Original Article

Orthostatic hypotension in the elderly: Prevalence and its management by simple isometric limb tensing exercises

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Abstract

Objective: Orthostatic hypotension (OH), an important cause of falls in the elderly, is grossly underdiagnosed. Our study aimed to determine the prevalence and associated factors of OH among the elderly attending a secondary care hospital. Furthermore, we assessed and compared the effectiveness of simple arm and leg tensing exercises, performed just prior to standing, to mitigate the orthostatic fall in blood pressure (BP) in elderly OH patients. **Materials and Methods:** A cross-sectional study screened elderly patients (≥65 years) for OH and recruited them into a randomized controlled trial (CTRI/2020/08/027182) of two parallel groups performing either arm tensing or leg tensing exercises just before standing up. We performed an interim analysis of the ongoing trial using paired *t*-test for within-group comparisons. Patients identified to have OH based on systolic or diastolic fall in BP were analyzed separately. Chi-square analysis compared the improvement in OH status between the two groups. **Results:** Nineteen out of 186 screened elderly patients were diagnosed with OH (10.21%, 95% CI: 7.99–12.43). Arm exercise significantly reduced the orthostatic-induced fall in systolic and diastolic BP, while leg exercise effectively reduced only the systolic fall in BP among patients with OH. The proportion of patients with OH after arm exercise (20%) was significantly lower than after leg exercise (77.8%) ($P = 0.023$, Fischer's exact test). **Conclusion:** We found a 10.21% prevalence of OH in our elderly population. Furthermore, we found that simple isometric arm tensing exercise ameliorates the fall in BP on standing up in OH patients.

Keywords: Autonomic nervous system, blood pressure, elderly, exercise, orthostatic hypotension

Introduction

Orthostatic hypotension (OH) in the elderly population is an important cause of mortality worldwide[1] and is a leading cause of falls in the elderly.[2] It is considered one of the debilitating features of autonomic dysfunction.[3] However, it is most often unrecognized clinically during the early stages and is underdiagnosed in the elderly in India. Though OH exists across all age groups, it is reportedly more prevalent with increasing age.[4] With the reaction time being naturally slow in the elderly, a diagnosis of OH puts them at a higher risk of losing their balance and experiencing falls. Unmasking the prevalence of OH among the elderly in India would therefore be of larger benefit to raise awareness of the problem so that they can seek timely medical attention. As only a few studies have investigated OH in the aging Indian population,[5] in the current study, we aimed to ascertain the prevalence of OH, examine the factors associated with it, and determine the effectiveness of isometric exercise in its management, among the elderly in India.

The prevention and treatment profiles for several disease conditions are different in the young and the elderly. A condition

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Received: 18-06-2023 **Revised:** 18-07-2023
Accepted: 09-08-2023 **Published:** 21-11-2023

Access this article online

Quick Response Code:

Website: http://journals.lww.com/JFMPC

DOI: 10.4103/jfmpc.jfmpc_1009_23

How to cite this article: Tephilla E, Elizabeth T, Shalini J, Vinod A. Orthostatic hypotension in the elderly: Prevalence and its management by simple isometric limb tensing exercises. J Family Med Prim Care 2023;12:2661-6.

like OH in the elderly needs to be managed by more age-friendly options. Any exercise, including isometric, activates the sympathetic nervous system, causing a moderate increase in arterial blood pressure (BP).[6] The magnitude of the hypertensive response relates directly to the intensity of effort and the quantity of muscle mass that is activated during isometric exercise. This form of exercise could therefore be performed effectively to stimulate an increase in BP when the normal regulatory mechanisms fail to prevent a drop in arterial BP. Isometric arm exercises have been reported to be beneficial in raising the BP during imminent syncope while standing, among patients with vasovagal syncope.[7] However, no studies have investigated the role of arm tensing exercise in reducing the fall in BP on standing in patients with OH. A study reported that isometric leg exercises performed using a device attached to the bed succeeded in reducing the fall in BP in elderly patients with OH.[8] We reasoned that the use of devices for performing exercises may not be readily accepted by the elderly of the Indian rural community. We felt that device-free isometric leg exercises would be met with better patient compliance in our elderly population. Lower body muscle tensing by itself has been demonstrated to raise the BP through increases in cardiac output in patients with vasovagal syncope/reaction.[9] These exercises, if found to be effective in reducing OH, could be incorporated into primary and secondary care settings without any additional infrastructure or specialized training.

Hence, we asked the question of whether device-free simple supine isometric arm and leg exercises performed just before standing up would be effective in reducing the orthostatic fall in BP in elderly patients with OH. We hypothesized that these interventions would counter the fall in BP produced by the orthostatic challenge, and to compare the relative effectiveness of isometric arm and leg exercise, we designed a randomized controlled trial (RCT) in elderly patients with OH.

Materials and Methods

Study design

The prevalence and the factors associated with OH in the elderly were studied using a cross-sectional design. The relative effectiveness of leg and arm tensing isometric exercises in reducing the fall in BP produced by standing in elderly OH patients was studied with the design of a two-armed RCT. Ethical clearance was obtained from the institutional review board, and the study was prospectively registered at the Clinical Trials Registry – India (CTRI/2020/08/027182). Elderly patients aged 65 years or older, who received care at a secondary care hospital were recruited into the study after informed written consent. Exclusion criteria were grade III and IV heart failure and inability to stand up independently.

Demographic information and clinical history were obtained from the patient's hospital records. Self-reported symptoms related to OH, frequency of nocturia, and history of previous falls were documented. An automatic BP monitor (Model HEM-7361T, Omron Healthcare, Kyoto, Japan) provided the recorded BP on an Excel sheet with the time and date stamp. OH was diagnosed following the consensus statement released in 2011 by the Joint Consensus Committee of the American Autonomic Society, according to which OH is defined as a sustained reduction in systolic BP (SBP) of at least 20 mmHg or diastolic BP (DBP) of 10 mmHg within 3 min of standing.[10] BP was repeatedly measured during 10 min of supine rest, and the value at the 10th min was taken as the supine BP for further calculation. The patient then stood up independently following verbal instruction, and the BP was measured at the 1st and 3rd min after standing. The subjective feeling of light-headedness, blurring of vision, impending sense of fainting, and nausea associated with the orthostatic challenge were enquired about and documented. The change in the SBP and DBP from the supine value at the 1st and 3rd min after standing was computed. The highest fall in BP at these two-time points was considered for meeting the criteria for diagnosis of OH, as done in previous studies,[11] and for all subsequent analysis in the current study.

The patients identified with OH were randomized into two groups using block randomization with block sizes of two and four and a 1:1 allocation ratio, and the sequence was concealed in sealed opaque envelopes to allow for blinded allocation. One group was assigned to the arm tensing exercise intervention (arm exercise group), and the other group was assigned to the leg tensing exercise intervention (leg exercise group). The intervention study was carried out on the same day, repeating the basic protocol described above for detecting OH, with the subjects in both groups resting initially for 10 min and then standing up on command, additionally implementing the exercise intervention for 30 s just prior to standing up [Figure 1]. The subjects in the arm exercise group gripped one hand with the other (with fingers opposing and the palm of one hand facing up and the other facing down) and pulled the hands apart with maximum force for 30 s while in the supine posture and just before standing up. Participants in the leg exercise group pressed the dorsum of one foot down with the sole of the other for 30 s, while the first foot offered maximum opposing resistance, both legs being kept extended while lying down and just before standing up. The BP was recorded at the first and third minute after standing [Figure 1]. The change in BP was computed similarly to the baseline evaluation that screened for OH, and the highest fall at the two-time points was considered for analysis.

Statistical analysis

Previous studies have reported a prevalence of OH of 30–35% among the elderly.[5,10,11] Assuming a value of 35%, we calculated the sample size of 186 for the cross-sectional study to determine the prevalence of OH. We expected to find 64 patients with OH from this sample and planned to randomize them equally into the arm and leg exercise groups.

Epi Info software version 7 was used for data entry, and analysis was done using SPSS Ver. 24. Continuous variables

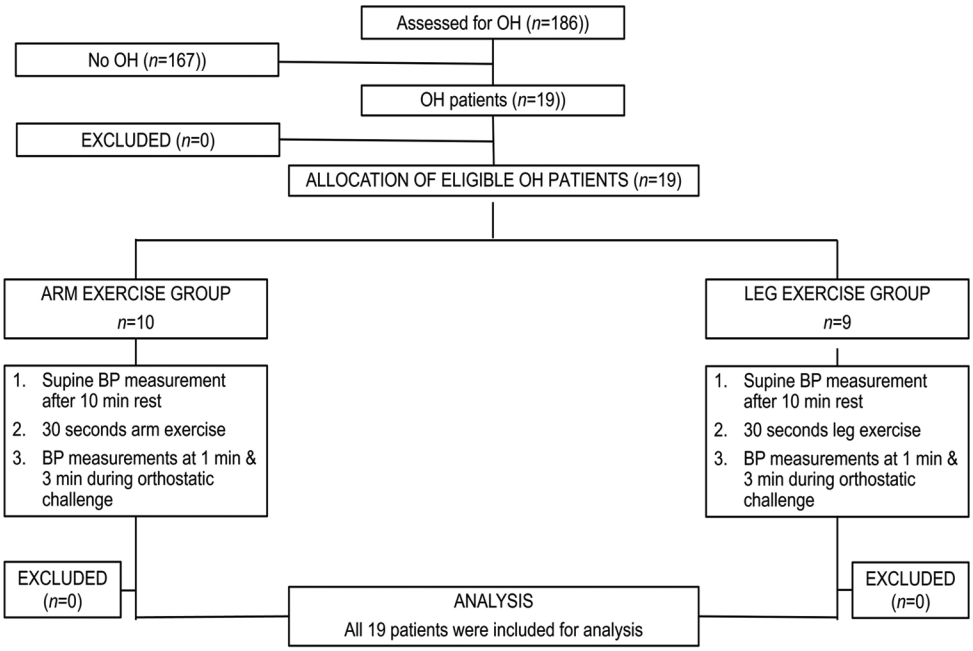

Figure 1: Participant flow diagram. OH = orthostatic hypotension, BP = blood pressure

like fall in SBP and DBP were described in terms of mean and standard deviation (mean ± SD). Categorical variables were described in terms of proportions and prevalence with 95% confidence intervals. The expected outcome was a reduction in the orthostatic-induced fall in SBP and DBP by the exercise intervention. Paired t-tests were used for all paired comparisons. Comparison between the arm exercise group and the leg exercise group was done by Chi-squared analysis. A *P* value of less than 0.05 was considered significant.

Results

Demographic data and clinical history of the 186 participants (68.89 ± 5.31 years, 74% females) recruited for the cross-sectional study are given in Table 1. Almost two-thirds of our study population reported complaints related to OH, like giddiness and fainting episodes. However, a smaller proportion of patients (5.4%) reported an event of fall in the recent past, and even fewer patients reported nocturia.

We observed a prevalence of 10.21% (95% CI: 7.99–12.43) OH in our study population. No associations were observed between OH and gender, diabetes mellitus, antihypertensive usage, experience of symptoms of OH, and history of falls [Table 1]. Neither did we find any association of OH with hypertension and usage of anti-diabetic and sedative medications. There were no patients with Parkinson's disease. Only one patient had varicose veins, and that patient did not have OH.

We conducted an interim analysis of the RCT when analyzing the results of the cross-sectional study of 186 patients (recruited from August 2020 to July 2022) and found that of the 19 patients who met the criteria for OH, 10 were randomized to the arm exercise group and the remaining nine to the leg exercise group [Figure 2]. Baseline measurements were comparable across groups [Table 2]. When considering the arm and leg exercise groups together, we found that the exercise intervention *per se* significantly reduced the mean fall in systolic and diastolic blood pressures on standing up (ΔSBP pre = 18.2 ± 9.7 mmHg, ΔSBP post = 12 ± 9.8 mmHg, *P* value = 0.007, *n* = 19); (ΔDBP pre = 10.05 ± 6.3 mmHg, ΔDBP post = 5.1 ± 8.15 mmHg, *P* value = 0.004, *n* = 19). Within group comparison done to analyze the effect of each exercise intervention on the fall in SBP and fall in DBP separately [Figure 3] showed that arm exercise effectively reduced the systolic (ΔSBP pre = 22 ± 2.09 mmHg, post = 6.8 ± 7.8 mmHg; *P* = 0.004, *n* = 7) and diastolic (ΔDBP pre = 12.3 ± 2.7 mmHg, post = 5.6 ± 6.7 mmHg; *P* = 0.006,

Table 1: Demography, clinical features, and medical history of patients (*n*=186)

Variables	Categories	Mean±SD or number (%)		*P*
		OH (*n*=19)	No OH (*n*=167)	
Age (years)		67.74±2.51	69.02±5.53	0.08*
Gender	Females	13 (9.4)	125 (90.6)	0.544**
	Males	6 (12.5)	42 (87.5)	
Diabetes mellitus	Present	13 (11.2)	103 (88.8)	0.565**
	Absent	6 (8.6)	64 (91.4)	
Antihypertensives	Present	12 (10.5)	102 (89.5)	0.86**
	Absent	7 (9.7)	65 (90.3)	
Falls	Present	2 (20)	8 (80)	0.271#
	Absent	17 (9.7)	159 (90.3)	
Symptoms related to OH	Present	10 (8.4)	109 (91.6)	0.277**
	Absent	9 (13.4)	58 (86.6)	
Nocturia	Present	1 (12.5)	7 (87.5)	0.585#
	Absent	18 (10.1)	160 (89.9)	

SD=standard deviation, OH=orthostatic hypotension. *Unpaired *t*-test, **Chi-square test, #Fisher's exact test

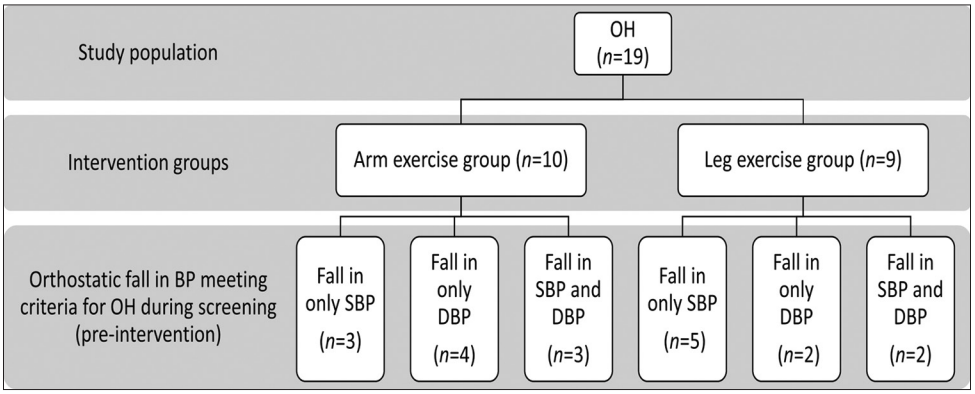

Figure 2: Description of OH patients by intervention and criteria for diagnosis of OH pre-intervention. OH = orthostatic hypotension, BP = blood pressure, SBP = systolic blood pressure, DBP = diastolic blood pressure

Table 2: Demography, clinical features, and medical history of patients in the arm and leg exercise groups (*n*=19)

Variables	Mean±SD or number (%)		*P*
	Arm exercise group (*n*=10)	Leg exercise group (*n*=9)	
Age (years)	67.2±1.87	68.33±3.08	0.357*
Females	5 (50)	8 (88.9)	0.141**
Diabetes mellitus	8 (80)	5 (55.6)	0.350**
Antihypertensives	5 (50)	7 (77.8)	0.35**
History of falls	0	2 (22.2)	-
Past symptoms of OH	4 (40)	5 (55.6)	0.656**
OH symptoms during the initial orthostatic challenge	2 (20)	4 (44.4)	0.35**
SBP fall during the initial orthostatic challenge (mmHg)	18.7±5.2	18.2±12	0.91**
DBP fall during the initial orthostatic challenge (mmHg)	10±4.2	10.1±8.4	0.971**

SD=standard deviation, OH=orthostatic hypotension, SBP=systolic blood pressure, DBP=diastolic blood pressure. *Unpaired *t*-test, **Fisher's exact test

n = 6) fall in BP on standing, while leg exercise effectively reduced only the systolic fall (ΔSBP pre = 23.7 ± 3.5 mmHg, post = 17 ± 8.6 mmHg; *P* = 0.02, *n* = 7), and not the diastolic fall in BP (ΔDBP pre = 16.25 ± 9.25 mmHg, post = 13.25 ± 4.27 mmHg, *P* value = 0.5, *n* = 4) among patients with OH. The proportion of patients with OH after arm exercise (20%) was lower than the proportion of patients with OH after leg exercise (77.8%); this difference was statistically significant (*P* = 0.023, Fischer's exact test) [Figure 4].

Discussion

We found a prevalence of 10.21% (95% CI: 7.99–12.43) OH in the elderly aged 65 years and older, receiving care from a secondary care hospital in India. We observed no significant association between comorbid conditions and OH in our study population. Further, we found that a simple isometric arm tensing exercise performed just before standing was more effective in alleviating OH than a leg tensing exercise.

The 10.21% prevalence of OH observed in our study, concurs with the report by Zhu *et al.*[12] of 11% in the elderly Asian population. However, our findings differ from the finding by Baliga R *et al.*[5] of a prevalence of less than 1% OH in the healthy geriatric Indian population. This incongruity is explained by the inclusion of those with prevailing comorbidities in our study. The prevalence rate of OH we have detected is, therefore, comparatively higher and is similar to the 9.6% observed by Sasidharan *et al.*[13] among healthy community-dwelling elderly in South India. It is noteworthy that the prevalence we observed among patients who sought medical care from a secondary care hospital is only slightly more than that detected in healthy elderly people of the same age group.[13]

We found diabetes mellitus to be the most prevalent comorbid condition among our study population. Of the entire number of patients with diabetes, 11.5% were found to have OH. However, we detected no significant association of OH with diabetes, though it is known to increase the likelihood of OH.[14,15] Diagnosing OH in diabetic patients is important for early management, as evidence shows a higher 10-year mortality in diabetic patients with OH compared to those without OH.[16] Neither did we find any significant association of OH with the use of antihypertensives and sedatives. While some studies report an association between antihypertensive use and OH,[17] other studies show no association.[18] Our observation of no significant association between OH and diabetes, hypertension, or medication usage is inconsistent with the findings of an association between them by Sasidharan *et al.*[13] This difference could be attributed to the fact that while we documented the comorbidities from the hospital records, the same information was self-reported by the patients in the study reported by Sasidharan *et al.*, which the authors report as a limitation of their study. Although Parkinson's disease is reported to be associated with OH,[19,20] none of our patients had Parkinson's disease.

Despite many nonpharmacological interventions being recommended for the treatment of OH[21–23], they are met with low patient compliance rates.[24] The maneuvers implemented in our study to counter the fall in BP on standing are simple and device free. By activating core body muscles, OH patients

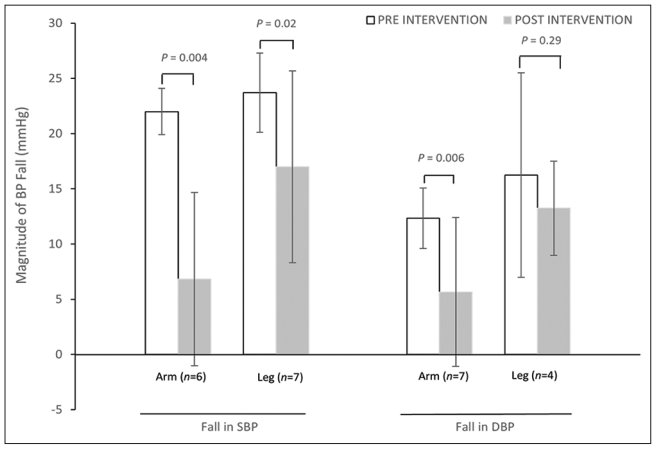

Figure 3: Comparison of the magnitude of fall in systolic and diastolic blood pressures, before and after intervention, in the arm and leg exercise groups. SBP = systolic blood pressure, DBP = diastolic blood pressure

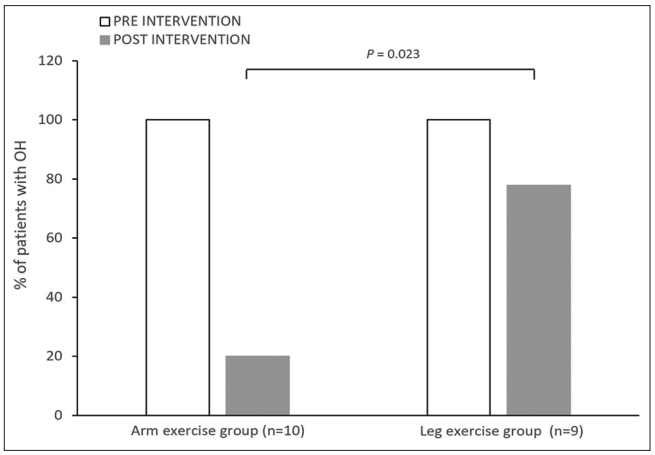

Figure 4: Comparison of change in OH status with intervention in the arm and leg exercise groups. OH = orthostatic hypotension

mitigated the fall in BP that occurred during an orthostatic challenge. Our data show that arm exercises are beneficial in lowering the fall in BP on standing up and are also more effective than leg exercises. Arm exercises may be better tolerated than compression stockings, which have an overall poor patient compliance.[24]

We observed that patients found it easier to perform the arm exercises than the leg exercises. While none of the patients in the arm exercise group complained about performing the exercise, some of the patients in the leg exercise group expressed that it was uncomfortable to perform the exercise. A physiological explanation for the larger reduction in BP fall with the arm than with leg exercise is probably because, for a given intensity of exercise output, the sympathetic stimulation with arm exercise is greater than with leg exercise.[25] Also, the smaller arm muscle mass and blood supply offer higher resistance to blood flow than the larger leg muscle mass.[26] It follows that the BP response will be larger with arm exercise than with leg exercise, which may account for the greater success with arm exercise in ameliorating the OH which we observed in our study.

Given that a large proportion of patients, including the elderly, seek care in primary and secondary-level settings, screening for OH and intervening through simple exercises would reduce the incidence of falls and its complications in the elderly.

A limitation of our study is that we did not quantify the effort exerted during the intervention. Hence, we were unable to assess whether patients exerted equivalent amounts of effort during the arm and leg exercises. Patient compliance and satisfaction, however, are important factors determining the outcome and benefits of any such interventions, and we found that patient acceptance was better with arm exercise than with leg exercise. This favors the use of arm exercise for the management of OH and adds to the evidence provided by our interim analysis. Our results indicate that arm exercise is more efficient than leg exercise in overcoming OH in the elderly, though the patient numbers we report in this interim analysis are small.

Conclusion

Our study provides evidence for the notable existence of OH among the elderly receiving care from a secondary care hospital in a rural population in India, with more than half the study population reporting OH-related symptoms. We observed no significant association between comorbid conditions and OH in our study population. Notably, we found that simple isometric arm tensing exercises, performed in the supine position and just before standing, which find good acceptance in the elderly, are clinically beneficial in reducing the orthostatic-induced fall in SBP and DBP in elderly patients. Further, isometric arm exercise was more beneficial than leg exercise in relieving the OH. The interim analysis we report involves a small number of patients; nevertheless, the results are striking and noteworthy. Arm exercises can be easily performed by elderly OH patients prior to standing up from the supine position. Hence, we are compelled to report the promising results of our interim analysis.

Research quality and ethics statement

All authors of this manuscript declare that this scientific study follows standard reporting guidelines set forth by the Consolidated Standards of Reporting Trials (CONSORT). Further, all authors endorse that this study was conducted after obtaining approval from the institutional review board and ethics committee of Christian Medical College, Vellore (IRB Min No 12464 dated 18/12/2019) and that this study was conducted in accordance with the tenets of the Helsinki Declaration.

Declaration of patient consent

The authors certify that all appropriate consent was obtained.

Financial support and sponsorship

This study was funded by an institutional research grant from Christian Medical College, Vellore.

Conflicts of interest

There are no conflicts of interest.

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