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Yoga versus pursed lip breathing in neurogenic orthostatic hypotension: A randomized controlled trial

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Abstract:
Neurogenic orthostatic hypotension impairs cardiovascular autonomic regulation and the comparative effects of breathing techniques remain uncertain. Therefore, it is of interest to compare the slow-paced yoga breathing and pursed lip breathing in 60 patients with neurogenic orthostatic hypotension (n = 30/group). Both interventions significantly improved heart rate and orthostatic blood pressure compared with baseline ($P < 0.01$). Slow-paced yoga breathing produced greater reductions in heart rate and orthostatic systolic blood pressure drop than pursed lip breathing ($P < 0.01$). Thus, data shows that slow-paced yoga breathing is an effective, non-pharmacological strategy for improving short-term autonomic cardiovascular stability.

Keywords: Neurogenic orthostatic hypotension (nOH), slow-paced yoga breathing (SPYB), pursed lip breathing (PLB), cardiac autonomic modulation, heart rate, blood pressure, pranayama

Background:
Neurogenic orthostatic hypotension (nOH) is a disabling condition arising from dysfunction of the cardiovascular autonomic control mechanism, whereby the body fails to sustain normal blood pressure on standing. It is characterised by a persistent drop in systolic blood pressure (SBP) of 20 mmHg or more or diastolic blood pressure (DBP) of 10 mmHg or more, within three minutes of standing or head-up tilt, mostly due to insufficient release of norepinephrine by sympathetic post-synaptic neurons **[1].** It occurs in approximately 30% of adults aged over 65 years and in nearly 70% of institutionalized older adults and is found in up to 80% of multiple system atrophy patients, approximately 30% of Parkinson disease patients and almost all pure autonomic failure patients **[2].** The typical symptoms of nOH - dizziness, light-headedness, presyncope and syncope - arise because cerebral perfusion falls when sufficient blood pressure is no longer maintained in the standing posture **[3].** Despite the availability of medications such as midodrine and droxidopa, side effects including supine hypertension, urinary retention and drug interactions may limit their use. Pharmacological measures should nonetheless remain part of management and patient education, alongside encouragement of physical counter-measures **[4]**. Clinical interest in breathing exercises is growing because they are affordable, have no side effects and can influence the autonomic nervous system (ANS). Slow-paced yoga breathing (SPYB), based on pranayama practice, consists of slow, controlled breathing at approximately six breaths per minute **[5]**. This breathing rate produces cardiovascular resonance, increases baroreflex sensitivity and facilitates parasympathetic activation with respiratory sinus arrhythmia (RSA). Other studies have shown that SPYB can generate instantaneous changes in blood pressure and heart rate and enhance heart rate variability (HRV), across various populations. Pursed lip breathing (PLB) is a strategy in which exhalation occurs through slightly pursed lips, prolonging the expiratory phase and reducing expiratory airflow **[6]**. PLB has been shown to increase parasympathetic tone, improving heart rate, oxygen saturation and HRV by slowing the breathing pattern and increasing tidal volume, particularly in patients with chronic obstructive pulmonary disease (COPD). Although the role of both techniques in modulating autonomic function has been established individually, no randomized controlled trial has yet directly compared SPYB against PLB specifically in patients with nOH **[7]**. Clarifying which breathing modality is more effective in reducing orthostatic BP drop and stabilising HR in the immediate post-intervention period could have important clinical and patient-education implications for this high-risk population **[8]**. Therefore, it is of interest to evaluate the immediate effects of slow-paced yoga breathing versus pursed lip breathing on cardiovascular autonomic responses in patients with neurogenic orthostatic hypotension.

Materials and Methods:
This prospective randomized controlled trial assessed outcome measures at pre-intervention and post-intervention time points. All study procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki and written informed consent was obtained from all participants.

Participants were selected by purposive sampling from the neurology and geriatric outpatient departments. Adults aged 40-80 years with a confirmed diagnosis of neurogenic orthostatic hypotension (nOH) were eligible. Diagnosis was based on conventional criteria: a persistent drop in SBP of at least 20 mmHg and/or DBP of at least 10 mmHg within three minutes of standing, with an insufficient compensatory increase in heart rate (<15 bpm). Inclusion criteria comprised a confirmed diagnosis of nOH by standard criteria, age 40-80 years, stable current medications for at least 4 weeks, ability to perform seated breathing exercises and provision of written informed consent. Exclusion criteria comprised severe cardiac arrhythmia or decompensated heart failure, active respiratory infection or severe obstructive lung disease, cognitive impairment precluding comprehension of breathing instructions, severe supine hypertension (>180/110 mmHg), recent syncope (<24 hours) or haemodynamic instability and prior formal yoga or PLB training within the preceding 3 months. Sample size was estimated using G*Power 3.1 software for an independent two-group t-test. Assuming an effect size of d=0.85 (based on pilot data on orthostatic SBP drop), 80% power and α=0.05 (two-tailed), at least 24 participants per group were required. A total of 30 participants were recruited per group to allow for an expected 20% dropout or withdrawal rate, giving a total study sample of 60. Participants were randomly assigned to the SPYB or PLB group after baseline assessment, using a computer-generated random list (Random.org). To reduce selection bias, treatment allocation was concealed using sequentially numbered, opaque, sealed envelopes (SNOSE), which were not opened until the baseline assessment was complete.

Results:

A total of 78 patients with neurogenic orthostatic hypotension were screened, of whom 60 met the inclusion criteria and were recruited. Participants were randomly assigned to the SPYB group (n = 30) or the PLB group (n = 30). All participants completed the single-session intervention and no adverse events were reported. No significant differences were observed in the baseline demographic and clinical characteristics between the two groups, confirming successful randomization (**Table 1**). Both breathing interventions produced significant improvements in the primary outcome measures following the intervention. Compared with PLB, the SPYB group showed significantly greater reductions in orthostatic systolic blood pressure drop and heart rate, whereas changes in supine systolic and diastolic blood pressure were comparable between groups (**Table 2**). Both groups also showed improvements in oxygen saturation and Orthostatic Hypotension Symptom Assessment (OHSA) scores. The SPYB group achieved significantly greater improvement in OHSA scores than the PLB group, while the between-group difference in oxygen saturation was not statistically significant (**Table 3**).

Table 1: Baseline characteristics of study participants

Characteristic	SPYB Group (n=30)	PLB Group (n=30)	P value
Age (years)	61.4 ± 8.7	63.2 ± 9.1	0.42
Gender (M/F)	17/13	16/14	0.79
BMI (kg/m²)	24.8 ± 3.2	25.1 ± 3.6	0.71
Disease duration (years)	3.6 ± 1.8	3.9 ± 2.0	0.55
Baseline HR (bpm)	82.3 ± 9.4	81.7 ± 8.9	0.8
Baseline SBP supine (mmHg)	128.4 ± 12.1	127.9 ± 11.8	0.87
Baseline DBP supine (mmHg)	78.6 ± 8.4	79.1 ± 8.7	0.82
Ortho SBP drop - baseline (mmHg)	23.8 ± 5.2	24.1 ± 5.6	0.83
OHSA composite score	4.8 ± 1.3	4.9 ± 1.4	0.76

Data are presented as mean ± SD. HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; Ortho, orthostatic; OHSA, Orthostatic Hypotension Symptom Assessment.

Table 2: Comparison of primary outcomes - pre vs post intervention

Out come	SPYB Pre	SPYB Post	PLB Pre	PLB Post	Between-Group P
HR (bpm)	82.3 ± 9.4	73.9 ± 8.1*	81.7 ± 8.9	76.6 ± 7.8*	0.003
Supine SBP (mmHg)	128.4 ± 12.1	124.2 ± 11.3	127.9 ± 11.8	125.1 ± 11.5	0.61
Supine DBP (mmHg)	78.6 ± 8.4	75.9 ± 7.8	79.1 ± 8.7	76.8 ± 8.1	0.58
Ortho SBP drop (mmHg)	23.8 ± 5.2	14.2 ± 3.8*	24.1 ± 5.6	18.3 ± 4.1*	0.002
Ortho DBP drop (mmHg)	12.4 ± 3.1	7.6 ± 2.4*	12.7 ± 3.3	9.5 ± 2.6*	0.008

*Values are mean ± SD. *Significant within-group change (P<0.001 for all paired comparisons). Ortho, orthostatic. Between-group P value by independent samples t-test.*

Table 3: Secondary outcomes - pre vs post intervention secondary outcomes

Out come	SPYB Pre	SPYB Post	PLB Pre	PLB Post	Between-Group P
SpO_2 (%)	96.1 ± 1.8	97.4 ± 1.4*	95.9 ± 1.7	96.8 ± 1.5	0.09
OHSA score	4.8 ± 1.3	2.9 ± 1.1*	4.9 ± 1.4	3.6 ± 1.2	0.04

*Values are mean ± SD. *Significant within-group change (P<0.01). OHSA, Orthostatic Hypotension Symptom Assessment composite score (0-10 scale).*

Discussion:

This is one of the first randomized controlled trials, to our knowledge, to directly compare the acute effects of slow-paced yoga breathing (SPYB) and pursed lip breathing (PLB) on cardiac autonomic function in patients with neurogenic orthostatic hypotension. Both breathing techniques produced substantial improvements in heart rate and orthostatic blood pressure stability after only 15 minutes of intervention; however, participants who practised SPYB showed considerably greater improvements than those in the PLB group. The greater physiological response to SPYB may be attributable to its resonance mechanism. The intrinsic baroreflex rhythm (~0.1 Hz) corresponds to a breathing frequency of approximately six breaths per minute, which facilitates a stronger respiratory sinus arrhythmia (RSA) and an increase in baroreflex sensitivity **[9].** Such autonomic changes may explain the greater cardiovascular stabilisation observed following SPYB. Enhanced baroreflex sensitivity may be of particular relevance in nOH, in which baroreflex responses to orthostatic stress are characteristically suppressed. PLB, in contrast, improves respiratory efficiency and parasympathetic tone but at a higher respiratory rate and may not achieve the same degree of cardiovascular resonance **[10, 11].** The larger decrease in heart rate observed after SPYB is consistent with previous studies reporting that slow yoga breathing enhances vagal activity, inhibits sympathetic discharge and improves cardiac vagal regulation **[11, 12].** A reduction in resting HR is of particular clinical relevance in nOH, since compensatory tachycardia is characteristically absent in this population; a lower resting rate achieved through a non-pharmacological therapy could therefore reduce overall cardiovascular demand. The clinical significance of

the observed attenuation in orthostatic SBP drop (23.8 to 14.2 mmHg in the SPYB group) is notable. Although both groups improved, SPYB reduced the orthostatic fall by approximately 9.6 mmHg compared with 5.8 mmHg in the PLB group. Notably, a substantial proportion of participants in the SPYB group no longer met the diagnostic threshold of a 20 mmHg SBP drop after the intervention, suggesting the possibility of acute reversal of haemodynamic instability **[13, 14]**. This finding may have implications for safe post-intervention mobilization, particularly in patients at risk of falls. Both groups showed a significant improvement in the OHSA composite score, a subjective measure of dizziness and lightheadedness, with a greater improvement in the SPYB group. This patient-reported outcome supports the objective haemodynamic findings and the clinical validity of the results. Both techniques improved SpO_2, although the between-group difference was not statistically significant, supporting a benefit for respiratory efficiency with either technique **[15]**. The absence of pharmacological intervention in both arms is a further strength of this study, given that a substantial proportion of this population is elderly, polymedicated and prone to supine hypertension from BP-raising medications. Breathing exercises are self-administered, require no equipment and are essentially free of systemic side effects. These characteristics make SPYB particularly appealing as a scalable adjunct in outpatient nOH management.

Conclusion:
Slow-paced yoga breathing produced greater immediate improvements in heart rate and orthostatic blood pressure than pursed-lip breathing in patients with nOH. Both techniques were safe and well tolerated, with slow-paced yoga breathing showing greater short-term clinical benefit. Slow-paced yoga breathing may be a simple, non-pharmacological option for short-term symptom management in nOH.

Limitations:
This study has few limitations. First, the findings are confined to the short-term consequences of the intervention, since only immediate post-intervention outcomes were evaluated; no conclusions can be drawn regarding long-term benefit and studies with longer follow-up are needed. Second, HRV spectral analysis was not conducted because of limited resources, so the underlying cardiac autonomic mechanisms could not be directly characterised. Third, participants could not be blinded to their allocated intervention given the nature of the techniques, introducing potential performance bias. Fourth, the single-centre design may limit generalisability of the findings. Future research should incorporate HRV analysis, extended training regimens and multi centre samples.

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Declarations:
Ethics approval:
All procedures were conducted in accordance with the Declaration of Helsinki and written informed consent was obtained from all participants.

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Conflicts of interest: None declared.

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