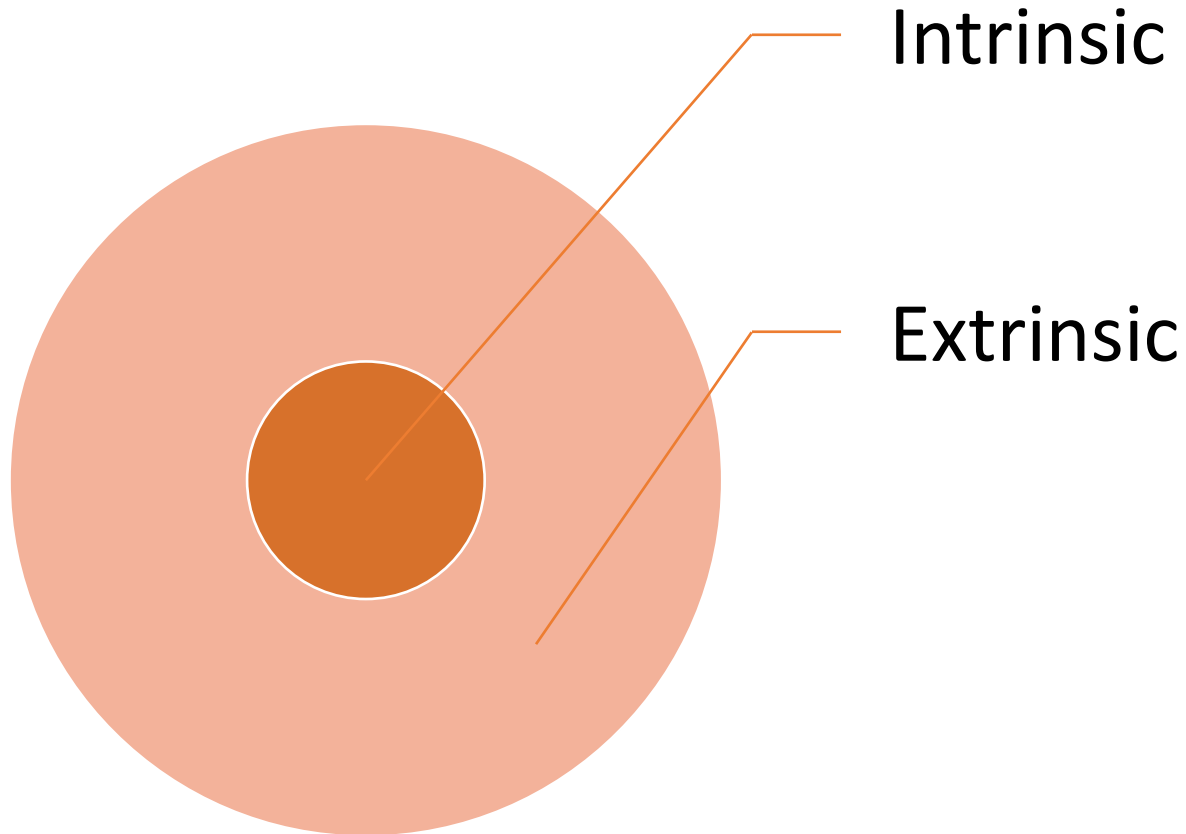
Environmental risk

- Old, unstable, and low-lying furniture
- Beds and toilets of inappropriate height
- Grab bars
- Uneven stairs and inadequate railing
- Rugs, carpets, cords, wires
- Slippery floors and bathtubs
- Lighting or glaring
- Cracked and uneven sidewalks
- Pets
- Toys

Physical examination

- Cardiovascular system: pulse, BP/orthostatic hypotension (supine/upright)
- Nervous system: muscle tone, power, cerebellar signs
- Musculoskeletal system: spine, foot, joint
- Vision
- Gait and balance

Causes of falls



Accident = true or interaction ?

WHO Global Report on Fall
Prevention in Older Age 2008

Behavioral
factor

- Polypharmacy
- Excess alcohol intake
- Lack of exercise
- Inadequate footwear

Biological
factors

- Age, gender, race
- Chronic illnesses eg PD, OA
- Physical, cognitive, affective capacities decline

Environmental
factors

- Poor building design
- Slippery floor and stairs
- Looser rugs
- Insufficient lighting
- Cracked or uneven sidewalk

Socioeconomic
factors

- Low income, educational level
- Inadequate housing
- Lack of social interaction
- Limited access to health and social services
- Lack of community resources

Causes of falls

- **Situational factors**

- Acute host factors
- Environmental hazards

- **Predisposing factors**

- **NS:**
 - **Central nervous system** (eg. Parkinson, Stroke, cerebellar diseases, dementia, spinal cord)
 - **Peripheral nervous system:** neuropathy, vision/ vertigo
- **Musculoskeletal problems:** spine, joint, foot
- **CVS:** orthostatic hypotension, arrhythmia, etc
- **Medications:** sedatives/ anticholinergics, antihypertensives

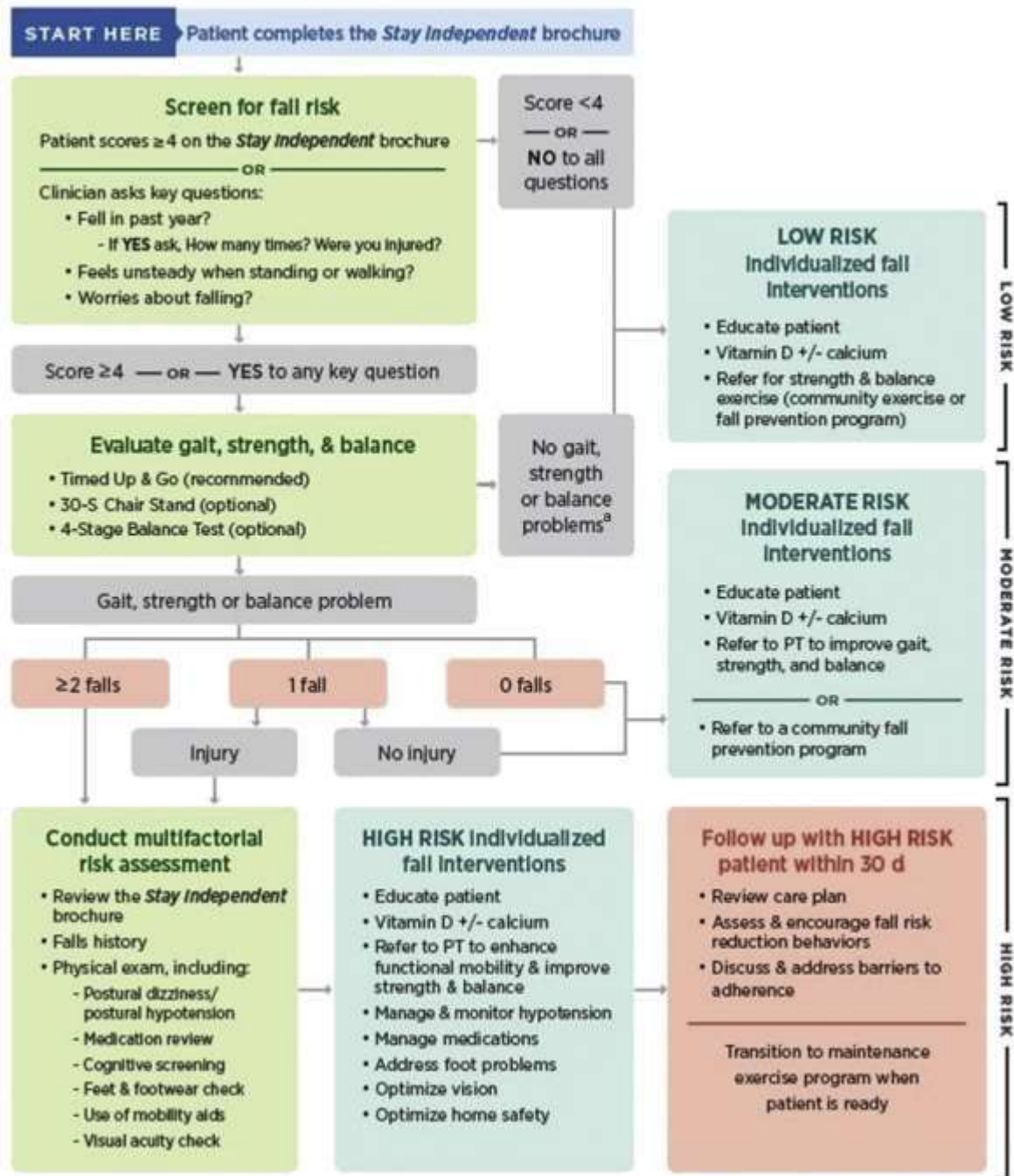
Drugs and fall risk

Drug class	Odds ratio	95% CI
Antihypertensive agents	1.24	1.01–1.50
Diuretics	1.07	1.01–1.14
B blockers	1.01	0.86–1.17
Sedatives and hypnotics	1.47	1.35–1.62
Neuroleptics and antipsychotics	1.59	1.37–1.83
Antidepressants	1.68	1.47–1.91
Benzodiazepines	1.57	1.43–1.72
Narcotics	0.96	0.78–1.18
Nonsteroidal anti-inflammatory drugs	1.21	1.01–1.44

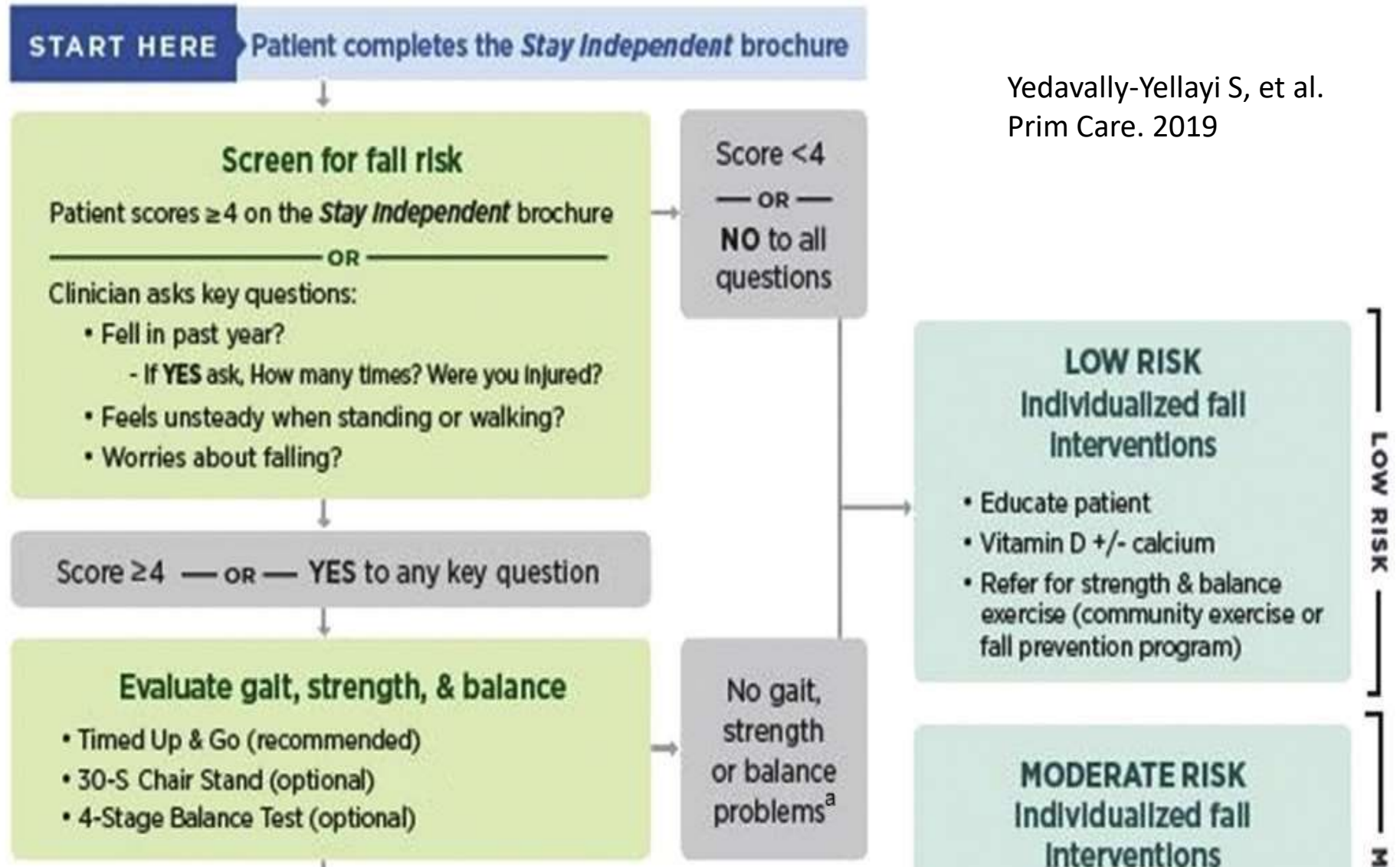
Risk factors for falls

- Female gender, low body weight, age >80 years
- Number of falls in previous year/month
- Use of sedatives, particularly with long half-life
- Limited physical activity
- Difficulties rising from sitting position
- Reduced muscle strength in the lower limbs
- Impaired balance
 - Standing
 - Walking
 - Turning
- Impaired postural reflexes
- Impaired vision
- Impaired cognitive functions, depression, anxiety

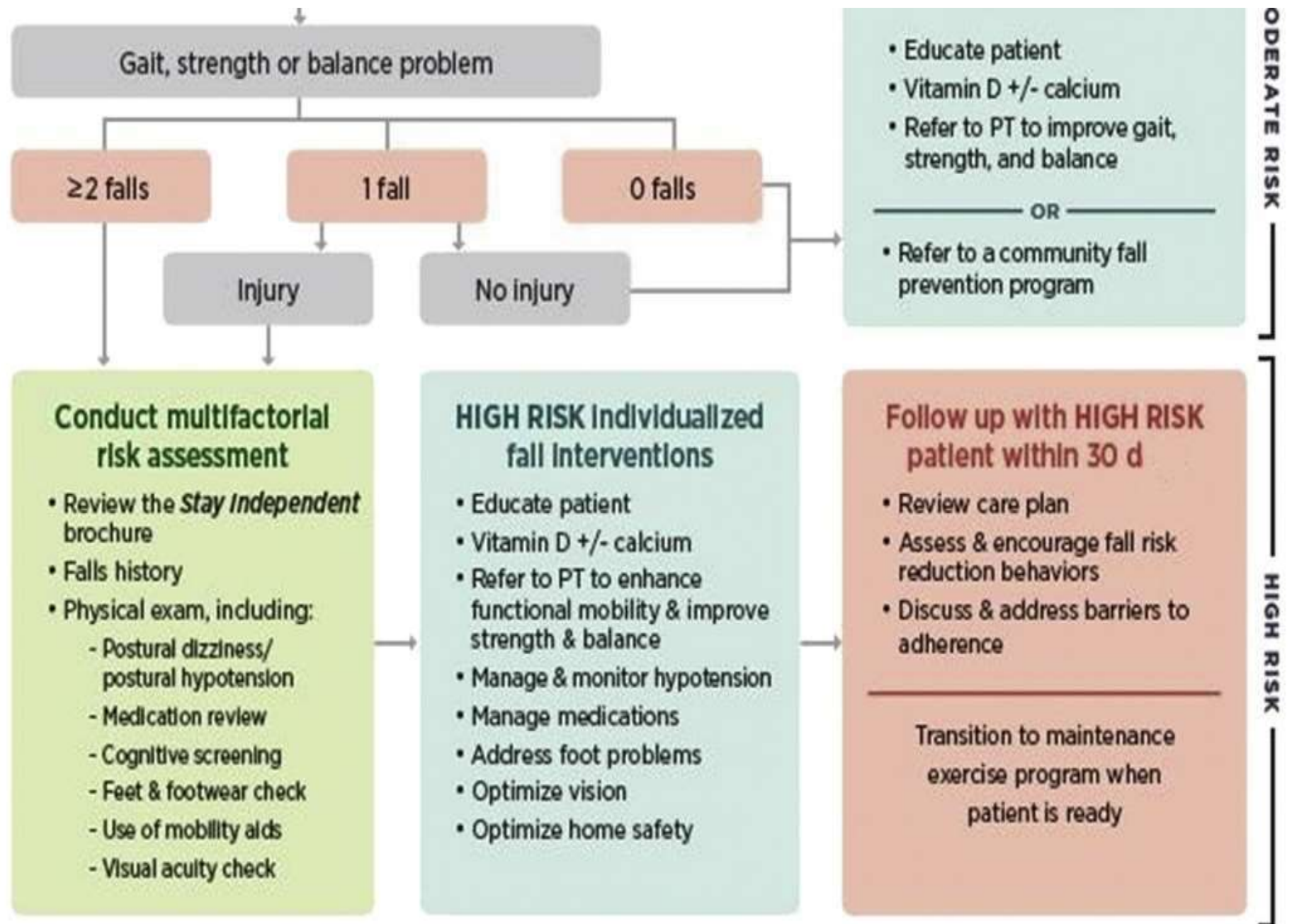
Algorithm for Fall Risk Screening, Assessment, and Intervention



Algorithm for Fall Risk Screening, Assessment, and Intervention



Yedavally-Yellayi S, et al.
Prim Care. 2019



Fall prevention in older people

1. **Primary prevention:** health promotion/disease prevention in those who have no history of falls and no fall risk
2. **Secondary prevention:** assessment of fall risk for early detection of those who are at risk
3. **Tertiary prevention:** prevention of recurrent falls, to reduce the complication of falls

General measures to prevent falls and fall-related injuries

- Check entire list of medication
- Avoid sedatives, particularly with long half-life
- Avoid (classical) neuroleptics and tricyclic antidepressants
- Check the indications for and dose of atypical neuroleptics
- Increase physical activity
- Healthy diet, avoid malnutrition and overweight
- Muscle training
- Balance training

- Anxiolytic and antidepressant therapy
- Behavioral therapy for anxiety, depression and dementia
- Therapy of orthostatic hypotension
- Treatment for osteoporosis
- Adequate footwear
- Protective devices such as hip protectors
- Remove risks at home and adjust personal environment
- Electronic warning systems

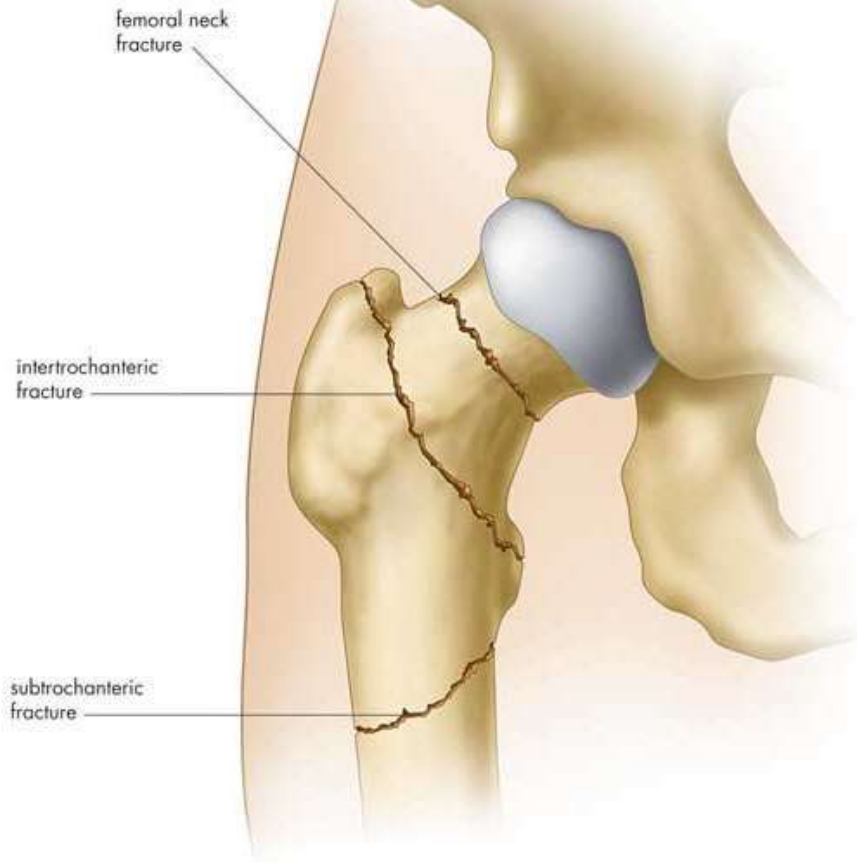
USPSTF recommendations 2018

- Recommends **exercise interventions** to prevent falls in community-dwelling adults 65 years or older who are **at increased risk** for falls. (B recommendation)
- Clinicians selectively offer **multifactorial interventions** to prevent falls in community-dwelling adults 65 years or older who are **at increased risk** for falls.
- Recommends **against vitamin D supplementation to prevent falls** in community-dwelling adults 65 years or older. (D recommendation) ... **who are not known to have osteoporosis or vitamin D deficiency**

Case 2: Osteoporosis and fracture

Clip falls

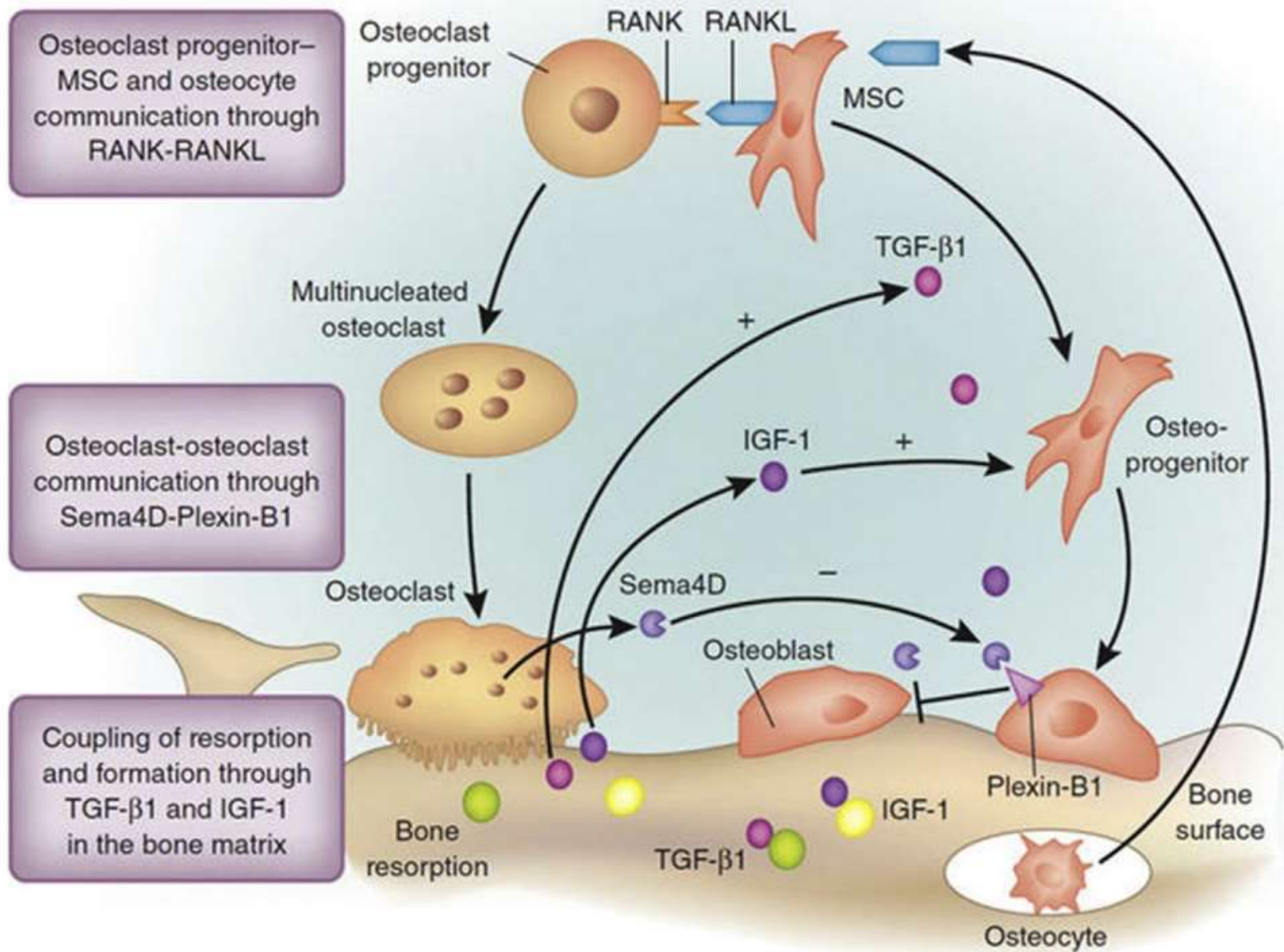
Figure 1:
Osteoporosis fracture prevention



Bone support and fracture prevention



Osteoporosis



Risk of osteoporosis?

Nonmodifiable Risk Factors for Osteoporosis

- Family history
- Race: Asian or Caucasian
- Advanced age
- Being female
- Low body weight <127 lb (<57.7 kg)

Modifiable Risk Factors for Osteoporosis

- Cigarette smoking
- Excessive use of alcohol
- Insufficient calcium and vitamin D intake
- Inadequate physical activity
- Estrogen or testosterone deficiency
- Chronic use of glucocorticoids*

Predisposing Conditions for Osteoporosis

- Endocrine
 - Cushing's syndrome
 - Hyperthyroidism
 - Estrogen or testosterone deficiency
- Renal
 - Renal failure or insufficiency
- Rheumatologic
 - Ankylosing spondylitis
 - Rheumatoid arthritis
- Gastrointestinal
 - Gastrectomy
 - Malabsorption

Medications Associated With an Increased Risk for Osteoporosis

- Glucocorticoids
- Heparin (long-term use)
- Anticonvulsants
- Lithium
- Immunosuppressants (eg, methotrexate, cyclosporine)
- Cytotoxic drugs
- Tamoxifen (premenopausal use)
- Excessive thyroxine
- Gonadotropin-releasing hormone agonists

T-Score cutoffs

Status	T-score
Normal	+2.5 to -1.0 inconclusive
Low bone mass (osteopenia)	Between -1.0 and -2.5
Osteoporosis	≤ -2.5
Severe osteoporosis	≤ -2.5 and fragility fracture

Screening for osteoporosis

- **Clinical risk factors**
- **Osteoporosis self-assessment tool for Asians (OSTA) index**
- **Nomogram for osteoporosis**
- **Bone mineral density (BMD)**

Clinical Risk Assessment Tools for Osteoporosis

- FRAX=Fracture Risk Assessment Tool
- ORAI=Osteoporosis Risk Assessment Instrument
- OSIRIS=Osteoporosis Index of Risk
- OST=Osteoporosis Self-Assessment Tool
- SCORE=Simple Calculated Osteoporosis Risk Estimation

FRAX score

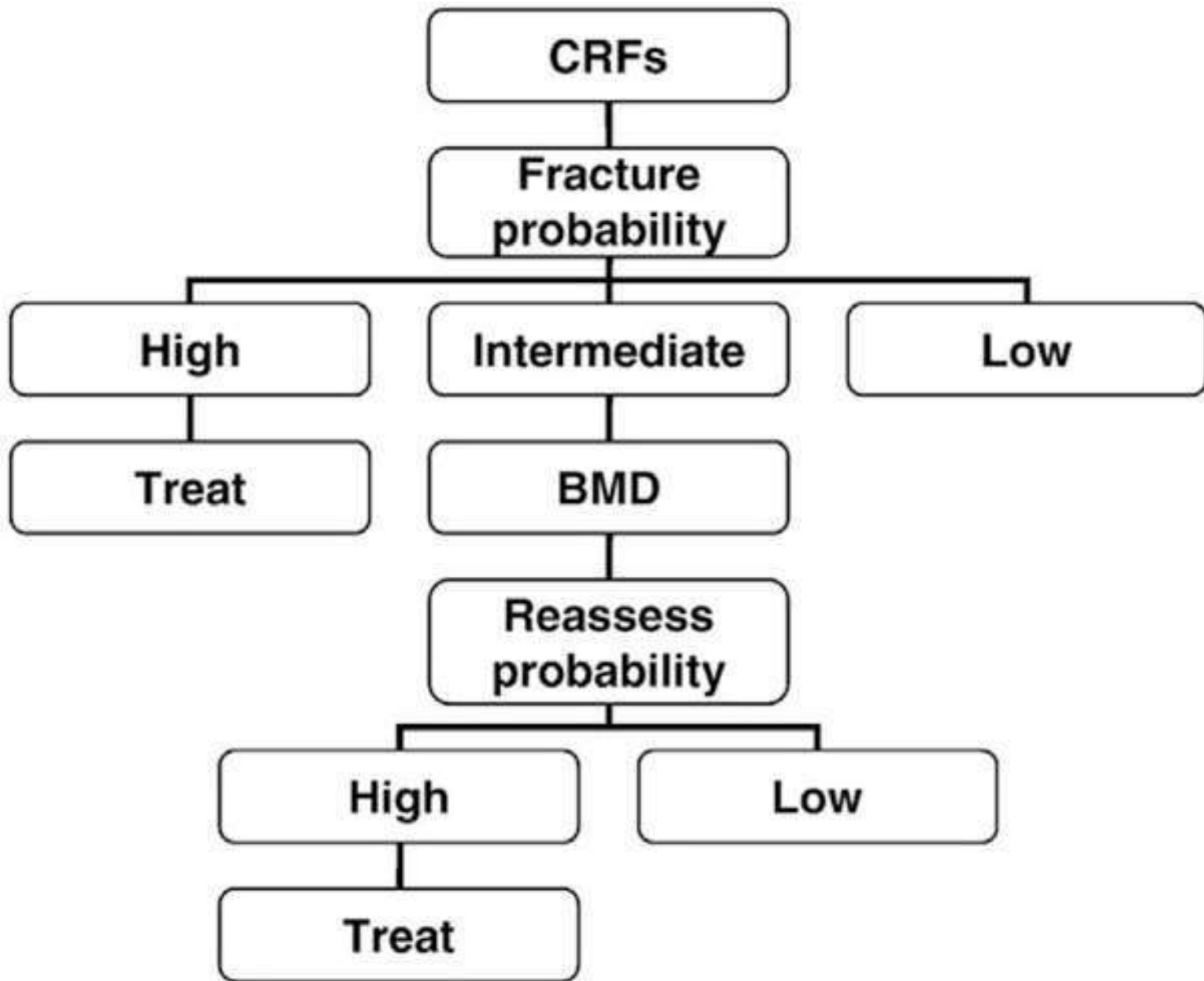
- **FRAX™** computer program
- <http://www.shef.ac.uk/FRAX/tool.jsp>
- **2 values:**
 - **10-year probability of hip fracture**
 - **10-year probability of other major osteoporotic fractures**
- **Use for estimation of therapeutic threshold**

DMS: OSTA

- **osteoporosis self-assessment tool for Asians (OSTA) index**
- **$0.2 \times (\text{Body weight} - \text{age})$**
- **If < -4 : at risk**

Screening recommendations

	Women	Men
National Osteoporosis Foundation (NOF)	<p>DEXA testing for all women >65 y old and postmenopausal women <65 y old, based on risk factor profile, younger postmenopausal women, women in menopausal transition</p> <ul style="list-style-type: none"> • DEXA testing for adults who have a fracture after age 50 y • DEXA testing for adults with a condition (eg, rheumatoid arthritis) or taking a medication (eg, glucocorticoids in a daily dose 5 mg prednisone or equivalent for 3 mo) associated with low bone mass or bone loss 	<p>DEXA testing for all men >70 y old, regardless of risk factor profile, and men age 50–69 y old with clinical risk factors for fracture</p>
US Preventive Services Task Force (USPSTF)	<ul style="list-style-type: none"> • BMD testing for all women >65 y old • BMD testing in women younger than 65 y old who are at increased risk osteoporosis as determined by a formal clinical risk assessment tool 	<p>Insufficient evidence to assess the balance of benefits and harms of screening in men</p>
UK National Osteoporosis Guidelines Group (NOGG)	<p>Does not recommend population screening. Fracture probability should be assessed in postmenopausal women using FRAX</p> <ul style="list-style-type: none"> • In individuals at intermediate risk, BMD testing using DEXA should be performed and fracture probability reassessed using FRAX. • Vertebral fracture assessment should be considered in postmenopausal women and men age >50 y if there is a history of 4 cm height loss, kyphosis, recent or current long-term oral glucocorticoid therapy, or a BMD T score of -2.5 	<p>Fracture probability should be assessed in men >50 y who have risk factors for fracture using FRAX</p>
<ul style="list-style-type: none"> • American Academy of Pain Medicine (AAPM) • American Association of Clinical Endocrinologists (AACE) • American Orthopaedic Association (AOA) • American Society for Bone and Mineral Research (ASBMR) • International Society for Clinical Densitometry (ISCD) 	<ul style="list-style-type: none"> • Measure height annually • NOF guidelines (as above) • Vertebral imaging in special populations (as above) 	



Most Common Bone Measurement Screening Tests for Osteoporosis

Screening Test	Description	Other Considerations
Central DXA	Most commonly studied and used bone measurement test to screen for osteoporosis; reference to which other tests are compared; uses radiation to measure BMD at the hip and lumbar spine	Most treatment guidelines recommend using BMD, as measured by central DXA, to define osteoporosis and the treatment threshold to prevent osteoporotic fractures
Peripheral DXA	Uses radiation to measure BMD at peripheral sites, such as the lower forearm and heel ; similar accuracy to that of central DXA (AUC, 0.67-0.80 in women with a mean age of 61 years [2 studies; n = 712])	Measured with portable devices , which may help increase access to screening in locations where machines that perform central DXA are not available; no treatment studies reviewed by the USPSTF used BMD measured by peripheral DXA to define treatment threshold
QUS	Uses ultrasound to evaluate peripheral bone sites (most commonly, the calcaneus); similar accuracy to that of central DXA (pooled AUC: 0.77 in women [7 studies; n = 1969] and 0.80 in men [3 studies; n = 5142])	No exposure to radiation ; measured with portable devices , which may help increase access to screening in locations where machines that perform central DXA are not available; does not measure BMD, and no treatment studies use QUS measurements to define treatment threshold; cannot be routinely used to initiate treatment without further DXA measurement

The utility of BMD as a clinical indicator of osteoporosis is limited, because BMD is only one of a number of important risk factors for fracture, and the majority of fragility fractures occur in individuals with BMD values above this threshold

Prevention & treatment of osteoporosis

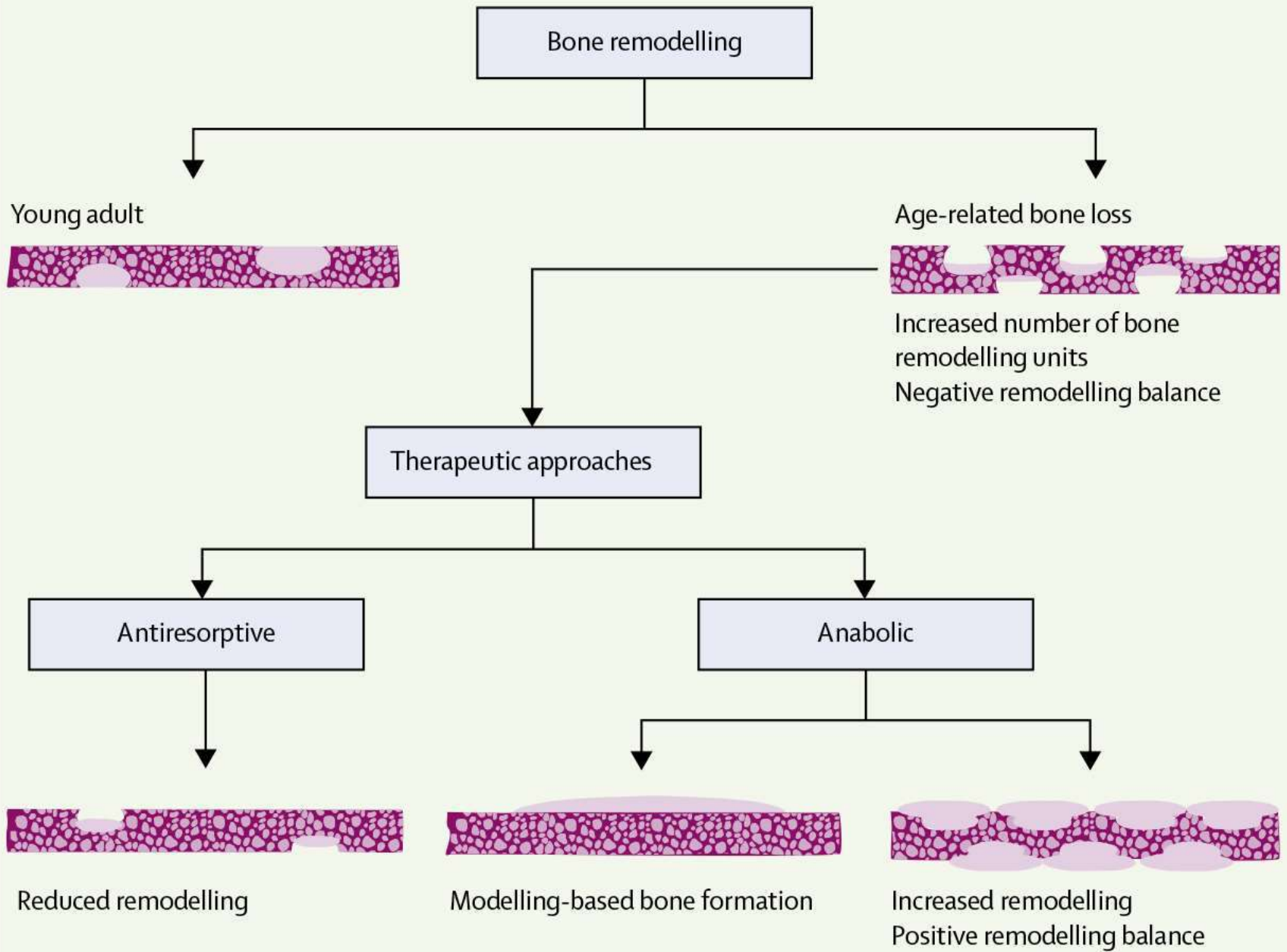
- **Primary prevention:** increase BMD to as high as possible before natural decline
- **Secondary prevention:** prevent decline of BMD before developing osteoporosis & prevent 1st fracture
- **Tertiary prevention:** prevent further BMD loss in osteoporotic pts. & prevent recurrent fracture

Management of osteoporosis

- **Exclude secondary causes as appropriate**
- **All patients should have adequate calcium and vitamin D supplementation**
- **Avoid excessive alcohol intake and all tobacco products**
- **Receive falls prevention counseling**
- **Engage in regular weight-bearing exercise**

Guidelines for treatment of osteoporosis

- History of hip or vertebral fracture
- T-score greater than or equal to -2.5 (DXA) at the femoral neck or spine
- T-score between -1 and -2.5 at the femoral neck or spine, and a 10-year probability of hip fracture 3% or a 10-year probability of any major osteoporosis-related fracture 20% based on the US-adapted FRAX algorithm



Drug treatment for osteoporosis

- **Calcium and vitamin D**
- **Pharmacologic Options**
 - ✓ **Bisphosphonates**
 - ✓ **RANKL inhibitor**
 - ✓ **Estrogen**
 - ✓ **Selective estrogen receptor modulators**
 - ✓ **Parathyroid hormone receptor agonists**
 - ✓ **Calcitonin**
 - ✓ **Investigational agents**

Vitamin D and calcium intake recommendations

Vitamin D

All individuals >50 y

800–1000 IU daily

Calcium

Men 50–70 y old

1000 mg daily

Men \geq 71 y

1200 mg daily

Women \geq 51 y

1200 mg daily

		Route of administration	Fracture risk reduction*		
			Vertebral	Hip	Non-vertebral
Bisphosphonate ^{110,111}					
Alendronate		Oral once daily or weekly	Yes	Yes	Yes
Risedronate		Oral once daily, weekly, or monthly	Yes	Yes	Yes
Ibandronate		Oral once monthly or intravenous every 3 months	Yes†	ND‡	ND‡
Zoledronic acid		Intravenous once yearly	Yes	Yes	Yes
RANK ligand inhibitor					
Denosumab ¹¹²		Subcutaneous injection every 6 months	Yes	Yes	Yes
Oestrogen§ ¹¹³					
Estradiol, estropipate, conjugated oestrogen		Oral, transdermal, implant	Yes	Yes	Yes
Selective oestrogen receptor modulators					
Raloxifene ¹¹⁴		Oral once daily	Yes	ND‡	No
Bazedoxifene ¹¹⁵		Oral once daily	Yes	ND‡	No
Bazedoxifene and conjugated oestrogen¶ ¹¹⁶		Oral once daily	No	No	No
Parathyroid hormone receptor agonist					
Teriparatide ¹¹⁷		Subcutaneous injection daily	Yes	ND‡	Yes
Abaloparatide (only available in the USA) ¹¹⁸		Subcutaneous injection daily	Yes	ND‡	Yes

ND=not determined. *Significant fracture risk reduction in primary analysis of a clinical trial. †Fracture risk reduction only shown with oral dosing. ‡Studies not powered to observe effect on hip or non-vertebral fracture risk. §Fracture risk reduction observed in low-risk women; approved for prevention but not treatment of osteoporosis.

¶No evidence of fracture prevention with this preparation; approved in some countries for prevention but not treatment of postmenopausal osteoporosis.

Table 3: Approved pharmacological interventions for osteoporosis

Adverse events		Contraindications and important warnings
Bisphosphonate	Common: upper gastrointestinal adverse reactions with oral dosing, acute phase reaction with intravenous dosing; uncommon: bone, joint and muscle pain; rare: eye inflammation, femoral shaft or subtrochanteric fractures with atypical radiographic features, osteonecrosis of the jaw	Hypersensitivity, hypocalcaemia; oral drugs: oesophageal abnormalities that delay emptying, inability to remain upright; zoledronic acid: impaired renal function (creatinine clearance less than 35 mL/min); warning: patients with severe renal impairment should use oral drugs with caution
RANK ligand inhibitor	Uncommon: skin rash; rare: cellulitis, femoral shaft or subtrochanteric fractures with atypical radiographic features, osteonecrosis of the jaw	Hypocalcaemia, pregnancy, hypersensitivity; warning: multiple vertebral fractures have occurred when denosumab has been discontinued
Oestrogen	Breast pain, headache, oedema	Undiagnosed uterine bleeding, breast cancer, oestrogen-dependent neoplasia, venous or arterial thromboembolic disease or thrombophilic disorders, substantial liver impairment, pregnancy
Selective oestrogen receptor modulators	Common; vasomotor symptoms, muscle cramps; uncommon: venous thrombosis	Venous thromboembolism, pregnancy
Parathyroid hormone receptor agonist	Common: muscle cramps, increased serum or urine calcium or serum uric acid; uncommon: orthostatic hypotension	Hypersensitivity, nephrolithiasis; warnings: should not be used in children or adolescents with open epiphyses, or patients with Paget's disease of bone, previous external beam or implant radiation involving the skeleton, bone metastases, history of skeletal malignancies, other metabolic bone diseases, or hypercalcaemic disorders; maximum duration of therapy over patient's lifetime is 24 months

Table 4: Adverse events and contraindications for approved pharmacological interventions for osteoporosis

Management of individuals on long-term bisphosphonate therapy

Compston JE, et al. Lancet 2019

