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RESEARCH PAPER

Asymptomatic orthostatic hypotension and risk of falls in community-dwelling older people

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Abstract

Introduction: Many older people with orthostatic hypotension (OH) may not report typical symptoms of dizziness, light-headedness or unsteadiness. However, the relationships between OH and falls in the absence of typical symptoms are not yet established.
Methods: Continuous orthostatic blood pressure (BP) was measured during active stand using a Finometer at Wave 1 of The Irish Longitudinal Study on Ageing in participants aged ≥ 70 years. OH, with and without dizziness, was defined as a sustained drop in systolic BP ≥ 20 and/or diastolic BP ≥ 10 mm Hg at 30, 60 and 90 seconds post-standing. The association between symptoms of dizziness and orthostatic BP was assessed with multi-level mixed-effects linear regression; logistic regression models assessed the longitudinal relationship between OH and falls at 6-year follow-up (Waves 2–5).
Results: Almost 11% ($n = 934$, mean age 75 years, 51% female) had OH, two-thirds of whom were asymptomatic. Dizziness was not associated with systolic BP drop at 30 ($\beta = 1.54$ (−1.27, 4.36); $p = 0.256$), 60 ($\beta = 2.64$ (−0.19, 5.47); $p = 0.476$) or 90 seconds ($\beta = 2.02$ (−0.91, 4.95); $p = 0.176$) after standing in adjusted models. Asymptomatic OH was independently associated with unexplained falls (odds ratio 2.01 [1.11, 3.65]; $p = 0.022$) but not explained falls (OR 0.93 [0.53, 1.62]; $p = 0.797$) during follow-up.
Conclusions: Two-thirds of older people with OH did not report typical symptoms of light-headedness. Dizziness or unsteadiness after standing did not correlate with the degree of orthostatic BP drop or recovery. Participants with asymptomatic OH had a significantly higher risk of unexplained falls during follow-up, and this has important clinical implications for the assessment of older people with falls.

Keywords: orthostatic hypotension, postural hypotension, falls, dizzy, blood pressure, older people

Key Points

- In total, 10% of a cohort of >900 community-dwelling people aged ≥70 years had orthostatic hypotension (OH) demonstrated during active stand.
- Two-thirds of older people with OH did not report symptoms of light-headedness during an active stand.
- Participants who reported light-headedness during the active stand did not have a greater drop in BP after standing.
- Participants with asymptomatic OH had a higher risk of unexplained falls than those who reported symptoms.
- These findings have important clinical implications for the assessment of older people with falls.

Background

Physiological regulation of blood pressure (BP) to achieve BP stabilisation after postural change is complex, with the primary short-term control mechanism involving stretch-dependent arterial baroreceptors, afferents of the autonomic nervous system (ANS) [1].

When we stand, blood pools in the legs, reducing venous return and causing a drop in systemic BP. This leads to a reduction in firing of baroreceptors located in the carotid sinus and aortic arch, resulting in increased sympathetic and reduced parasympathetic output. This, in turn, increases systemic vascular resistance and increases cardiac output, causing a rapid recovery of BP towards pre-standing values [2]. Additional mechanisms involved in BP recovery after standing include the calf muscle pump [3] and activation of the sympathetic response by venous distension in the legs [4].

Normally, one would expect BP to have recovered to pre-standing values by 30–40 seconds after standing [5]. Orthostatic hypotension (OH), characterised by delayed BP recovery after standing, is a clinical manifestation of failure of these BP stabilisation mechanisms. OH is defined as a sustained drop in systolic BP by at least 20 mmHg or diastolic BP by at least 10 mmHg within 3 minutes of standing. In classical or sustained OH, BP does not recover until beyond 40 seconds after standing, suggesting significant dysregulation of the baroreceptor–ANS reflex [6].

OH affects up to one in five community-dwelling older people [7] and is a significant risk factor for falls [8], cognitive decline [9], depression [10] and early mortality [11], particularly OH persisting across time points where time to recovery of BP is more prolonged [6].

While cerebral autoregulation can buffer long-term changes in cerebral perfusion to ensure steady cerebral blood flow, acute BP changes, such as when we change posture, are less well buffered and can lead to cerebral hypoperfusion [12]. This in turn leads to dizziness or light-headedness, which can act as a warning to sit down or lie down to prevent an impending fall or syncope. In some cases, however, cerebral hypoperfusion due to hypotension may not cause symptoms [13], and it is not uncommon clinically to see patients with severe OH who do not develop any symptoms of dizziness or light-headedness [14, 15].

The aim of this study therefore is to examine the link between typical OH symptoms, specifically dizziness and unsteadiness on rising from a chair and/or walking, and orthostatic BP in a cohort of community-dwelling older people. Our hypothesis is that in older adults these typical symptoms of OH would not be significantly associated with the degree of orthostatic BP drop and that a significant proportion of older people with OH demonstrated on the active stand may be asymptomatic. Further, we hypothesised that asymptomatic OH persisting from 30 to 90 seconds confers a higher risk of unexplained falls than symptomatic OH due to the absence of prodromal or warning symptoms.

Methods

Study design

This study utilises data from The Irish Longitudinal Study on Ageing (TILDA), a large population-based nationally representative sample of community-dwelling older adults aged ≥50 years. Waves of data collection are conducted at 2-year intervals and we used data from Waves 1 to 4, collected between 2009 and 2016, in this study.

This study cross-sectionally compares orthostatic BP profiles measured during the active stand at Wave 1 in participants with OH with and without co-existing symptoms of dizziness, unsteadiness when standing or unsteadiness when walking. We further clarify the longitudinal relationship between OH with and without symptoms and falls, both explained and unexplained, during 6-year follow-up.

The TILDA study design has been outlined previously [16]. Briefly, the first wave of data collection (Wave 1, 2009–11) was conducted using a stratified clustered procedure to randomly sample postal addresses from the Irish Geo-Directory (a listing of all residential addresses in Ireland) to ensure the sample was population representative. There are three components to data collection: a computer-assisted personal interview carried out by social interviewers in the participants' own home; a self-completion questionnaire completed and returned by the participant and a comprehensive centre-based health assessment or a modified home-based health assessment carried out by trained research nurses. Subsequent waves were conducted at 2-year intervals.

Participants were included in this study if they were aged ≥70 years at Wave 1 and underwent a health assessment including measurement of orthostatic BP by active stand. Participants were excluded from participation in TILDA at Wave 1, if they had a pre-existing diagnosis of dementia.

Orthostatic BP measurement

Orthostatic BP was measured during an active stand test using a Finometer® Midi as described previously [5]. The Finometer was calibrated against BP measured by a brachial sphygmomanometer and servo-calibration was switched off during the recording. Briefly, participants lay in the supine position for 10 minutes in a quiet room, before standing in a timely manner (<5 seconds) and were aided by a research nurse to mobilise as necessary. Participants stood still on rising and did not mobilise. Systolic BP, diastolic BP and heart rate were monitored for a further 2 minutes after standing. Throughout the recording, subjects stood quietly. After the 2-minute period, subjects were asked to report occurrence of orthostatic symptoms (dizziness or light-headedness).

OH was defined as a persisting drop in systolic BP ≥20 mm Hg and/or drop in diastolic BP ≥10 mm Hg at 30, 60 and 90 seconds after standing. Time-point values were 5-second moving averages, i.e. the 30-second time point was the average of 27.5–32.5 seconds. This represents 'Classical' or persistent OH rather than delayed BP recovery, which has been studied previously in the TILDA cohort [10, 17].

Symptomatic OH was defined as OH alongside symptoms of dizziness/light-headedness reported during the active stand. Asymptomatic OH was OH in the absence of these symptoms.

Delayed BP Recovery after standing was defined as a drop in systolic BP ≥20 mm Hg and/or drop in diastolic BP ≥10 mm Hg at 30 seconds after standing [17].

Other variables of interest derived from the active stand were the absolute systolic BP values for each time point after standing from baseline to 90 seconds, at 10-second intervals as well as the magnitude of drop in systolic BP at 30, 60 and 90 seconds after standing (baseline systolic BP minus systolic BP at 30, 60 and 90 seconds, respectively).

Participants were also asked, 'When getting up from a chair, do you feel (1) very steady, (2) slightly steady, (3) slightly unsteady, (4) very unsteady? And 'When standing, do you feel (1) very steady, (2) slightly steady, (3) slightly unsteady, (4) very unsteady?

Falls

At Waves 2–5, participants were asked 'Have you had any falls since the last interview?' This was used to derive the 'Falls' variable.

If they answered "yes" to this, participants were then asked, 'Were any of these falls non-accidental, i.e. with no apparent or obvious reason?' This was used to inform the 'Unexplained Falls' variable. Explained falls were therefore accidental falls, due to slips or trips.

Other measures

Heart disease was defined as a self-reported history of heart attack, angina, congestive cardiac failure and/or arrhythmia. The Fried Frailty score was used to define frailty status as non-frail, pre-frail or frail [18]. Cognitive impairment was defined as a Mini Mental State Examination score < 25.

Chronic disease burden was assessed by self-report of the following conditions: cancer, liver disease, kidney disease, thyroid, arthritis, lung disease. This was intended to broadly capture chronic disease burden across different systems given the association between OH and chronic conditions [19]. Parkinson's disease (PD), prior stroke and diabetes were also collected by self-report.

Statistical analysis

Data were analysed using Stata version 14.1 (Statacorp, Texas).

Baseline characteristics of the study sample by OH were presented descriptively using proportions and mean values with 95% confidence intervals (CIs).

Multi-level mixed effects linear regression models with systolic BP during active stand as the dependent variable were used to compare orthostatic BP in participants with OH with and without symptoms of dizziness during the active stand. These models were fully adjusted for age, sex, heart disease, frailty status, cognitive impairment and chronic disease burden and presented in graphical format. Covariates were chosen a priori, based on their hypothesised role in modifying the relationship between symptoms and OH.

Linear regression models presenting β-coefficients (with 95% CIs) were used to analyse the association of dizziness during the active stand and unsteadiness while standing or rising from a chair with drop in systolic BP at 30, 60 and 90 seconds, respectively, as dependent variables. These models were adjusted for age, sex, heart disease, frailty status and chronic disease burden.

Logistic regression models with delayed BP recovery at 30 seconds and OH as dependent variables were used to estimate odds ratios (with 95% CIs) for the association with dizziness during the active stand and unsteadiness while standing or rising from a chair. These models were also adjusted for age, sex, heart disease, frailty status and chronic disease burden.

Logistic regression models were used to obtain odds ratios with 95% CIs for the association between OH with and without symptoms at Wave 1 and falls (explained and unexplained) during follow-up. These models were also fully adjusted for age, sex, heart disease, frailty status, cognitive impairment, chronic disease burden and length of follow-up.

Results

Almost 11% (proportion 0.11 [95% CI 0.09–0.13]) of the study sample ($n = 934$, mean age 75 years, 51% female) had OH. Two-thirds of participants with OH were asymptomatic (proportion 0.64 [95% CI 0.54–0.73]).

Table 1 demonstrates the differences in baseline characteristics between those without OH and those with OH with and without symptoms. There were no significant differences between those with symptomatic and asymptomatic OH in terms of age, sex, heart disease, frailty status and chronic disease burden.

Figure 1 plots the systolic BP after standing during active stand in the three study groups, adjusting for age, sex, heart disease, frailty status and chronic disease burden. There was no difference in systolic BP at any time point during the active stand between those with OH causing symptoms and those who were asymptomatic. There was also no significant difference between symptomatic and asymptomatic OH groups in systolic BP reached during the active stand (85.5 [95% CI 74.0–97.0] vs. 88.6 [95% CI 82.2–95.0] mm Hg; $p = 0.6078$).

As shown in Table 2, dizziness reported during the active stand was not significantly associated with drop in systolic BP at 30 seconds ($\beta = 1.54$ [95% CI −1.27 to 4.36]; $p = 0.256$), 60 seconds ($\beta = 2.64$ [95% CI −0.19 to 5.47]; $p = 0.067$) or 90 seconds ($\beta = 2.02$ [95% CI −0.91 to 4.95]; $p = 0.176$) after standing in fully adjusted models. Unsteadiness when rising from a chair or when standing was also not significantly associated with the degree of systolic BP drop across time points during the active stand.

Table 1. Baseline characteristics of study sample

	No OH $N = 835$	OH Asymptomatic $N = 63$	OH symptomatic $N = 36$
Mean age (years), with 95% CI	74.7 (74.4–75.0)	76.5 (75.3–77.7)	75.1 (73.7–76.4)
Age group (Prop. with 95% CI):			
70–74	0.56 (0.52–0.59)	0.44 (0.32–0.57)	0.53 (0.36–0.69)
75–79	0.31 (0.28–0.34)	0.30 (0.20–0.43)	0.28 (0.15–0.45)
≥80	0.13 (0.11–0.16)	0.25 (0.16–0.38)	0.19 (0.9–0.36)
Female sex (Prop. with 95% CI)	0.50 (0.46–0.53)	0.54 (0.41–0.66)	0.67 (0.49–0.81)
Heart disease (Prop. with 95% CI): A	0.25 (22–28)	0.27 (0.17–0.40)	0.17 (0.07–0.33)
Fried Frailty Status (Prop with 95% CI): B			
Non-frail	0.58 (0.55–0.62)	0.59 (0.45–0.70)	0.64 (0.46–0.78)
Pre-frail	0.38 (0.35–0.42)	0.38 (0.27–0.51)	0.31 (0.17–0.48)
Frail	0.04 (0.03–0.05)	0.03 (0.01–0.12)	0.06 (0.01–0.21)
Cognitive impairment (Prop with 95% CI): C	0.06 (0.05–0.08)	0.10 (0.04–0.20)	0.11 (0.04–0.27)
Mean seated systolic BP, mm Hg (95% CI): D	142.0 (140.6–143.3)	147.3 (142.3–152.2)	141.9 (134.8–148.9)
Antihypertensive use (Prop with 95% CI): E	0.56 (0.52–0.59)	0.62 (0.49–0.73)	0.47 (0.31–0.64)
Antidepressant use (Prop with 95% CI)	0.06 (0.05–0.08)	0.08 (0.03–0.18)	0.11 (0.04–0.27)
Chronic disease number (Prop with 95% CI): F			
None	0.49 (0.46–0.53)	0.46 (0.34–0.59)	0.47 (0.31–0.64)
One	0.41 (0.38–0.44)	0.48 (0.35–0.60)	0.39 (0.24–0.56)
Two or more	0.10 (0.08–0.12)	0.06 (0.02–0.16)	0.14 (0.06–0.30)
Stroke	0.03 (0.02–0.04)	0.05 (0.01–0.14)	0.00 (0.00–0.00)
Diabetes	0.10 (0.08–0.12)	0.08 (0.03–0.18)	0.06 (0.01–0.21)
PD	0.00 (0.00–0.01)	0.00 (0.00–0.00)	0.06 (0.01–0.21)

Data presented is mean values and proportions with 95% CIs. OH was defined as a persisting drop in systolic BP ≥ 20 mm Hg and/or drop in diastolic BP ≥ 10 mm Hg at 30, 60 and 90 seconds after standing, measured using finometer during active stand. Symptomatic OH was defined as OH alongside symptoms of dizziness/light-headedness reported during the active stand. Asymptomatic OH was OH in the absence of these symptoms. A: Heart disease was defined as a self-reported history of heart attack, angina, congestive cardiac failure and/or arrhythmia; B: participants classified as non-frail, pre-frail or frail based on Fried Criteria (weight loss, exhaustion, grip strength, walking speed and physical activity); C: defined as a Mini-Mental State Examination Score < 25; D BP measured in seated position using Omron digital cuff, measured twice and average of 2 readings taken; E: prescribed medications with Anatomical Therapeutic Classification Codes C02, 03, 07, 08 and 09; F: the self-reported number of the following conditions: cancer, liver disease, kidney disease, thyroid, arthritis, lung disease.

Additionally, reporting dizziness during the active stand was not associated with delayed BP recovery at 30 seconds after standing (OR 1.22 [95% CI 0.91–1.65]; $p = 0.197$) or with OH (OR 0.98 [95% CI 0.63–1.53]; $p = 0.931$) in fully adjusted models. Similarly, unsteadiness when rising from a chair or when standing was not associated with delayed BP recovery or OH (Table 3).

Longitudinal analysis demonstrated that almost half (424/869; 49%) of the study sample had explained falls during follow-up, whereas almost one-quarter (201/869; 23%) reported unexplained falls. Mean follow-up time was 6.3 (95% CI 6.1–6.5) years. Asymptomatic OH was independently associated with a higher likelihood of unexplained falls (odds ratio 2.01 [95% CI 1.11–3.65]; $p = 0.022$) but not explained falls (odds ratio 0.93 [95% CI 0.53–1.62]; $p = 0.797$) during follow-up in fully adjusted models (Table 4). Symptomatic OH was not associated with a higher risk of either explained (odds ratio 0.90 [95% CI 0.37–2.19]; $p = 0.812$) or unexplained (odds ratio 0.81 [95% CI 0.40–1.66]; $p = 0.564$) falls during follow-up.

Of the cohort without OH ($n = 835$), over one-third (proportion 0.37 [95% CI 0.34–0.41]) reported dizziness or light-headedness during the active stand. There was no difference in likelihood of unexplained falls between those with (proportion 0.22 [95% CI 0.18–0.28]) and without (proportion 0.22 [95% CI 0.19–0.26]) dizziness/light-headedness in the non-OH group. Similarly, there was little or no difference in the likelihood of fracture by report of dizziness/light-headedness within the non-OH group (proportion 0.17 [95% CI 0.13–0.21] in those reporting dizziness compared with proportion 0.18 [95% CI 0.14–0.21] in those who did not report dizziness).

Discussion

This study demonstrates that over 10% of a cohort of more than 900 community-dwelling people aged ≥70 years had OH demonstrated during active stand, i.e. a sustained drop of 20 mm Hg in systolic BP and/or 10 mm Hg in diastolic BP at 30, 60 and 90 seconds after standing. Of those with OH, two-thirds were asymptomatic and did not report dizziness during the active stand.

There was no significant difference in terms of absolute BP parameters during the active stand in participants with OH who reported symptoms of dizziness compared with those without symptoms. Similarly, reporting dizziness during the active stand was not associated with a greater drop in systolic BP at 30, 60 or 90 seconds or with binary variables reporting the presence/absence of delayed BP recovery and

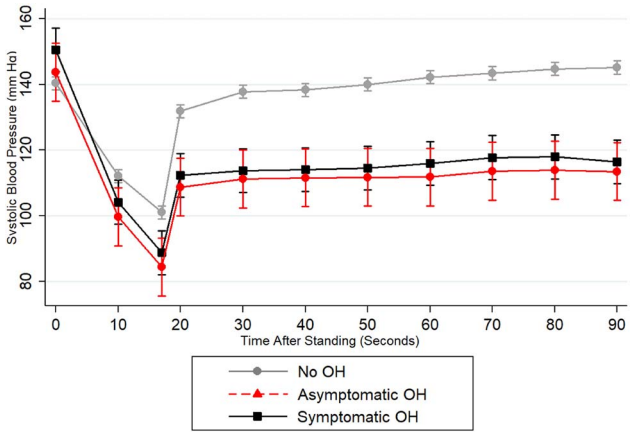

Figure 1. Systolic BP during active stand by OH with and without symptoms of dizziness. *Notes:* Graphical output from multi-level mixed-effects linear regression models with systolic BP (with 95% CIs) during active stand as dependent variable to compare orthostatic BP in participants with OH with and without symptoms of dizziness during the active stand. OH was defined as a persisting drop in systolic BP ≥ 20 mm Hg and/or drop in diastolic BP ≥ 10 mm Hg at 30, 60 and 90 seconds after standing, measured using finometer during active stand. Symptomatic OH was defined as OH alongside symptoms of dizziness/light-headedness reported during the active stand. Asymptomatic OH was OH in the absence of these symptoms. Analyses adjusted for age, sex, heart disease, Fried Frailty status, diabetes, PD, stroke and number of chronic diseases.

OH. Further, reporting unsteadiness when rising from a chair or when standing was also not associated with a greater orthostatic drop in systolic BP during the active stand or with OH.

Participants with asymptomatic OH did however have a significantly higher risk of unexplained falls during follow-up, whereas those with symptomatic OH did not. Asymptomatic OH did not increase the risk of explained falls during follow-up.

OH represents severe dysregulation of BP stabilisation mechanisms, and one might expect that this would be associated with significant symptoms of postural dizziness [20]. While not yet well-defined, the concept of hypotensive unawareness in the setting of OH has been described in smaller studies previously, however. For example, almost 20% of a cohort of participants with OH due to autonomic failure did not report postural dizziness, whereas 88% endorsed non-specific symptoms such as weakness, lethargy or fatigue on changing posture [21]. Further, less than half of participants with severe OH identified during tilt table testing reported typical symptoms of postural dizziness, whereas one-third were asymptomatic entirely [22].

This lack of awareness of hypotension has important implications clinically. Rather than presenting with falls in the context of postural dizziness, people with severe asymptomatic OH are more likely to present with falls without warning or prodrome, raising the suspicion of an arrhythmogenic cause for which the patient may undergo inappropriate testing [23]. Absence of symptoms also makes it more difficult to identify OH as the primary cause of falls, especially when assessment involves less sensitive methods of orthostatic BP measurement such as lying/sitting to standing BP [24]. Our findings also raise the issue of how older people with asymptomatic OH should be managed, as addressing postural BP drops in the absence of dizziness or light-headedness may prevent future falls and fracture.

Importantly, studies have also shown previously that asymptomatic OH appears to confer similar risks in terms of non-falls related adverse events. For example, over one-third of patients with OH due to PD were asymptomatic, and asymptomatic OH was associated with similar impairments in physical functioning when compared with symptomatic OH in this cohort [25]. Further, asymptomatic and symptomatic OHs also appear to confer similar risk of cognitive decline in patients with PD [26].

There are several possible reasons why older people with OH may not exhibit typical dizzy symptoms. The sensation of dizziness is somewhat subjective and rather than feeling dizzy, light-headed or unsteady in the context of hypotension, older people may instead experience leg weakness or neck pain, which may actually represent 'typical' OH symptoms in this cohort and were not captured in this study [27]. In any case, only 50–70% of acutely unwell older people present with so-called typical symptoms of their underlying illness [28, 29]. Further, as seen in problems with gait and balance [30], older people tend to compensate for gradual-onset conditions such as OH and may therefore have less awareness of symptoms or at least be less likely to report them as a problem. It has also been suggested that lack of awareness of hypotension in OH may be related to hypoperfusion-related changes in the reticular activating system, leading to inattention to the warning signs of dizziness or presyncope [31].

Consistent with prior studies [32], this study also demonstrates a strong association between frailty status and unexplained falls, with a two- and fivefold increased likelihood of unexplained falls in those with pre-frailty and frailty, respectively. While OH was more prevalent in the cohort with frailty, there was no significant association with asymptomatic OH and frailty. The study was not powered to detect this association, however, given the relatively low prevalence of frailty in the study sample.

There are some limitations of this study that should be noted. Variables including falls, heart disease and chronic diseases are based on self-report and may therefore be subject to recall bias. Linkage of TILDA data with healthcare services records pertaining to admissions with falls and fracture

Table 2. Linear regression models with systolic BP drop at 30, 60 and 90 seconds as dependent variables

	sBP drop at 30s		sBP drop at 60s		sBP drop at 90s	
	β-Coefficient (95% CI)	*P*	β-Coefficient (95% CI)	*P*	β-Coefficient (95% CI)	*P*
Dizzy during active stand						
Unadjusted	1.27 (−1.56 to 4.10)	0.378	2.38 (−0.44 to 5.20)	0.098	1.70 (−1.21 to 4.62)	0.252
Adjusted	1.54 (−1.27 to 4.36)	0.256	2.64 (−0.19 to 5.47)	0.067	2.02 (−0.91 to 4.95)	0.176
Unsteady rising from chair						
Unadjusted	1.26 (−2.63 to 5.15)	0.526	1.09 (−2.79 to 4.97)	0.580	0.13 (−3.88 to 4.14)	0.948
Adjusted	1.22 (−2.89 to 5.34)	0.545	1.26 (−2.88 to 5.41)	0.476	0.99 (−3.29 to 5.28)	0.650
Unsteady when standing						
Unadjusted	4.98 (−0.23 to 10.19)	0.061	3.11 (−2.09 to 8.31)	0.241	1.36 (−4.02 to 6.74)	0.620
Adjusted	4.65 (−0.98 to 10.28)	0.105	3.40 (−2.27 to 9.07)	0.240	2.08 (−3.78 to 7.95)	0.486

Linear regression models reporting β-coefficients and 95% CIs with systolic BP drop at 30, 60 and 90 seconds as dependent variables. Systolic BP drop at specific time points is difference between pre-standing baseline systolic BP and systolic BP at 30, 60 and 90 seconds after standing as measured with finometer during active stand. Abbreviations: sBP = systolic blood pressure. Analyses adjusted for age, sex, heart disease, Fried Frailty status, diabetes, PD, stroke and number of chronic diseases in adjusted models. Dizziness during active stand, unsteadiness rising from a chair and unsteadiness when standing were elicited by self-report.

Table 3. Logistic regression models with delayed BP recovery and OH as dependent variables

	Delayed BP recovery at 30s		OH	
	Odds ratio (95% CI)	*P*	Odds ratio (95% CI)	*P*
Dizzy during active stand				
Unadjusted	1.19 (0.88–1.59)	0.254	0.96 (0.62–1.48)	0.864
Adjusted	1.22 (0.91–1.65)	0.197	0.98 (0.63–1.53)	0.931
Unsteady rising from chair				
Unadjusted	1.32 (0.90–1.94)	0.158	1.59 (0.95–2.67)	0.080
Adjusted	1.28 (0.84–1.96)	0.253	1.64 (0.91–2.94)	0.098
Unsteady when standing				
Unadjusted	1.47 (0.90–2.41)	0.123	0.98 (0.45–2.09)	0.950
Adjusted	1.45 (0.83–2.54)	0.198	0.91 (0.38–2.17)	0.826

Logistic regression models reporting odds ratios with 95% CIs with delayed BP recovery at 30 seconds and OH as dependent variables. OH was defined as a persisting drop in systolic BP ≥ 20 mm Hg and/or drop in diastolic BP ≥ 10 mm Hg at 30, 60 and 90 seconds after standing. Delayed BP recovery after standing was defined as a drop in systolic BP ≥ 20 mm Hg and/or drop in diastolic BP ≥ 10 mm Hg at 30 seconds after standing. Analyses adjusted for age, sex, heart disease, Fried Frailty status, diabetes, PD, stroke and number of chronic diseases in adjusted models. Dizziness during active stand, unsteadiness rising from a chair and unsteadiness when standing were elicited by self-report.

was unfortunately not possible. This applies equally across all groups in the study however. At enrolment in TILDA participants with a history of dementia were excluded, reducing the likelihood of cognitive impairment affecting recall. It is still possible that participants with undiagnosed dementia were included; however, although it should also be noted that there was no significant difference in the proportion of participants with cognitive impairment across the three study groups. Symptoms of OH were not measured using a standardised questionnaire, which may mean that less typical symptoms of OH and severity of dizziness/light-headedness were not captured. Participants were, however, asked directly about symptoms during the active stand, linking symptoms more closely to orthostatic BP changes. It was not feasible to administer a questionnaire during the active stand. We did not capture Initial OH in the study, as the focus was on delayed BP recovery rather than the large immediate BP drops seen in initial OH. Further, we also only included BP measurements at 30, 60 and 90 seconds post-standing. While this would capture all participants with classical OH, it would possibly omit those with delayed OH, which is also associated with falls and adverse outcomes [33]. Strengths of the study include the measurement of orthostatic BP continuously with a finometer, the well-described cohort of community-dwelling older people and the robust follow-up of 6 years.

In conclusion, this study demonstrates that two-thirds of older people with persistent OH identified during an active stand were asymptomatic and did not report dizziness or light-headedness. Participants with asymptomatic OH had a higher risk of unexplained falls than those who reported symptoms. These findings have important clinical implications for the assessment of older people with falls, particularly falls without prodrome and unexplained falls, and for clinical trials assessing OH as reported symptoms correlate poorly with continuously measured orthostatic BP.

Table 4. Logistic regression model reporting odds ratios with unexplained falls as dependent variable

	Odds ratio (95% CI)	*z*	*P*
OH: Ref = No OH			
Asymptomatic	2.01 (1.11–3.65)	2.29	0.022
Symptomatic	0.86 (0.34–2.17)	−0.31	0.754
Age: Ref = 70–74 years			
75-79 years	1.31 (0.90–1.89)	1.43	0.154
≥ 80 years	1.36 (0.83–2.23)	1.33	0.183
Female sex	1.24 (0.88–1.76)	1.21	0.226
Heart disease A	1.20 (0.82–1.77)	0.93	0.350
Frailty Status: Ref = Non-frail B			
Pre-frail	1.95 (1.37–2.77)	3.74	<0.001
Frail	4.90 (2.13–11.27)	3.73	<0.001
Cognitive impairment C	1.65 (0.72–3.76)	1.19	0.233
Chronic disease number: Ref = 0 D			
1 Chronic disease	1.17 (0.81–1.68)	0.82	0.412
≥2 Chronic diseases	1.43 (0.75–2.71)	1.09	0.277
Stroke	1.71 (0.68–4.31)	1.13	0.259
Diabetes	1.07 (0.57–1.99)	0.21	0.837
PD	2.95 (0.51–16.91)	1.21	0.225
Follow-up (years)	1.22 (1.14–1.32)	5.32	<0.001

OH was defined as a persisting drop in systolic BP ≥ 20 mm Hg and/or drop in diastolic BP ≥ 10 mm Hg at 30, 60 and 90 seconds after standing, measured using finometer during active stand. Symptomatic OH was defined as OH alongside symptoms of dizziness/light-headedness reported during the active stand. Asymptomatic OH was OH in the absence of these symptoms. A: Heart disease was defined as a self-reported history of heart attack, angina, congestive cardiac failure and/or arrhythmia; B: participants classified as non-frail, pre-frail or frail based on Fried Criteria (weight loss, exhaustion, grip strength, walking speed and physical activity); C: defined as a Mini-Mental State Examination Score < 25; D: the self-reported number of the following conditions: cancer, liver disease, kidney disease, thyroid, arthritis, lung disease.

Additionally, further work delineating the spectrum of symptoms in the setting of severe OH and determining how best to measure them is warranted.

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