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The Geriatric Challenge of Concurrent Hypertension and Orthostatic Hypotension, a systematic review

Vandana

Associate Professor, Department of Physiotherapy, Jagannath University, Delhi NCR, Bahadurgarh

Abstract: The simultaneous occurrence of hypertension and orthostatic hypotension (OH) in older adults presents a significant and growing challenge for clinicians. Once viewed as a contradiction, this combination is now understood as a distinct geriatric syndrome, stemming from common underlying failures in blood pressure (BP) regulation[19]. Managing this dual condition is exceptionally difficult because treatments aimed at lowering high BP can worsen OH, while the presence of OH complicates any attempt to safely manage hypertension[1]. This review aims to synthesize the current literature to define these conditions, examine their shared pathophysiology, and underscore the clinical impact of their coexistence. Subsequently, it will propose a theoretical model for a non-pharmacological treatment—Structured Postural Orthostatic Training (SPOT)—and assess the fragmented evidence that supports its potential use in this vulnerable demographic. The primary objective is to outline the current state of knowledge, pinpoint significant gaps in the evidence, and suggest a clear path for future research.

Introduction:

1.1 Defining the Conditions: Consensus Criteria and Clinical Picture

A precise understanding of the diagnostic criteria for both hypertension and OH in the elderly is essential for grasping their clinical overlap and the challenges they pose.

Orthostatic Hypotension (OH)

Orthostatic hypotension is a clinical finding, defined by a joint consensus from the American Autonomic Society and the American Academy of Neurology as a sustained drop in systolic blood pressure (SBP) of 20 mmHg or more, or a drop in diastolic blood pressure (DBP) of 10 mmHg or more, within three minutes of standing up[1,2]. This standard is the basis for diagnosis in both clinical and research settings. The condition can be symptomatic, causing signs of insufficient blood flow to the brain like dizziness, lightheadedness, vision changes, or fainting (syncope), or it can be asymptomatic and only discovered through routine measurement[3]. Variants of this condition include initial OH, which is a larger but brief BP drop (≥40 mmHg SBP or ≥20 mmHg DBP) within 15 seconds of standing, and delayed OH, where the BP drop occurs after more than three minutes of being upright[10].

Hypertension in the Elderly

Hypertension in older individuals is typically defined by the same BP thresholds used for younger adults. However, treatment goals are frequently adjusted based on factors like frailty, other health conditions, and life expectancy[13]. Modern guidelines advocate for starting antihypertensive medication to lower the risk of cardiovascular events, but they also stress the need for caution to avoid side effects, including episodes of low blood pressure[13,17].

Prevalence and Coexistence

The likelihood of having OH increases significantly with age, with estimates for community-dwelling adults over 65 ranging from 5% to 30%[2]. This figure escalates in institutional settings, affecting up to 50% of nursing home residents and 68% of patients on geriatric hospital wards[1]. The key clinical issue is the extensive overlap between these conditions. About 10% of all hypertensive patients also have OH, and conversely, as many as 70% of individuals with OH are also hypertensive[4]. This high rate of co-occurrence indicates that they are not separate issues but are linked through shared physiological mechanisms that decline with age.

1.2 The Pathophysiological Link: Faulty Baroreflex, Stiff Arteries, and Autonomic Failure

The phenomenon of having high blood pressure while lying down and low blood pressure while standing up originates from a fundamental failure in the body's BP control systems[5].

The Normal Response to Standing

In a healthy person, moving from lying down to standing initiates a rapid series of adjustments to fight gravity. Upon standing, 300 to 800 mL of blood pools in the lower body and abdominal veins, which reduces blood return to the heart, decreases cardiac output, and threatens to lower BP[5]. This potential drop is detected by baroreceptors in the carotid arteries and aorta, which signal the brainstem to mount a compensatory response through the autonomic nervous system. This response involves increased sympathetic activity and reduced parasympathetic activity, leading to a faster heart rate, stronger heart contractions, and constriction of blood vessels, all of which quickly restore normal BP[6].

The Impact of Aging and Hypertension

The aging process degrades this system. Baroreflex sensitivity—the effectiveness of the response to BP changes—declines with age[7]. The heart becomes less flexible and cannot increase its output as quickly, and the skeletal muscle pump in the legs, which

helps return blood to the heart, weakens. Chronic hypertension accelerates this age-related decline by causing structural damage to blood vessels, leading to arterial stiffness and endothelial dysfunction. Stiff arteries cannot effectively buffer pressure fluctuations and also dull the sensitivity of the baroreceptors within their walls[5,6]. This establishes a detrimental cycle where hypertension weakens the very reflexes needed to prevent orthostatic BP drops, making OH a frequent result of long-standing high blood pressure.

The Medication Dilemma

This inherent physiological weakness is often exposed or worsened by the medications used to treat hypertension. Diuretics can cause volume depletion, while alpha-blockers, beta-blockers, and other vasodilators can interfere with the necessary vasoconstriction to maintain BP when upright[17]. This creates a therapeutic paradox: while uncontrolled hypertension causes the vascular and autonomic damage leading to OH, the medications used to control it can acutely worsen the condition[18]. However, recent large-scale meta-analyses have begun to question the idea that aggressive BP lowering always increases OH risk, suggesting that effective long-term BP control might improve vascular health and autonomic function enough to actually reduce the incidence of OH[19]. This shifts the clinical focus from simply avoiding antihypertensives to carefully optimizing treatment, preferring drugs less likely to cause OH and adding non-pharmacological methods to reduce hypotensive effects[20].

1.3 Clinical Importance: Health Risks and the Case for Non-Pharmacological Treatment

The significance of OH goes beyond its immediate symptoms; it serves as a powerful indicator of physiological vulnerability and an independent predictor of negative health outcomes.

Symptoms and Quality of Life

For many, OH is a disabling condition. Symptoms like dizziness, fatigue, cognitive slowness, and syncope can severely restrict mobility and independence, harming overall quality of life[21]. The fear of falling can lead to reduced activity, which in turn causes deconditioning, muscle weakness, and social withdrawal.

Link to Adverse Health Outcomes

A substantial body of research has confirmed OH as a predictor of serious health problems. Studies have shown that OH is independently linked to a higher risk of falls, fractures, heart failure, stroke, cognitive decline, and dementia[4]. Crucially, OH is an independent predictor of all-cause mortality, increasing the relative risk by about 50%[4]. This strong connection implies that OH should be seen not as an isolated finding but as a sign of systemic frailty. The systems that fail to cause OH—cardiovascular, neurological, and musculoskeletal—are the same ones that define frailty. Thus, identifying OH in an older hypertensive patient should trigger a comprehensive geriatric evaluation.

The Rationale for a Non-Pharmacological First Approach

Given the risks associated with polypharmacy in the elderly and the challenges of treating OH with medication without worsening supine hypertension, a non-pharmacological approach is universally recommended as the initial treatment[22,23]. These strategies aim to correct underlying issues like volume depletion and deconditioning without the side effects of drugs. Among these, structured exercise training shows great promise for improving not only orthostatic tolerance but also the broader syndrome of frailty with which OH is deeply connected[24].

2.0 A Proposed Framework for Structured Postural Orthostatic Training (SPOT)

Although exercise is widely recommended for OH, there is no standardized, evidence-based protocol for elderly patients with coexisting hypertension. The term "Structured Postural Orthostatic Training" (SPOT) is proposed here to define a comprehensive, multi-stage exercise program. Since direct evidence is limited, this framework is built by adapting principles from well-established exercise protocols for Postural Orthostatic Tachycardia Syndrome (POTS)—a related condition—and merging them with known non-pharmacological strategies for OH.

2.1 Foundational Ideas: Learning from Postural Orthostatic Tachycardia Syndrome (POTS) Protocols

POTS is a form of dysautonomia that mainly affects younger people and is marked by an excessive heart rate increase upon standing, usually without a drop in blood pressure[25]. Despite this key difference from OH, the underlying issues, such as deconditioning and autonomic dysregulation, are similar, making POTS treatment models a valuable reference[26].

Justification for Extrapolation

The structured exercise programs for POTS are among the most well-researched non-pharmacological treatments for any type of orthostatic intolerance. Studies show these programs lead to physiological improvements like increased heart size, expanded blood volume, and better autonomic control[26,27]. These changes directly address the main problems in OH: a less effective cardiac pump and low intravascular volume. Therefore, the principles behind these protocols provide a strong basis for adapting them to an elderly population with OH.

Key Protocol Models

The most influential models are the Levine Protocol and the CHOP Modified Dallas Protocol[27,28]. These are not just general exercise suggestions but are highly structured, progressive regimens grounded in exercise physiology[29,30]. Their success in treating POTS, with some studies showing over 50% of patients no longer meeting diagnostic criteria after completing the program, makes a compelling case for applying their core

principles to OH[26].

2.2 Core Elements: The Triad of Aerobic, Resistance, and Counter-Maneuver Training

The proposed SPOT framework is a multi-system approach, with each part designed to tackle a specific aspect of orthostatic intolerance.

Aerobic (Endurance) Training

The foundation of SPOT is progressive aerobic reconditioning. A key feature of the POTS protocols is the initial focus on recumbent exercises like a recumbent stationary bicycle, rowing machine, or swimming[27],[28]. This strategy allows for effective cardiovascular training to improve heart function and expand plasma volume while avoiding the upright posture that triggers symptoms. Training intensity is carefully controlled, usually with target heart rates or, more suitably for an elderly population on certain medications, the Rating of Perceived Exertion (RPE) scale.

Resistance (Strength) Training

The second element is resistance training, focusing on the large muscles of the lower body and core. When contracted, these muscles act as a "muscle pump," compressing veins and pushing pooled blood back to the heart. Strengthening these muscles improves this pump's efficiency and enhances venous return upon standing[24]. To ensure safety, these exercises are initially performed while seated or lying down, such as with seated leg presses, calf raises, and core exercises.

Physical Counter-Maneuvers

The third component focuses on active symptom management. SPOT includes specific training in physical counter-maneuvers that can be used at the first sign of symptoms to quickly raise blood pressure[31],[32]. These include leg crossing with muscle tensing, squatting, or tensing abdominal and arm muscles. These actions mechanically compress veins in the legs and abdomen, squeezing blood back toward the heart.

2.3 The Principle of Graduated Orthostatic Stress: A Phased Progression

A core principle of SPOT is the gradual reintroduction of orthostatic stress, allowing the autonomic nervous system to adapt over time.

- Phase 1: Foundational Reconditioning (Horizontal Focus): For the first 1-2 months, all training is done in a recumbent or seated position. The goal is to build a fitness base without triggering orthostatic symptoms.
- Phase 2: Gradual Upright Progression: In months 3-4, upright exercise is cautiously introduced, starting with semi-recumbent activities like an upright bike before moving to fully upright machines like an elliptical or treadmill.
- Phase 3: Full Upright and Maintenance: In the final phase, the patient transitions to mostly upright training, focusing on building a sustainable long-term maintenance program.

It is crucial that this framework, derived from protocols for a younger group, be significantly modified for a frail, hypertensive geriatric population. Progression must be slower and more individualized, with a strong emphasis on supervision and balance training to prevent falls. Resting and nocturnal BP must be monitored to avoid dangerous pressure increases. Using RPE to guide intensity is preferred over heart rate targets, which can be affected by medications like beta-blockers.

3.0 A Review of Clinical Evidence for Exercise in Treating OH in Older Adults

The clinical evidence for structured exercise in treating OH in older adults is still emerging and methodologically varied. Although no studies have evaluated a complete SPOT program as described, several trials have examined its core elements, particularly resistance training and isometric maneuvers. This section analyzes these studies, which, despite limitations, offer valuable insights. The table below summarizes the most relevant trials.

Table 1: Summary of Key Studies on Exercise Training for Orthostatic Hypotension in Older Adults

Study (Year)	Design	Participants (N, Age, Condition)	Intervention Protocol	Key Findings	Limitations
Brilla et al. (1998)	Pre-post intervention	24 community-dwelling older adults with OH (Mean: 71)	8-week heavy-resistance strength training (80% of 1-RM).	**Improved BP response** when rising from a chair; minimal effect on resting BP.	Small sample, no control group, short duration.
Tankersley (2001)	Controlled trial	13 elderly (Mean: ~68), 7 in Resistance group	12-week low-moderate intensity training (22-57% 1-RM), 2x/wk.	Increased lean mass/strength; **no improvement in** cardiovascular response to head-up tilt.	Very small sample, high dropout, low intensity.
Lee et al. (2022)	RCT	40 middle-older adults (Mean: ~60). HEX, LEX, or Control groups.	24-week whole-body training (2x/wk): HEX (80% 1-RM) vs. LEX (50% 1-RM).	**HEX group specifically** improved resting HR, DBP, and autonomic response (HRV).	Not focused on diagnosed OH; younger "older" population.
Mol et al. (2023)	RCT	19 elderly with diagnosed OH	Acute, pre-emptive isometric exercise (arm or leg tensing) for 30s before standing.	Both reduced BP drop; **arm tensing** was significantly more effective.	Acute effect only; not long-term; small sample.

3.1 Resistance and Strength Training Studies

Resistance training is the most-studied modality for OH in older adults, but results are conflicting and appear to depend on training intensity.

An analysis of Brilla et al. (1998) reveals it was one of the first studies to explore this area. Twenty-four older adults (mean age 71) with OH criteria engaged in an 8-week heavy-resistance program at 80% of their one-repetition maximum (1-RM). The main finding was a significant improvement in their hemodynamic response when rising from a chair, with a less severe drop in systolic BP. However, the study's pre-post design without a control group is a major weakness, making it impossible to rule out placebo effects or other factors. The small sample size and short duration also limit its generalizability[33].

A more recent and rigorous study by Lee et al. (2022) randomized 40 adults (mean age ~60) into high-intensity (HEX, 80% 1-RM),

low-intensity (LEX, 50% 1-RM), or control groups for 24 weeks. While both exercise groups gained strength, only the HEX group showed significant improvements in resting cardiovascular measures and a better autonomic response to an orthostatic test, suggesting a more robust compensatory reflex. A key limitation is that participants were not specifically recruited for having OH, so the study shows that high-intensity training can improve the physiological response to orthostasis but doesn't prove it can treat existing OH[34].

In contrast, the controlled trial by Tankersley (2001) provides a critical counterpoint. Thirteen elderly individuals were assigned to a 12-week resistance training group (n=7) or a control group. The training intensity was relatively low to moderate (progressing from ~22% to 57% of 1-RM). Although the exercise group improved strength, there was no improvement in their cardiovascular responses to an orthostatic challenge via a head-up tilt test. The study's very small sample size and low training intensity are significant limitations. When compared with the other studies, this suggests a potential intensity threshold is required to achieve central autonomic benefits beyond just muscle strength[35].

3.2 Isometric and Counter-Maneuver Training

Another area of research focuses on the immediate effects of isometric maneuvers for symptom relief. A randomized controlled trial by Mol et al. (2023) examined the acute effectiveness of 30-second isometric exercises performed just before standing in 19 elderly patients with diagnosed OH. Patients performed either an arm-tensing or leg-tensing maneuver. Both significantly reduced the orthostatic BP drop, but the arm exercise was notably more effective. This study provides strong evidence for a simple, practical behavioral intervention, although it only assessed the acute effect and was not a long-term training study.

3.3 Findings from Systematic Reviews

Systematic reviews that have compiled evidence on non-pharmacological interventions offer a more cautious view. A key review by Gibbons et al. (2020) examined various interventions, including exercise, for OH. While individual studies on physical maneuvers showed benefits, the formal meta-analysis found no statistically significant effect of resistance exercise on OH outcomes. This discrepancy is likely due to the high degree of variation (heterogeneity) among the included studies, which pooled data from different populations and used different protocols. The review concluded that the overall evidence remains mixed[22].

Other reviews have consistently found a strong link between OH and an increased risk of falls and impaired balance[37],[38]. While not intervention studies, this research reinforces the rationale for investigating physical training programs that could address both the hemodynamic issue and its most significant clinical consequence.

4.0 Synthesis and Critical Appraisal of the Evidence

A thorough review of the literature shows that while a SPOT program is physiologically sound, the direct clinical evidence is a mosaic of fragmented and often contradictory studies. No study has evaluated a comprehensive SPOT program in the target population. This section synthesizes these findings, appraises the evidence quality, and identifies key gaps for future research.

4.1 Evaluating the Efficacy of SPOT Components

The current evidence does not permit a definitive conclusion on a complete SPOT program; instead, each part must be evaluated separately.

- Resistance Training: This component has the most research, but findings are inconsistent. High-intensity training (around 80% 1-RM) appears to drive favorable autonomic adaptations[33],[34], whereas lower-intensity training does not[35]. This suggests that training intensity is a critical factor. The systematic review by Gibbons et al. found no overall significant effect, reflecting the inconsistency in the literature[22].
- Aerobic Training: There are no direct studies evaluating a progressive aerobic conditioning program, especially one starting with recumbent exercise, for treating OH in this specific population. The evidence is entirely extrapolated from POTS research, making it a well-reasoned but unproven hypothesis[26],[27].
- Isometric Maneuvers: The evidence for the acute benefit of physical counter-maneuvers is relatively strong. The trial by Mol et al. demonstrated that pre-emptive tensing can significantly reduce the orthostatic BP drop.

This analysis shows a major evidence gap: a comprehensive program is proposed based on physiological principles, but research has only tested its isolated parts. The potential synergistic benefits of combining these elements remain theoretical.

4.2 Gaps in the Literature: The Need for Targeted Trials

The fragmented evidence is a result of major research gaps. A robust trial to test SPOT is needed. Key gaps include:

- Population: A lack of studies exclusively in elderly individuals with diagnosed, coexistent hypertension and OH.
- Intervention: No trial has tested an integrated, multi-phase SPOT protocol combining all three components in a progressive manner.
- Duration and Adherence: Studies are short-term (8-24 weeks). The long-term durability of benefits and the feasibility of adherence in a frail population are unknown.
- Outcomes: The most critical gap is the reliance on surrogate hemodynamic endpoints (e.g., mmHg BP

drop). There is a severe lack of data on patient-centered outcomes like fall rates, functional status, and quality of life. The goal of treatment should be to prevent falls and improve function, not just to change a physiological measurement.

4.3 Methodological Weaknesses of Current Evidence

Existing studies are further weakened by several methodological issues:

- Sample Size: Most intervention studies are small and likely underpowered to detect a clinically important effect.
- Control Groups: Some early influential studies lacked a control group.
- Measurement Heterogeneity: OH is assessed differently across studies (active stand vs. passive tilt-table), making it hard to compare results.
- Publication Bias: Positive results may be more likely to be published, potentially overestimating the true effect of exercise.

In summary, the current evidence is insufficient to either support or reject the efficacy of a comprehensive SPOT program. While promising signals exist for its individual components, the evidence is too fragmented and methodologically flawed to support routine clinical implementation.

5.0 Conclusion and Future Directions

The combination of hypertension and orthostatic hypotension in the elderly is a major clinical syndrome linked to significant morbidity and mortality. Management is complex, positioning non-pharmacological strategies like structured exercise as the primary approach. However, this review finds a major gap between the strong physiological rationale for a SPOT program and the weak evidence base supporting it.

5.1 Summary of Findings and Clinical Implications

Current evidence allows for several conclusions. First, the concept of a multi-component SPOT program is physiologically plausible and highly promising for addressing the multiple deficits of OH.

Second, clinical evidence is limited to studies of its isolated components. High-intensity resistance training seems to improve autonomic responses, and isometric maneuvers can provide acute relief. However, no study has examined the combined effects of these elements in a long-term program for elderly patients with both hypertension and OH.

For clinicians today, a pragmatic approach is necessary. Non-pharmacological management should be the first-line therapy[31,32]. Patient education on avoiding triggers, staying hydrated, and using counter-maneuvers is evidence-based and essential. A supervised, progressive exercise program can be considered, with the understanding that the evidence is still evolving. Based on current data, such a program should likely focus on high-intensity resistance training tailored to the individual's ability. Careful monitoring of both orthostatic symptoms and supine BP is crucial.

5.2 A Roadmap for Future Research: Designing the Definitive SPOT Trial

To advance the field, a definitive, large-scale, multi-center randomized controlled trial is urgently needed. The design of such a trial should be informed by past limitations and prioritize patient-centered outcomes.

- Population: The study should enroll older adults (e.g., age 70+) with a confirmed dual diagnosis of hypertension and symptomatic OH.
- Intervention: The intervention group would receive a standardized, multi-phase SPOT program delivered by trained professionals, following the principles outlined in this review.
- Comparator: An active control group receiving a general wellness and flexibility program of equivalent contact time would be ideal to control for non-specific effects.
- Primary Outcome: The primary outcome must be clinically meaningful to patients, such as the rate of falls over a 12-month follow-up period.
- Secondary Outcomes: A range of secondary outcomes should be assessed, including symptom burden, functional status (e.g., Timed Up and Go test), quality of life, and 24-hour ambulatory BP monitoring. Adherence and safety must also be meticulously tracked.

Conducting such a trial would be a major effort, but it is the essential next step to provide the high-quality evidence needed to transform the management of this common and challenging geriatric syndrome. If proven effective, SPOT could offer a safe, non-pharmacological way to reduce falls, improve function, and enhance the quality of life for millions of older adults.

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