Age-Related Balance Decline (Presbystasis):

A Vestibular Physician's Deep Review of Presbyvestibulopathy, Multisensory Loss, and Fall Prevention

Vestibular Medicine for Vestibular Physicians

Systemic & Multisensory Balance Disorders — Module 4.3

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How to Use This Review

This literature review forms part of the Vestibular Medicine for Vestibular Physicians series published by the Australian Dizziness Clinics Education Hub. It is written for vestibular physicians, neuro-otologists, advanced ENT trainees, and vestibular physiotherapists working at the deep end of multisensory and systemic vestibular practice, where a working command of mechanism, criteria, and atypical presentations is expected rather than optional.

The review is dense by design — intended as a 30–40 minute deep read or a desktop reference. It is supported by an A4 clinician cheat sheet, short-form clinician videos, audio episodes, and a patient information leaflet within the same Education Hub module.

Callout Box Guide

☐ **Key Point:** Foundational concepts and summary statements that anchor the core clinical content of each section.

☐ **Clinical Insight:** Clinically relevant observations for direct application in assessment and management.

☐ **Clinical Pearl:** High-yield memorable clinical points — the take-home messages most likely to change practice.

☐ **Important:** Red flags, atypical presentations, and critical safety points requiring escalation or imaging.

Table of Contents

I. Introduction and Epidemiology

Age-related balance decline — described clinically as presbystasis and, in its vestibular-specific form, as presbyvestibulopathy — is among the most prevalent yet systematically under-recognised causes of morbidity in adults aged 60 years and older [1,2]. Unlike discrete peripheral vestibular disorders such as benign paroxysmal positional vertigo (BPPV) or vestibular neuritis, presbystasis does not arise from a single lesion but reflects the progressive, cumulative attrition of multiple sensory and motor subsystems that collectively underpin postural stability [3,4]. Vestibular physicians encounter this condition daily yet it is frequently mis-labelled as 'non-specific dizziness', 'multifactorial imbalance', or attributed entirely to medication or comorbidity without formal vestibular assessment.

Population-based data establish a steep age gradient. Dizziness and unsteadiness affect approximately 30% of adults aged 60-69, rising to over 50% in those aged 80 or older [1,5]. A landmark analysis of US National Health and Nutrition Examination Survey data by Agrawal and colleagues demonstrated that 35% of adults aged 40 years or older — equivalent to 69 million Americans — had vestibular dysfunction on posturographic testing, with prevalence doubling in each succeeding decade [6]. The subset fulfilling Barany Society criteria for presbyvestibulopathy has been estimated at 14-35% of community-dwelling adults aged 70 and above, though ascertainment varies widely with the diagnostic criteria applied [7,8].

Table 1. Epidemiology of age-related balance decline and presbyvestibulopathy.

Measure	Estimate	Source / Notes
Dizziness prevalence, age 60-69	~30%	Community survey data [1,5]
Dizziness prevalence, age >=80	>50%	Community survey data [1,5]
Vestibular dysfunction age >=40 (posturography)	35% (69 million US adults)	Agrawal et al. 2009 [6]
Presbyvestibulopathy, community age >=70	14-35%	Varies with criteria used [7,8]
Falls prevalence, age >=65	~30% per year	WHO; 50% in age >=80 [9]
Annual fall-related mortality (US)	~36,000 deaths	CDC WISQARS 2020 [10]

The burden of presbystasis is measured most starkly through falls epidemiology. Approximately one in three community-dwelling adults aged 65 and older falls each year, rising to one in two for those aged 80 and above [9]. Falls are the leading cause of injury-related death in older adults, accounting for approximately 36,000 deaths annually in the United States alone [10]. Critically, vestibular dysfunction is an independent predictor of falls in this population — adults with vestibular impairment carry significantly higher odds of falling than age-matched controls even after adjustment for vision, cognition, medication, and musculoskeletal status [6,11,12].

The economic costs are substantial. Direct medical costs of fall-related injuries in the United States exceeded USD 50 billion annually in pre-2020 estimates, and this figure does not capture indirect costs including informal caregiving, residential care transitions, and loss of productive capacity [10,13]. The disability-adjusted life-years attributable to vestibular dysfunction in older adults rival those of many better-funded neurological conditions. Early detection and multidomain intervention can reduce fall rates by 20-40%, making presbystasis a high-value public health target [14].

☐ **Key Point:** Presbystasis and presbyvestibulopathy are not diagnoses of exclusion applied when a specific disorder cannot be found — they are defined entities with formal Barany Society criteria, measurable functional impact, and evidence-based treatments that reduce falls and improve quality of life.

Sex and racial differences in presbystasis prevalence are increasingly recognised. Women report subjective dizziness and unsteadiness at higher rates than men across all age groups, a pattern partially explained by higher rates of osteoporosis, sarcopenia onset, and hormonal effects on vestibular end-organ function [2,7]. Data from the Hispanic Community Health Study and the Health and Retirement Study indicate that Hispanic and African American older adults carry a higher burden of falls and balance-related disability than non-Hispanic white adults, attributed to higher prevalences of diabetes, hypertension, and polypharmacy rather than intrinsic vestibular differences [3,8]. Multimorbidity substantially amplifies fall risk: each additional chronic condition in an older adult with established vestibular loss is associated with a 15–20% incremental increase in annual fall probability [3,8]. These data underscore that presbystasis cannot be managed in isolation from the patient's global medical context — a principle that drives the multidisciplinary assessment model detailed in Section VIII.

II. Pathophysiology — Age-Related Changes in Vestibular, Visual, and Proprioceptive Systems

The balance system integrates afferent signals from three principal sensory channels — the vestibular labyrinth, the visual system, and the somatosensory / proprioceptive system — within the brainstem, cerebellum, and cortex to generate motor commands that maintain postural stability [3,15]. In young adults, this system demonstrates substantial redundancy: loss of one channel can be compensated by the remaining two, a phenomenon known as sensory reweighting [16]. Ageing degrades each channel independently and, critically, impairs the central reweighting mechanism itself, so that the organism becomes progressively less able to substitute an intact modality for a failing one [3,16].

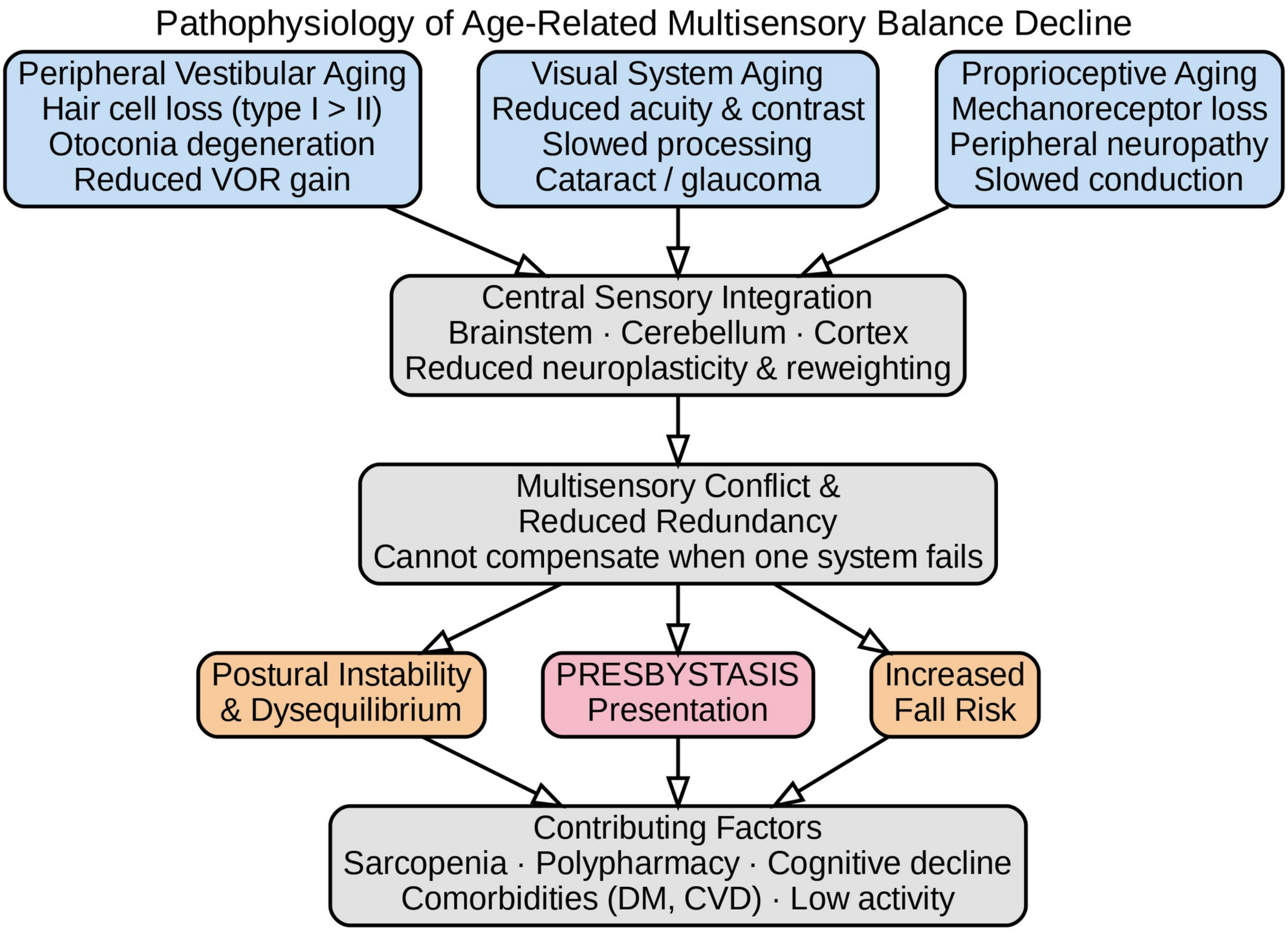

Figure 1. The triad model of presbystasis pathogenesis: age-related degeneration across the vestibular, visual, and proprioceptive systems converges on central integration failure and postural instability.

Source: Adapted from Peterka [16] and Woollacott & Shumway-Cook [3].

Peripheral Vestibular Aging

The vestibular end-organs undergo consistent, progressive degeneration with advancing age. Post-mortem temporal bone studies by Merchant and colleagues demonstrated a linear decline in hair cell density across the utricular and saccular maculae beginning in the sixth decade, with type I hair cells disproportionately affected relative to type II [17]. The cristae of the semicircular canals show analogous losses, most pronounced in the horizontal and posterior canals [17,18]. Afferent nerve fibre counts in the vestibular nerve decline by approximately 40% between the third and ninth decades, predominantly affecting large-diameter, rapidly-conducting fibres [18,19].

Functional consequences are predictable. The vestibuloocular reflex (VOR) gain — the ratio of eye velocity to head velocity — declines measurably with age, particularly for high-frequency (greater than 2 Hz) head movements, which are also the movements that vHIT specifically tests [20,21]. Caloric responses diminish progressively after the sixth decade, with population-based normative data showing bilateral symmetrical reduction rather than unilateral weakness [22]. Otoconia become irregular in morphology, reduced in density, and increasingly prone to displacement — explaining the well-documented rise in BPPV prevalence with age [23,24]. The net effect is a vestibular periphery that provides degraded, noisier signals to the central integration centre.

Visual System Aging

Vision contributes to balance through two mechanisms: gaze stabilisation (preventing retinal slip during head movement) and spatial orientation (providing a gravitational reference through visual scene processing) [3,15]. Both mechanisms degrade with age. Contrast sensitivity falls across all spatial frequencies, with particularly pronounced losses at medium and high frequencies relevant to detecting floor surface and edge boundaries [25]. Depth perception — dependent on binocular disparity and motion parallax — degrades as a consequence of reduced accommodation, lens yellowing, and slower neural processing [25]. Peripheral visual field constriction reduces the moving-field cues used for postural sway correction.

Age-related conditions including cataract, glaucoma, macular degeneration, and diabetic retinopathy compound these physiological changes. The presence of reduced visual acuity (worse than 20/40) doubles the risk of falls independent of other factors, and vision correction — even with simple cataract extraction — produces measurable falls reduction [25,26]. Importantly, older adults with concurrent vestibular loss are less able to substitute visual cues for vestibular loss, because the central reweighting mechanism itself is impaired; the synergy between visual and vestibular deficits is therefore multiplicative rather than additive [3,16].

Proprioceptive and Somatosensory Aging

Somatosensory contributions to balance arise from joint mechanoreceptors (particularly at the ankle and knee), muscle spindles, Golgi tendon organs, and plantar cutaneous afferents. All decline with age. Vibration threshold at the great toe increases by approximately 0.5 dB per year after age 50 and is a sensitive marker of peripheral proprioceptive function [27,28]. Ankle joint position sense accuracy falls by 20-40% between young adulthood and the eighth decade, and this loss correlates significantly with sway velocity during quiet standing [27]. Peripheral neuropathy — present in approximately 15% of adults aged 60 or older — further degrades this channel and is strongly associated with postural instability and falls [28,29].

Central Integration and Sensory Reweighting

The brainstem and cerebellum integrate multisensory afferents and generate the corrective motor responses that maintain upright stance. Age-related white matter changes — visible as periventricular and subcortical hyperintensities on MRI — disrupt the rapid conduction between sensory relay stations and the motor cortex, increasing reaction time and reducing the precision of balance corrections [30,31]. Cerebellar volume declines by approximately 2-3% per decade after age 50, with preferential atrophy of the anterior vermis — a region critical for lower-limb coordination and postural adaptation [31].

Sensory reweighting — the ability to up-regulate the relative contribution of an intact modality when another is degraded — requires rapid computation of sensory conflict and redistribution of central gain [16]. This process is impaired in older adults even before overt cognitive decline, producing a system that is poorly adaptive to environmental transitions (moving from a carpeted to a smooth floor, stepping from bright into dim light, or standing in a moving bus) [16,32]. The clinical consequence is that presbystasis patients fall most often precisely in the moments of sensory transition — the first seconds after rising from a chair, turning in a corridor, or stepping onto an escalator — when rapid reweighting is demanded [32].

☐ **Clinical Insight:** Each sensory modality failing in isolation is often clinically compensated. It is the combination of degraded inputs across all three channels — vestibular, visual, and proprioceptive — together with impaired central reweighting, that tips the patient into symptomatic presbystasis. Identifying all three domains is therefore essential to understanding and targeting treatment.

III. Clinical Features — Presentation of Multisensory Dizziness and Dysequilibrium

Presbystasis presents differently from acute peripheral vestibular disorders. Rather than discrete vertiginous episodes, patients describe a persistent or chronic background of unsteadiness, a sensation that the ground is unreliable, or difficulty walking in challenging environments [1,2,33]. The complaint is often captured poorly by standard dizziness questionnaires designed around episodic vertigo. Eliciting the correct clinical picture requires asking specifically about: the quality of balance rather than the presence of vertigo; circumstances that worsen unsteadiness; a detailed falls history; activity restriction; and the degree to which symptoms limit participation in daily life.

Symptom characterisation is the first diagnostic challenge. Patients may describe dizziness, lightheadedness, unsteadiness, a floating sensation, or simply 'not feeling right when walking'. These descriptors broadly map to different physiological contributions: lightheadedness often suggests orthostatic hypotension or cardiovascular contribution; floating or rocking may reflect vestibular hypofunction or persistent posturo-perceptual dizziness (PPPD); frank dysequilibrium is the dominant feature of multisensory loss and proprioceptive deficits [1,33,34]. Many presbystasis patients report all three symptom types at different times, reflecting the multidomain nature of the condition.

Contextual Triggers

A defining feature of presbystasis is contextual worsening — unsteadiness that is notably worse in specific environments that challenge or remove reliable sensory inputs [3,32]. Characteristic triggers include: walking on thick carpet, grass, gravel, or sand (proprioceptive challenge); walking in a supermarket or other visually complex environment (visual conflict); darkness or dim lighting (loss of visual input); and moving surfaces such as escalators, buses, or boats (vestibular and visual conflict) [33]. This pattern of environment-dependent worsening distinguishes presbystasis from most central pathologies and from BPPV, which is triggered by specific head positions rather than sensory environments.

Falls history must be systematically documented. Critically, vestibular physicians should ask not only whether the patient has fallen but also the circumstances: falls during turning, reaching, or stepping up / down suggest balance system failure; falls during orthostatic transitions suggest autonomic or cardiovascular contributions; falls with specific head positions suggest BPPV; and falls in the dark specifically implicate vestibular and / or proprioceptive deficiency [9,35]. Near-falls — episodes of instability that are caught without frank falling — are often more informative than falls in higher-functioning patients who are adapting by limiting their activity.

Activity Restriction and Psychological Impact

Activity avoidance is near-universal in symptomatic presbystasis and is a principal driver of secondary disability. Patients progressively curtail walking distances, avoid stairs, cease driving, reduce social participation, and withdraw from exercise — creating a de-conditioning spiral that further worsens balance [36,37]. Fear of falling, assessed with the Falls Efficacy Scale International (FES-I) or the Activities-specific Balance Confidence (ABC) scale, is elevated in the majority of presbystasis patients irrespective of their objective fall history and is an independent predictor of future falls and institutionalisation [36,37]. Anxiety and depression co-occur in approximately 30–40% of patients with chronic dizziness in older age groups [34].

□ **Clinical Pearl:** Ask specifically: 'Do you hold onto furniture or walls when walking indoors?' and 'Have you changed how much you go out because of your balance?' Positive answers to either question identify activity restriction and fear of falling that will not emerge from standard dizziness history-taking.

IV. Diagnostic Criteria and Clinical Assessment

Barany Society Criteria for Presbyvestibulopathy (2019)

The Barany Society Classification Committee published consensus diagnostic criteria for presbyvestibulopathy in 2019, providing — for the first time — a validated, internationally agreed framework for diagnosing the vestibular component of age-related balance decline [7]. These criteria are operationally important because they distinguish presbyvestibulopathy from bilateral vestibular hypofunction (BVH) on the basis of severity, distinguish it from medication-induced vestibulopathy, and require objective vestibular testing rather than diagnosis by exclusion.

Table 2. Barany Society diagnostic criteria for presbyvestibulopathy (2019) [7].

Criterion	Specification
A. Chronic vestibular syndrome	Unsteadiness or postural instability or non-spinning dizziness present for >=3 months
B. Mild bilateral vestibular loss	>=1 of: vHIT gain 0.6-0.8 bilaterally; caloric reduced but >=25% canal paresis each side; VHIT catch-up saccades with gain 0.6-0.8; low-frequency VOR gain 0.1-0.3 on rotary chair (0.1 Hz)
C. Age >=60 years	Age criterion required
D. Exclusions	Not better explained by BVH, unilateral VH, central vestibular disorder, BPPV, medication, or another specific diagnosis

The 2019 criteria require objective vestibular testing — a deliberate departure from the previous practice of diagnosing presbystasis clinically. The mild bilateral loss threshold (vHIT gain 0.6-0.8) is carefully calibrated to be below the lower limit of young-adult normal but above the severe bilateral loss seen in true BVH (gain below 0.6), which warrants its own distinct management pathway [7,38]. Vestibular physicians should note that a proportion of clinically symptomatic patients with the presbystasis syndrome will not meet the strict criteria — in these cases the functional and multidomain approach to management is unchanged.

Diagnostic Algorithm — Age-Related Balance Decline (Presbystasis)

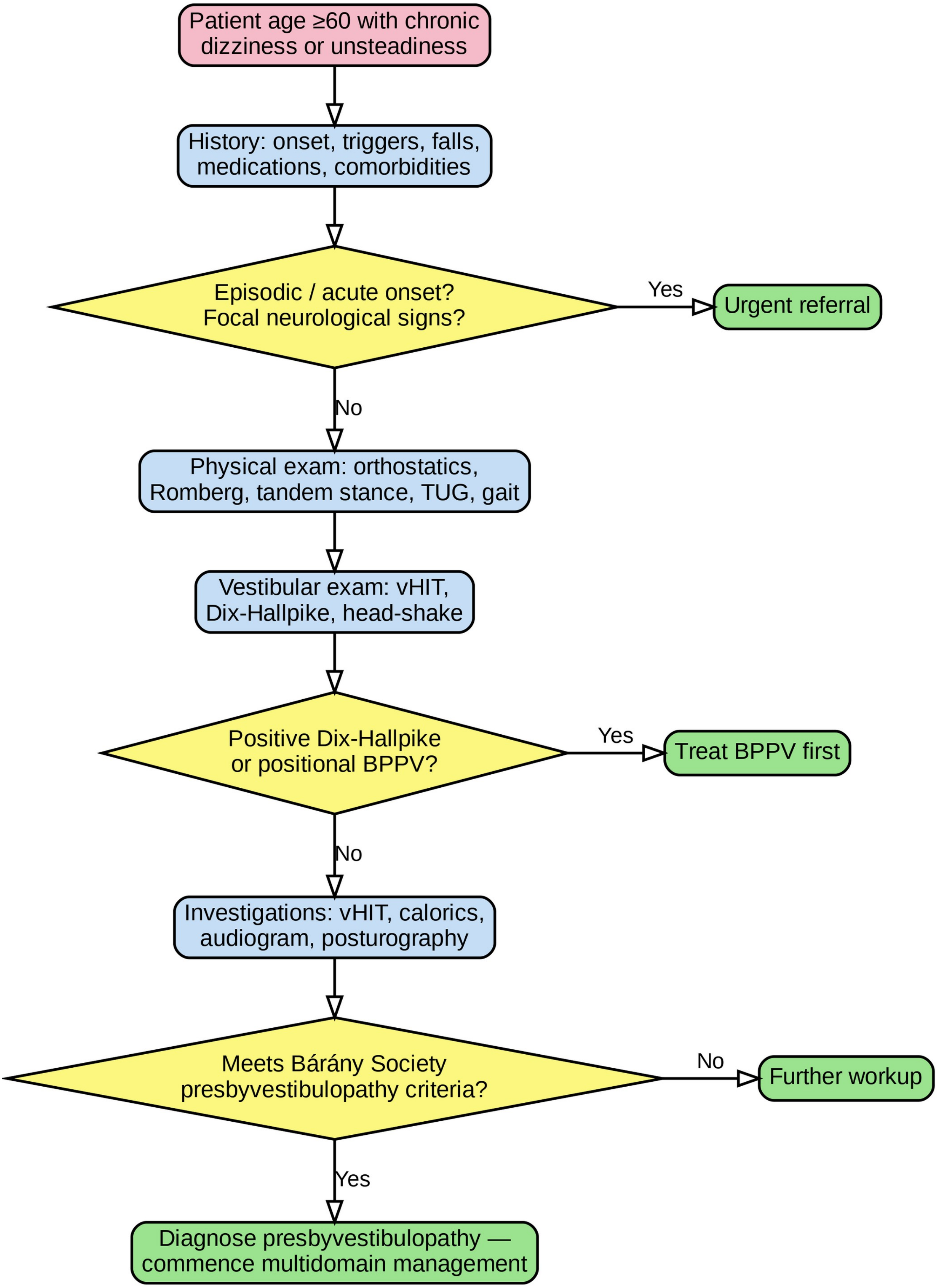

Figure 2. Diagnostic algorithm for age-related balance decline (presbystasis), incorporating history, clinical examination, and Barany Society presbyvestibulopathy criteria.
Source: Adapted from Agrawal et al. [7] and Bhatt et al. [12].

Clinical Assessment Tools

A structured battery of clinical performance tests is essential for baseline characterisation, treatment targeting, and outcome monitoring [35,39]. The Timed Up and Go (TUG) test — in which the patient rises from a standard chair, walks 3 metres, turns, returns, and sits — is the most widely validated single measure of functional mobility and fall risk in older adults [39,40]. A TUG time of 12 seconds or more is associated with doubled fall risk; a time of 20 seconds or more indicates significant functional impairment requiring urgent multidisciplinary review [40]. Dual-task TUG (performed while counting backwards by sevens) amplifies the fall-risk signal in cognitively intact patients and unmasks those whose balance depends critically on conscious attention to gait [40].

Table 3. Clinical assessment tools for presbystasis — reference values and interpretation.

Tool	Task	Normal / Concern threshold	Domains assessed
Timed Up and Go (TUG)	Rise, walk 3 m, return, sit	Normal <10 s; fall risk >=12 s; impaired >=20 s	Mobility, strength, balance
Dual-task TUG	TUG + serial subtraction	Dual-task cost >20% suggests cognitive-motor interference	Cognition, dynamic balance
Tandem stance	Feet heel-to-toe, eyes open then closed	Unable to hold 10 s EC = proprioceptive / vestibular concern	Static balance, sensory
Single-leg stance	One leg, arms folded, eyes open/closed	Normal >10 s EO; >5 s EC; concern <5 s EO in age >=65	Static balance
Functional Gait Assessment (FGA)	10 tasks: walking at speed, turns, obstacles	Maximum 30; concern <22/30 = elevated fall risk	Dynamic gait, head movements
Dynamic Gait Index (DGI)	8 gait tasks with head movements	Maximum 24; concern <19/24	Dynamic gait, vestibulo-spinal
Berg Balance Scale (BBS)	14 static / dynamic tasks	Maximum 56; concern <45; >=56 normal older adult	Comprehensive balance

The Functional Gait Assessment (FGA) is particularly informative for vestibular physicians because it includes tasks specifically sensitive to vestibular function — walking with horizontal head turns, vertical head turns, and walking with narrow base of support — that isolate vestibulo-spinal reflex integrity beyond the simpler measures [41]. The FGA has excellent test-retest reliability (ICC 0.84-0.89) and sensitivity for fall prediction in vestibular populations [41]. Establishing baseline FGA and TUG scores at presentation enables objective tracking of rehabilitation response and provides medicolegal documentation of functional change.

☐ **Clinical Pearl:** The FGA walking-with-head-turns subtest is the single most sensitive clinical item for vestibular gaze stabilisation failure. A score of 0-1 on this item (stopping, stepping, or losing balance during head-turn walking) is pathognomonic of vestibulo-spinal dysfunction and mandates formal vHIT and caloric assessment.

V. Investigations — vHIT, Caloric Testing, Posturography, Sensory Organisation Test

Objective vestibular investigation in presbystasis serves three purposes: to quantify the degree of vestibular deficit, to meet formal Barany Society criteria, and to differentiate presbyvestibulopathy from bilateral vestibular hypofunction (which requires more aggressive management), unilateral peripheral loss, and central vestibular disorders [7,22,38]. A targeted investigation strategy avoids over-investigation of a common age-related condition while ensuring that clinically significant or treatable pathology is not missed.

Video Head Impulse Test (vHIT)

vHIT assesses VOR gain and the presence of compensatory saccades for each of the six semicircular canals [20,42]. In presbyvestibulopathy, the hallmark finding is mildly reduced bilateral gain (0.6-0.8) without overt catch-up saccades, reflecting diffuse bilateral degeneration rather than focal canal dysfunction [7,20]. This pattern differs qualitatively from acute unilateral loss (asymmetric gain with covert saccades on the lesioned side) and from true BVH (gain below 0.6 bilaterally, often with overt saccades). Age-related normative data for vHIT gain must be applied carefully — gain values that would be normal in a 30-year-old may indicate early bilateral loss in an 80-year-old [20,42].

Measurement quality is critical. The vHIT requires precise goggle fit, appropriate head impulse amplitude (10-15 degrees), and sufficient impulse velocity (150-200 degrees per second) to engage the high-frequency VOR and reveal gain deficits [42]. In older patients with arthritis, pain, or apprehension, achieving adequate impulse velocity can be challenging and may require modified technique. Practitioners should report the number of valid impulses per canal and flag results based on fewer than eight valid impulses as potentially unreliable.

Caloric Testing

Bithermal caloric testing assesses low-frequency VOR function (approximately 0.003 Hz) and remains the gold standard for identifying unilateral canal paresis [22]. In presbystasis the typical finding is bilaterally reduced but symmetric caloric responses rather than the asymmetric canal paresis characteristic of unilateral peripheral hypofunction [22,38]. A canal paresis of less than 25% on Jongkee's formula, in the context of symmetrically reduced absolute responses, supports presbyvestibulopathy. Canal paresis exceeding 25% should prompt investigation for other diagnoses including acoustic neuroma, Meniere's disease, or post-infectious labyrinthopathy [22,38].

Rotary Chair Testing

Rotary chair (computerised rotational chair, CRC) provides frequency-specific VOR assessment across a range from 0.01 to 1 Hz and is particularly useful when caloric responses are equivocal or when bilateral low-frequency loss is suspected [22,43]. In presbyvestibulopathy, VOR gain at 0.1 Hz is typically 0.1-0.3 (mildly reduced), phase lead is increased, and asymmetry is absent or minimal [7,43]. True BVH produces gain below 0.1 at 0.1 Hz. Rotary chair also detects oscillopsia-provoking bilateral loss that may be missed on vHIT when compensatory saccades are absent [43].

Posturography and Sensory Organisation Test

Computerised dynamic posturography (CDP) with the Sensory Organisation Test (SOT) provides quantitative assessment of the relative contribution of visual, vestibular, and somatosensory inputs to postural stability under six progressively challenging conditions [44,45]. In presbyvestibulopathy the characteristic SOT profile shows preferential impairment under conditions 5 and 6 — where somatosensory input is disrupted and the visual signal is either absent or conflicting — reflecting dependence on vestibular input that has itself become unreliable [44,45]. This profile differs from pure proprioceptive loss (impaired conditions 2, 3, 5, 6) and from cerebellar ataxia (impaired across most or all conditions) [44].

While CDP is not universally available, its clinical value in presbystasis is substantial: it quantifies fall risk, guides which sensory rehabilitation tasks to prioritise, and provides objective response-to-treatment data [45]. Where CDP is unavailable, the clinical foam-and-tilt battery — tandem and single-leg stance on stable versus foam surface, eyes open and eyes closed — provides a proxy assessment of sensory organisation that is feasible in any vestibular clinic [35].

□ **Clinical Insight:** vHIT, caloric, and posturography are complementary rather than redundant in presbystasis. vHIT tests high-frequency VOR; calorics test low-frequency VOR; SOT tests postural stability across sensory conditions. A full assessment uses all three to characterise the deficit across frequencies and functional contexts.

VI. Differential Diagnosis

Presbystasis is a diagnosis that requires affirmative criteria and systematic exclusion of conditions that present similarly but demand different management [7,33]. Vestibular physicians must be vigilant for five key conditions that can mimic or co-exist with presbystasis: bilateral vestibular hypofunction (BVH), BPPV, orthostatic hypotension (OH), central vestibular or cerebellar disorders, and medication-induced vestibulopathy [38,46].

Table 4. Differential diagnosis of age-related balance decline.

Condition	Key distinguishing features	Investigations	Action
Bilateral vestibular hypofunction (BVH)	Oscillopsia, falls in dark, severe imbalance; vHIT gain <0.6 bilaterally	vHIT, caloric, rotary chair	Distinguish from presbyvestibulopathy; VR essential; exclude ototoxicity
BPPV	Positional vertigo with specific head triggers; positive Dix-Hallpike	Dix-Hallpike, supine roll test	Treat first before attributing to presbystasis; often co-exists
Orthostatic hypotension	Lightheadedness on standing; >=20 mmHg SBP drop after 3 minutes upright	Lying-standing BP x3; 24-hour BP monitor	Medication review, compression, fludrocortisone if severe
Central vestibular / cerebellar ataxia	Direction-changing or gaze-evoked nystagmus; truncal ataxia; dysmetria	MRI brain (FLAIR, DWI, T2); neurological review	Do not label as presbystasis until central cause excluded
Medication-induced vestibulopathy	Onset correlating with medication change; aminoglycosides, loop diuretics, cisplatin, phenytoin	Medication history; vHIT; caloric	Identify and cease or substitute offending agent where possible
Peripheral neuropathy without vestibular loss	Distal sensory loss, vibration threshold increased; balance worse on foam	Vibration threshold, NCS/EMG; SOT somatosensory condition	Neuropathy-targeted management alongside balance rehab

The most clinically important distinction is between presbyvestibulopathy and true bilateral vestibular hypofunction (BVH). BVH — defined by vHIT gain below 0.6 bilaterally — produces a more severe syndrome including oscillopsia (blurred vision during head movement), pronounced imbalance in darkness, and a higher fall rate [38,46]. The Barany Society classification explicitly separates BVH from presbyvestibulopathy on this quantitative threshold. Management of true BVH is more intensive, longer-duration, and may involve vestibular implantation in refractory cases [38,46].

BPPV and presbystasis co-exist in a substantial proportion of older patients — as many as 20-30% of patients presenting with age-related balance decline will have concurrent BPPV [24]. Because BPPV is treatable in a single encounter and its treatment will reduce both fall risk and symptom burden substantially, it must always be assessed before attributing symptoms entirely to presbystasis [24,47]. A systematic Dix-Hallpike and supine roll test should be part of every initial evaluation.

☐ **Important:** Do not attribute persistent gaze-evoked nystagmus, direction-changing nystagmus, truncal ataxia, dysarthria, or dysphagia to age-related decline. These findings require MRI of the posterior fossa before a diagnosis of presbystasis is confirmed.

Orthostatic hypotension (OH) and POTS are frequently concurrent in the presbystasis population and must be actively sought, as treatment of postural haemodynamic instability often produces greater functional gains than vestibular rehabilitation alone in these patients [8,44]. A 10-minute active stand test with blood pressure and heart rate measurements at 1, 3, 5, and 10 minutes is a practical office-based screen that adds minimal clinic time [44]. Central vestibular causes of balance decline — particularly cerebellar atrophy, normal-pressure hydrocephalus, and cerebrovascular disease affecting the posterior circulation — must be excluded before attributing balance impairment to presbystasis alone [5,6]. The distinguishing features are gait-first deterioration (normal pressure hydrocephalus), abnormal eye movements on clinical testing (cerebellar disease), and asymmetric neurological signs (cerebrovascular disease); MRI brain with posterior fossa cuts is warranted when any of these features are present [5,6].

VII. Management — Vestibular Rehabilitation and Exercise

Vestibular rehabilitation (VR) — physiotherapist-supervised exercise that drives central compensation, sensory reweighting, and motor adaptation — is the cornerstone of presbystasis management and carries the most robust evidence base among all interventions for this condition [48,49,50]. Randomised controlled trials and meta-analyses consistently demonstrate that structured VR reduces sway, improves TUG and FGA scores, lowers fall rates, and reduces subjective dizziness (DHI scores) compared with no treatment or general physical activity alone in older adults with vestibular dysfunction [48,49,50]. The key principle is specificity: exercises must challenge the exact sensory and motor deficits identified in the individual patient.

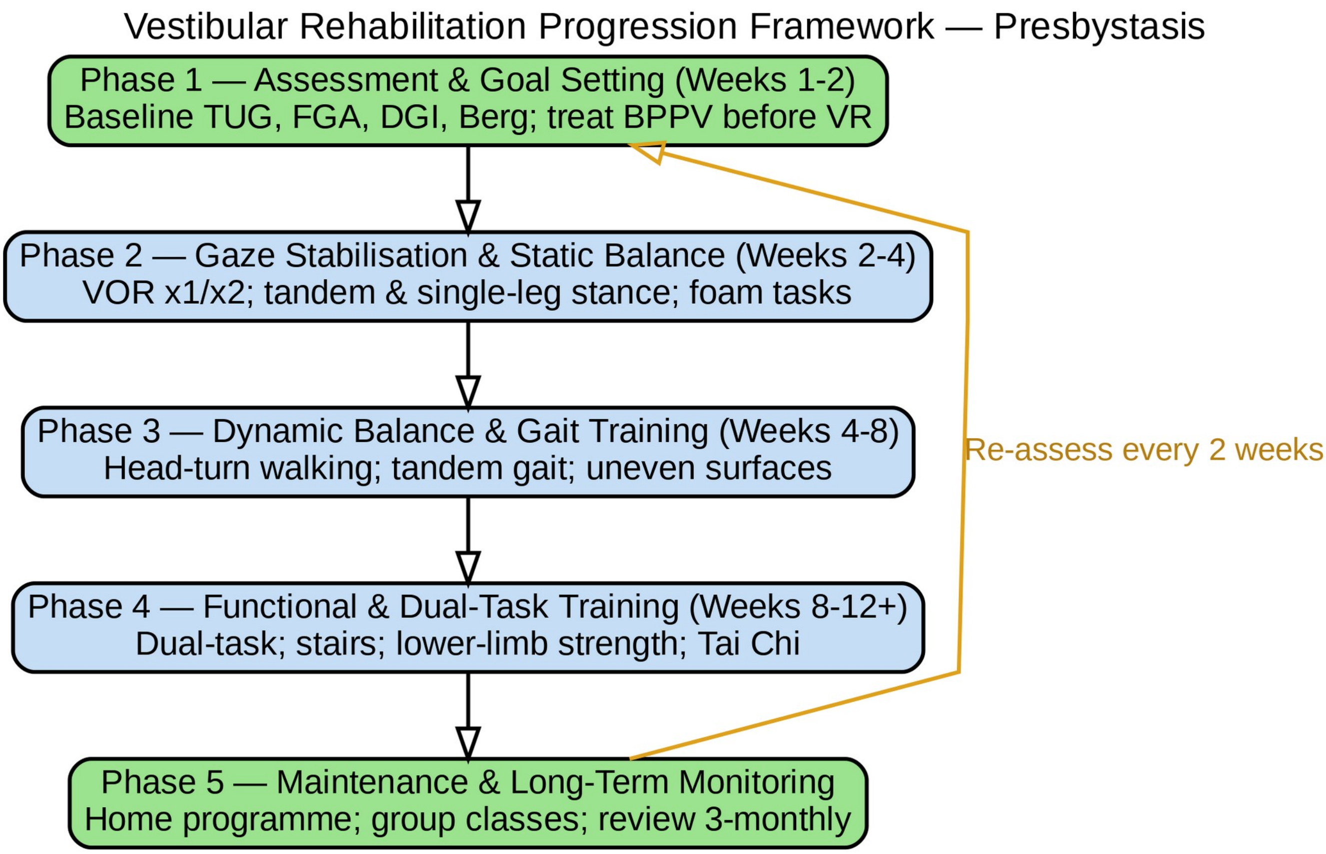

Figure 3. Vestibular rehabilitation progression framework for presbystasis: five phases from initial assessment through to long-term maintenance, with re-assessment every four weeks.

Source: Adapted from Herdman [48], Whitney & Sparto [50], and Shepard [49].

Gaze Stabilisation Exercises

Gaze stabilisation exercises target VOR adaptation by exposing the vestibular system to controlled retinal slip, driving central adaptation of VOR gain [48,50]. The fundamental exercise is VOR x1 viewing: the patient holds a target card at arm's length and moves their head horizontally (or vertically) while keeping the target focused, at progressively increasing speeds and durations. VOR x2 viewing — where the target moves in the opposite direction to the head — provides a greater adaptation stimulus and is introduced once the patient tolerates x1 without significant symptom provocation [48,50]. Evidence from RCTs demonstrates improved VOR gain after 6-8 weeks of gaze stabilisation training even in older adults with established presbyvestibulopathy [50].

Balance Retraining

Balance retraining exercises systematically manipulate the available sensory inputs to force the central system to utilise and improve weighting of specific modalities [48,49]. Static balance tasks progress from wide-base to tandem stance, from eyes open to eyes closed, and from firm surface to foam — each step reducing one reliable sensory input to force increased reliance on the others. Dynamic balance tasks progress from quiet standing to walking with head turns, to walking on uneven surfaces, to walking in busy visual environments [49]. The vestibular physiotherapist's role is to identify the precise task threshold at which the patient destabilises and to work in the zone just below that threshold, provoking adaptation without provoking falls.

Strength and Resistance Training

Lower limb muscle strength — particularly ankle dorsiflexion, knee extension, and hip abductor strength — is a critical determinant of balance recovery speed and fall-prevention capacity [51]. Progressive resistance training targeted at the lower limb, performed 2-3 times weekly, significantly reduces fall rates in community-dwelling older adults when combined with balance training, with meta-analysis showing a 34% reduction in fall rate (rate ratio 0.66, 95% CI 0.50-0.88) for combined programmes [14,51]. Tai Chi is a particularly valuable adjunct: it incorporates slow, controlled movement through perturbed postures, simultaneously training proprioception, lower limb strength, attentional focus on body position, and medial-lateral sway recovery [52].

Table 5. Vestibular rehabilitation exercise types and supporting evidence for presbystasis.

Exercise type	Mechanism	Evidence (RCT/meta-analysis)	Dose
Gaze stabilisation (VOR x1/x2)	VOR gain adaptation via retinal slip	Improved VOR gain and DHI vs control [50]	3x daily, 20 min total; 6-8 weeks minimum
Static balance (tandem/foam/EC)	Sensory reweighting and substitution	Improved sway and SOT scores [49]	3x daily, 10-15 min
Dynamic gait with head turns	Vestibulo-spinal reflex training	Improved FGA; reduced fall rate [41,49]	Daily 15-20 min; progress surfaces
Progressive resistance (lower limb)	Ankle / knee / hip strength for recovery speed	34% fall-rate reduction combined [14,51]	2-3x/week; 8-12 reps; 3 sets
Tai Chi	Proprioception, strength, attentional balance	48% fall reduction in 10-week trial [52]	Weekly class + 15 min daily home practice

☐ **Clinical Pearl:** The single most important modifiable predictor of VR outcome in presbystasis is adherence. A 6-8 week supervised programme with a home component, supported by clear written instructions and regular telephone follow-up, achieves far better outcomes than a more intensive clinic-only programme that the patient attends inconsistently.

VIII. Pharmacological and Multidisciplinary Approaches

No pharmacological agent has demonstrated efficacy specifically for presbyvestibulopathy or presbystasis in powered randomised trials, and vestibular suppressants — betahistine, prochlorperazine, cinnarizine — are contraindicated in chronic compensatory vestibular disorders because they suppress the central adaptation mechanisms that rehabilitation attempts to drive [53]. The pharmacological agenda in presbystasis is therefore primarily one of medication review and deprescribing rather than treatment initiation.

Medication Review and Deprescribing

Polypharmacy — the concurrent use of five or more medications — is present in approximately 40% of community-dwelling adults aged 65 and older and is independently associated with a 2.3-fold increase in fall risk [46,53]. Multiple drug classes cause vestibular or balance side effects. Aminoglycosides, loop diuretics (at high doses), platinum-based chemotherapy, and quinine are directly vestibulotoxic and can cause or worsen bilateral vestibular loss [46,53]. Benzodiazepines, Z-drugs, tricyclic antidepressants, and first-generation antihistamines increase fall risk through sedation and reduced reaction time [53]. Antihypertensives, particularly alpha-blockers and high-dose diuretics, worsen orthostatic hypotension. Identifying and deprescribing or substituting causative agents is among the most impactful single interventions available to the vestibular physician.

The Beers Criteria (American Geriatrics Society) and the STOPP/START criteria provide validated frameworks for identifying potentially inappropriate medications in older adults and are applicable to vestibular practice [53]. Systematic medication review using these tools, conducted in collaboration with the patient's general practitioner or geriatrician, can reduce fall rates by 10-20% in polypharmacy patients [53,54].

Vitamin D and Bone Health

Vitamin D deficiency (serum 25-OH vitamin D below 50 nmol/L) is prevalent in up to 40% of older adults in temperate climates and has been associated with both increased fall risk and reduced muscle strength in multiple cohort studies [24,54]. The relationship between vitamin D and vestibular otoconia health is of particular mechanistic interest: 25-OH vitamin D receptors are expressed in the inner ear and vitamin D metabolites regulate calcium homeostasis within the endolymph, influencing otoconia integrity [24]. Vitamin D supplementation (800-2000 IU daily) with or without calcium reduces falls by approximately 19% in vitamin D-deficient older adults and reduces BPPV recurrence rate in a randomised trial — suggesting a dual vestibular and musculoskeletal benefit [24,54].

Multidisciplinary Team (MDT) Approach

The complex, multidomain nature of presbystasis means that unidisciplinary management is systematically insufficient, particularly for patients at high falls risk [14,55]. An MDT approach brings together vestibular physicians (diagnosis, investigations, and VR prescription), vestibular physiotherapists (supervised exercise, gait training, home programme), occupational therapists (environmental modification, assistive devices, home safety assessment), clinical pharmacists or geriatricians (medication review, deprescribing), and optometrists or ophthalmologists (vision correction) [14,55].

Table 6. Multidisciplinary intervention domains in presbystasis management.

Domain	Intervention	Evidence level
Vestibular rehabilitation	VOR exercises, balance retraining, gait training, home programme	Level I — RCT meta-analyses [48,49,50]
Strength training	Progressive lower-limb resistance training 2-3x/week	Level I — RCT meta-analyses [14,51]
Medication review	Deprescribing vestibulotoxics; benzodiazepine withdrawal; OH management	Level II — systematic reviews [53,54]

Vision correction	Cataract surgery, new spectacle prescription, glaucoma treatment	Level II — cohort studies [25,26]
Environmental modification	OT home assessment; remove trip hazards; improve lighting; grab rails	Level I — RCT meta-analyses [14,55]
Nutritional / pharmacological	Vitamin D 800-2000 IU/day if deficient; calcium if osteoporotic	Level I — RCT data [24,54]

□ **Clinical Insight:** Geriatric falls services that deliver all MDT components concurrently — rather than sequentially — achieve the greatest falls reduction. Referral to a comprehensive falls clinic rather than individual domain referrals in series is the preferred model for high-risk patients.

IX. Falls Prevention — Risk Assessment, Environmental Modification, Multidomain Intervention

Falls prevention in presbystasis operates at three levels: individual risk stratification and targeted intervention, environmental modification, and population-level community programmes. Vestibular physicians play a central role in the first tier — identifying vestibular dysfunction as a modifiable falls-risk component — and should be familiar with the validated risk stratification tools and the evidence base for multicomponent intervention [9,14,55].

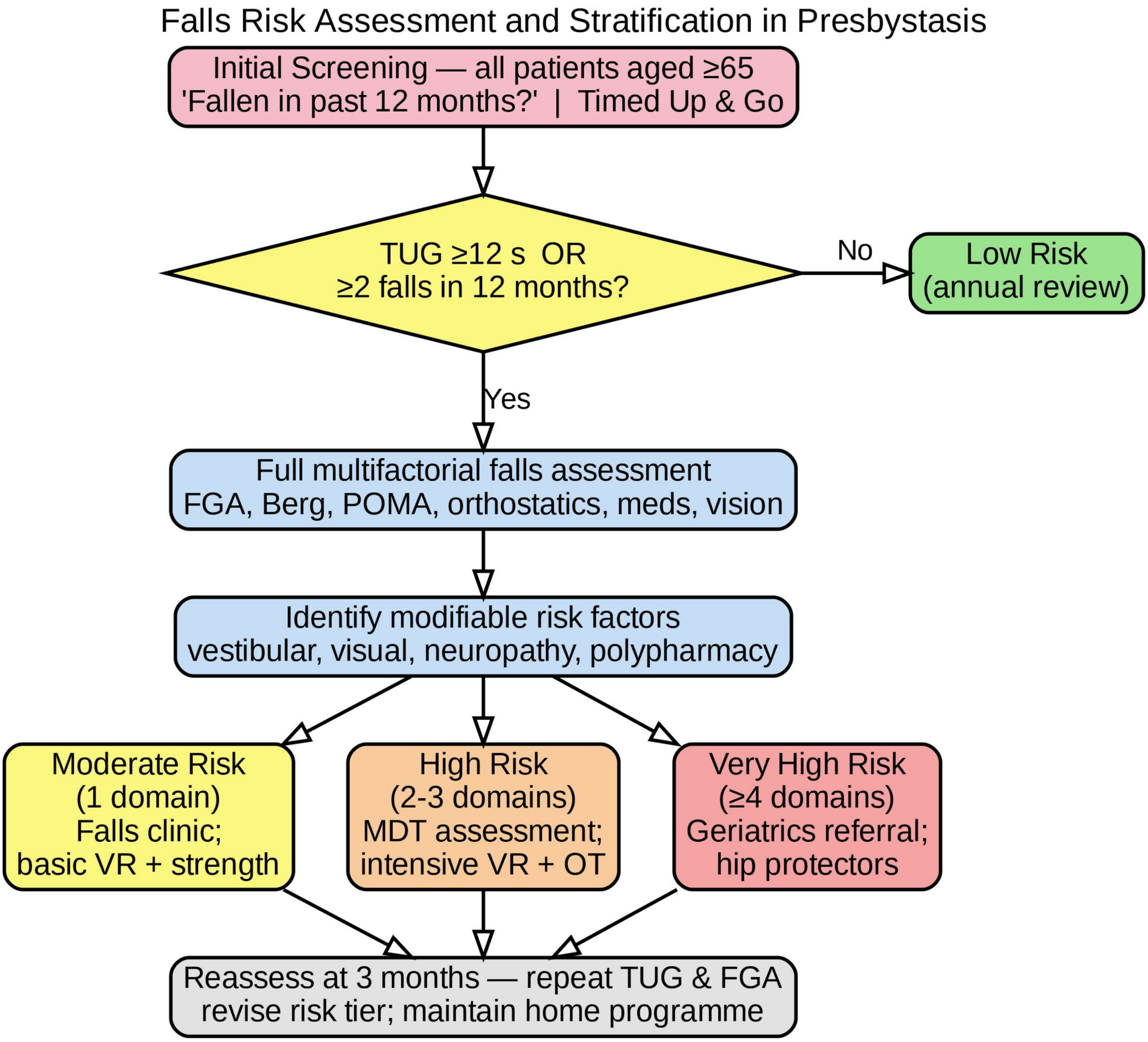

Figure 4. Falls risk stratification algorithm for patients with presbystasis: initial screening using TUG and falls history, stratification into moderate / high / very high risk tiers, and matched intervention intensity.

Source: Adapted from National Institute for Health and Care Excellence (NICE) Falls Guidelines [55] and Bhatt et al. [12].

Risk Stratification Tools

The World Health Organisation and national guidelines endorse a two-question initial screen for community-dwelling older adults: 'Have you fallen in the past 12 months?' and 'Do you feel unsteady when standing or walking?' [9,55]. A positive answer to either triggers full multifactorial assessment. The TUG time (12 seconds or more) and the STEADI (Stopping Elderly Accidents, Deaths, and Injuries) algorithm developed by the US Centers for Disease Control and Prevention provide structured clinical frameworks for identifying and stratifying fall risk [9,55]. Full risk assessment includes: gait and balance testing, orthostatic blood pressure, medication review, cognitive screen, and vision assessment [9].

Environmental Modification

Occupational therapist-led home safety assessment and modification — removing loose rugs and floor clutter, installing grab rails in bathroom and stairways, improving lighting in hallways and at step edges, and providing non-slip flooring in bathrooms — reduces falls in high-risk older adults by approximately 20% [55,56]. The benefit is proportional to baseline fall risk: environmental modification alone has minimal effect in low-risk individuals but is highly effective in those with prior falls [56]. Footwear advice — avoiding loose slippers, recommending supportive closed-toe footwear with thin soles for improved proprioceptive feedback — is a low-cost, high-yield component [35].

Multidomain Intervention Programmes

The PROFET (Prevention of Falls in the Elderly Trial), CHIP (Canterbury Home Injury Prevention), and multiple Cochrane systematic reviews establish that multidomain falls prevention programmes — combining exercise, medication review, vision correction, and environmental modification — reduce fall rates by 20-40% in community-dwelling older adults [14,55,56]. Exercise is the single most important component: exercise-based interventions alone reduce falls by approximately 23%, and the effect size is larger when balance and strength training are combined [14]. Group-based exercise — particularly Tai Chi, Otago exercise, and falls-specific balance classes — achieves comparable outcomes to individual supervised therapy at reduced cost and with superior long-term adherence [52,56].

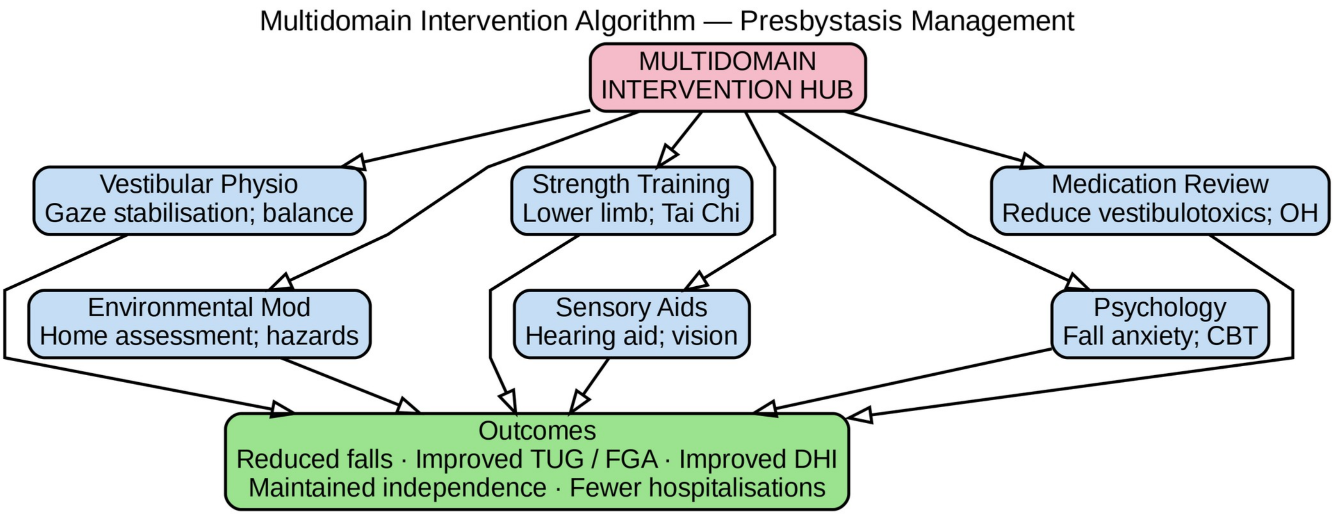

Figure 5. Multidomain intervention algorithm for presbystasis: six intervention domains (vestibular physiotherapy, strength training, medication review, environmental modification, sensory aids, and psychological support) converging on a central multidisciplinary hub.

Source: Adapted from Gillespie et al. [14] and National Ageing Research Institute [55].

Patient and carer education is an undervalued component of all falls prevention programmes. Explicitly naming presbystasis as a medical diagnosis, explaining its multisensory basis, and framing exercise as a treatment (rather than a lifestyle recommendation) substantially improves adherence in controlled trials [36,37]. Addressing fear of falling — which independently reduces activity and worsens physical conditioning — requires motivational interviewing, graduated exposure to feared activities within the rehabilitation programme, and, where clinically significant anxiety is present, referral for cognitive behavioural therapy [36,37].

☐ **Key Point:** Falls prevention is the dominant outcome measure for presbystasis management. Every treatment decision — VR programme design, medication review, environmental modification — should be evaluated in terms of its contribution to reducing fall rate, fall-related injury, and consequent hospitalisation.

X. Guidelines, Controversies and Future Directions

Current Guidelines

The Barany Society 2019 consensus criteria for presbyvestibulopathy [7] represent the most significant guideline development for this condition, providing operational diagnostic criteria for the first time. Separately, the NICE Falls in Older People Clinical Guideline (CG161, updated 2019) [55] and the American Geriatrics Society / British Geriatrics Society Clinical Practice Guideline for Falls Prevention (2010, with updates) [9] provide evidence-graded recommendations for multifactorial falls assessment and intervention. The Cochrane systematic review by Gillespie and colleagues on interventions for preventing falls in older people in community settings [14] remains the most comprehensive synthesis of the intervention evidence and is updated regularly.

Controversies

Several active controversies surround presbystasis and presbyvestibulopathy. The first concerns the diagnostic threshold: the Barany criteria's choice of vHIT gain 0.6 as the lower boundary of presbyvestibulopathy (below which the label shifts to BVH) is pragmatic but acknowledges that population-level data on the gain distribution in healthy older adults are still incomplete [7]. Large normative studies with age-stratified vHIT reference ranges are needed to validate and, if necessary, refine these thresholds.

A second controversy is whether vestibular suppressant medications have any role in the symptomatic management of chronic presbystasis. Betahistine — widely prescribed in Australia and Europe for non-specific dizziness in older adults — has no evidence of benefit in chronic compensatory vestibular disorders and theoretical potential for harm by reducing the central histaminergic tone that facilitates vestibular compensation [53]. Guidelines consistently recommend against routine vestibular suppressant use in chronic vestibular syndromes, yet prescribing rates in the older population remain high [53].

A third controversy concerns the relative role of central versus peripheral degeneration. While the Barany criteria focus on the peripheral vestibular contribution (and require objective evidence of mild peripheral dysfunction), many patients fulfilling the clinical syndrome have normal vHIT and caloric responses, with central sensory reweighting failure as the predominant mechanism [3,32]. Whether these patients should be classified separately, and whether rehabilitation programmes should be modified based on the predominant deficit site (peripheral versus central), is an area of active investigation [32].

Future Directions

Several research trajectories hold promise for improving outcomes in presbystasis. Wearable inertial measurement unit (IMU) technology now permits ambulatory, home-based assessment of gait quality, turn speed, and sit-to-stand transfer performance — data that are more ecologically valid than clinic-based assessments and may capture falls risk and treatment response with greater sensitivity [57]. Early trials of wearable biofeedback devices — vibrotactile or auditory cues that signal postural sway direction — show promise in improving balance in older adults with vestibular loss, though device form factor and adherence remain barriers to clinical translation [57].

Vestibular implant technology — cochlear-implant-style devices that deliver direct electrical stimulation to the ampullary nerve branches — has advanced substantially in preclinical and small-cohort human trials [58]. While current indications target severe BVH rather than presbyvestibulopathy, the technology may eventually offer neuromodulatory options for patients with more moderate bilateral loss. Gene therapy and cell therapy approaches targeting hair cell regeneration — well advanced in the hearing loss field — are being explored in vestibular paradigms and may offer disease-modifying options within a ten-year horizon [58].

At the service delivery level, telehealth-delivered vestibular rehabilitation — demonstrated to be non-inferior to in-person VR for vestibular neuritis and BPPV follow-up in multiple trials — may substantially improve access for older adults with mobility limitations, rural location, or transport barriers [59]. Combined exercise and cognitive training ('exergaming') platforms that simultaneously deliver balance challenge and cognitive engagement address the dual-task impairment characteristic of presbystasis and have demonstrated significant falls reduction in pilot RCTs [60].

☐ **Clinical Pearl:** Presbystasis is not a terminal diagnosis. Structured vestibular rehabilitation, medication optimisation, and multidomain falls prevention can meaningfully reduce fall rates, improve functional mobility, and restore quality of life even in octogenarians. The framing of 'just getting old' should be actively challenged in clinical encounters.

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