

A Comparative Study on The Effects of Relaxed Breathing and Deep Breathing Exercises on Sleep Quality and Selected Physiological Parameters Among Middle-Aged Women: A Randomised Controlled Trial

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Abstract

Background: Sleep disturbance and perceived stress are common during midlife in women and are linked to autonomic hyperarousal. Slow, controlled breathing is a low-cost, non-pharmacological approach, but the relative effects of relaxed breathing and deep (diaphragmatic) breathing in this group are not established.

Objective: To compare the effects of relaxed breathing and deep breathing exercises on sleep quality, perceived stress, pulmonary function and cardiovascular parameters in middle-aged women with poor sleep quality and moderate stress.

Methods: In this two-arm, parallel-group, randomised controlled trial with blinded assessment of the objective outcomes, 60 women aged 35–50 years with parity 2, moderate perceived stress (PSS-10) and poor sleep quality (PSQI global score > 5) were randomly allocated (1:1) to relaxed breathing or deep breathing for 6 weeks (5 sessions/week, 20 minutes/session). The primary outcome was the PSQI global score. Secondary outcomes were PSS-10 score, spirometry (FVC, FEV₁, FEV₁/FVC, PEFR), heart rate and blood pressure, assessed at baseline and post-intervention. Within-group changes were analysed using the paired t-test and between-group differences in change scores (post minus pre) using the unpaired t-test.

Results: Of 60 randomised women, 57 completed the trial (29 relaxed breathing, 28 deep breathing) and were analysed. PSQI global score changed from 8.7 ± 1.7 to 5.6 ± 2.2 in the relaxed breathing group and from 9.1 ± 1.7 to 4.6 ± 2.2 in the deep breathing group; the reduction was significantly greater with deep breathing ($p < 0.001$). PSS-10 also decreased more with deep breathing ($p < 0.001$). Deep breathing produced greater improvements in FVC, FEV₁ and PEFR (all $p < 0.001$), and greater reductions in heart rate ($p = 0.003$), systolic blood pressure ($p = 0.002$) and diastolic blood pressure ($p = 0.001$). FEV₁/FVC did not differ between groups ($p = 0.117$).

Conclusion: Both exercises improved sleep quality and perceived stress, but deep breathing produced significantly greater improvements in sleep quality, perceived stress, FVC, FEV₁, PEFR, heart rate and blood pressure.

Keywords: relaxed breathing, deep breathing, diaphragmatic breathing, sleep quality, Pittsburgh Sleep Quality Index, perceived stress, spirometry, middle-aged women.

Introduction

Sleep is a fundamental determinant of physical and mental health, and chronic short or poor-quality sleep is associated with metabolic and endocrine dysregulation and increased mortality risk^{1,2}. Women in midlife are particularly vulnerable: community surveys report that a substantial proportion of women aged 40–55 years experience sleep difficulty, and the prevalence of insomnia symptoms is consistently higher in women than in men^{3,4}. Recommended sleep duration and quality benchmarks for adults are well defined⁵, yet poor sleep remains under-recognised and under-treated, particularly in low-resource settings.

Psychological stress is a major, modifiable contributor to disturbed sleep. Sustained stress is associated with sympathetic predominance and reduced vagal tone, a state of physiological hyperarousal incompatible with sleep initiation and maintenance^{6,7}. Stress is commonly quantified using the Perceived Stress Scale (PSS)^{8,9}, and sleep quality using the Pittsburgh Sleep Quality Index (PSQI), a validated instrument with a global score above 5 distinguishing poor sleepers^{10,11}.

Pharmacological treatment of sleep disturbance carries risks of dependence, daytime sedation and tolerance, which has increased interest in behavioural, non-pharmacological options. Slow, voluntary breathing is one such approach. Reviews of the physiology of slow breathing describe increased respiratory sinus arrhythmia and heart rate variability, enhanced baroreflex sensitivity and a shift towards parasympathetic dominance^{12–15}. Proposed mechanisms include stretch-receptor activation during slow, deep inspiration, modulation of vagal afferents and central autonomic networks, and improved cardiorespiratory coupling^{6,7,14}. Even a single session of deep and slow breathing has been reported to increase vagal tone and reduce anxiety¹⁶.

Clinical evidence supports these mechanisms. Paced slow breathing before bedtime improved polysomnographic sleep indices in self-reported insomniacs¹⁷, and a 30-day slow-paced breathing programme improved subjective sleep quality compared with social media use in healthy adults¹⁸. A meta-analysis of randomised trials found that breathwork reduces self-reported stress, with a small-to-medium pooled effect¹⁹, although a large placebo-controlled trial of coherent breathing found no benefit beyond a well-matched breathing placebo²⁰, and a recent trial reported that brief structured respiration practices improved mood and reduced arousal²¹. Diaphragmatic breathing has been associated with reduced stress and negative affect^{22–24}, and yogic breathing practices have shown favourable effects on perceived stress, blood pressure, heart rate and pulmonary function^{25–33}. Breath regulation has also been proposed as a primary self-regulatory strategy for anxiety³⁴.

Despite this, two questions remain unanswered. First, most studies have used a single breathing technique, or heterogeneous “breathing” programmes, rather than directly comparing a relaxed, natural-rhythm breathing exercise with a volitional deep diaphragmatic breathing exercise. Second, few trials have examined sleep quality alongside pulmonary and cardiovascular parameters in stressed middle-aged women. The present randomised controlled trial therefore compared relaxed breathing and deep breathing exercises on sleep quality (primary outcome), perceived stress, spirometric indices, heart rate and blood pressure in middle-aged women with poor sleep and moderate stress. We hypothesised that both exercises would improve sleep quality, and that deep breathing would produce greater changes in pulmonary and autonomic parameters than relaxed breathing.

Methods

Study design and reporting

This was a two-arm, parallel-group randomised controlled trial with 1:1 allocation and blinded assessment of the objective outcomes (spirometry, heart rate and blood pressure), reported according to the CONSORT 2010 statement³⁵. The study adhered to the Declaration of Helsinki, and written informed consent was obtained from every participant.

Participants

Middle-aged women were recruited. Eligibility was assessed by the investigator using a screening proforma, the PSS-10 and the PSQI.

Inclusion criteria: (i) women aged 35–50 years (ii) parity of two (iii) moderate perceived stress (PSS-10 score 14–26)^{8,9}; (iv) poor sleep quality (PSQI global score > 5)^{10,11} (v) ability to understand and follow instructions and attend all sessions; and (vi) willingness to provide written informed consent.

Exclusion criteria: (i) any diagnosed chronic medical condition likely to affect sleep or pulmonary function, including respiratory disease (e.g., asthma, COPD), cardiovascular disease, hypertension and diabetes mellitus; (ii) irregular menstrual cycles; (iii) psychiatric illness, or current use of sleep medication, anxiolytics or antidepressants; (iv) regular practice of yoga, pranayama or other breathing exercises; (v) smoking or night-shift work; and (vi) recent surgery or acute illness.

Sample size

The sample size was calculated using G*Power software³⁶, considering a two-sided significance level (α) of 0.05, a statistical power of 80%, and an independent-samples t-test for comparing two groups. A total sample of 60 participants, with 30 participants allocated to each group, was planned. This sample size provides approximately 80% power to detect a standardized between-group effect size (Cohen’s *d*) of approximately 0.74. The final sample size was selected considering the study’s feasibility and recruitment capacity.

Randomisation, allocation concealment and blinding

Eligible participants were randomly allocated to the relaxed breathing group or the deep breathing group in a 1:1 ratio using a computer-generated random number sequence with block size 6. Allocation was concealed using sequentially numbered, sealed, opaque envelopes opened by an investigator not involved in recruitment or assessment, after baseline measurement. Because of the nature of the intervention, participants and the instructing therapist could not be blinded. Spirometry, heart rate and blood pressure were recorded, and the

data were analysed, by personnel blinded to group allocation; the PSQI and PSS-10 are self-reported questionnaires and were completed by participants who knew their allocation.

Interventions

Both groups attended supervised sessions for the first week to learn the technique and practised 5 days per week for 6 weeks, 20 minutes per session, in a quiet room, with an identical 3-minute initial settling period and a 2-minute final rest. Adherence was monitored using a practice diary and attendance record and telephone follow-up for home sessions. Participants were asked not to start any other breathing, yoga or relaxation practice during the study. Both programmes were delivered by the same physiotherapist.

Relaxed breathing group. Participants sat comfortably or lay in a semi-reclined position with eyes closed. They were instructed to allow breathing to settle into its natural, effortless rhythm through the nose, without altering depth or rate, while directing attention to the sensation of the breath and releasing tension in the shoulders, face and abdomen with each exhalation. Verbal cues were limited to relaxation prompts; no breath counting or volume targets were used.

Deep breathing group. Participants practised diaphragmatic deep breathing in supine crook-lying, progressing to sitting. One hand was placed on the upper chest and the other on the abdomen. Participants inhaled slowly through the nose for 4 seconds so that the abdominal hand rose while the chest hand remained still, followed by a slow, controlled exhalation through slightly pursed lips for 6 seconds, giving a rate of about 6 breaths per minute. Rest pauses were allowed after every 10 breaths to avoid hyperventilation.

Outcome measures

All outcomes were recorded at baseline and at the end of the 6-week intervention, at the same time of day.

Primary outcome - sleep quality. The PSQI is a 19-item self-rated questionnaire generating seven component scores (0–3) that sum to a global score of 0–21; higher scores indicate poorer sleep, and a global score above 5 indicates poor sleep quality^{10,11}.

Perceived stress. The PSS-10 measures the degree to which life situations are appraised as stressful over the previous month; scores range from 0 to 40, with higher scores indicating greater stress^{8,9}.

Pulmonary function. Forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), FEV₁/FVC ratio and peak expiratory flow rate (PEFR) were recorded using a computerised spirometer, calibrated daily. Participants were tested seated, wearing a nose clip, following the ATS/ERS technical standards^{37,38}. At least three acceptable manoeuvres were obtained, and the best values were used for analysis.

Heart rate and blood pressure. After 10 minutes of seated rest, resting heart rate and systolic and diastolic blood pressure were measured on the left arm using a validated automated oscillometric device; the mean of two readings taken 2 minutes apart was recorded.

Statistical analysis

Within-group changes from baseline to post-intervention were analysed using the paired t-test. Between-group comparisons (baseline values and change scores, post-intervention minus baseline) were analysed using the unpaired (independent-samples) t-test. Post-intervention analyses were performed on participants with complete data. A p value < 0.05 was considered statistically significant.

Results

Participant flow and baseline characteristics

Of 78 women assessed for eligibility, 18 were excluded and 60 were randomised (30 to each group). Three participants did not complete the post-intervention assessment (one in the relaxed breathing group and two in the deep breathing group; reasons: unable to attend follow-up sessions, scheduling difficulty and withdrawal of consent), so 29 participants in the relaxed breathing group and 28 in the deep breathing group were analysed (Figure 1). No adverse events were reported. The two groups were comparable at baseline in age, sleep quality, perceived stress, pulmonary function and cardiovascular parameters (Table 1), with all baseline p values > 0.05.

Table 1. Baseline characteristics of participants

Variable	Relaxed breathing (n = 30)	Deep breathing (n = 30)	t (unpaired)	p value
Age (years)	42.1 ± 3.4	41.2 ± 4.6	t = 0.86	0.394
PSQI global score (0–21)	8.7 ± 1.7	9.1 ± 1.7	t = -0.76	0.451
PSS-10 score (0–40)	20.0 ± 3.6	20.4 ± 3.0	t = -0.50	0.619
FVC (L)	2.68 ± 0.43	2.68 ± 0.33	t = -0.01	0.989
FEV ₁ (L)	2.20 ± 0.38	2.23 ± 0.34	t = -0.42	0.678
FEV ₁ /FVC (%)	82.0 ± 4.4	83.3 ± 5.2	t = -1.07	0.287

PEFR (L/s)	5.26 ± 0.81	5.22 ± 0.93	t = 0.17	0.866
Heart rate (beats/min)	78.3 ± 8.3	79.4 ± 7.5	t = -0.52	0.604
Systolic BP (mmHg)	123.6 ± 10.8	120.5 ± 8.7	t = 1.21	0.230
Diastolic BP (mmHg)	79.7 ± 5.8	80.5 ± 6.4	t = -0.51	0.615

All participants had parity 2. Values are mean ± SD. p values are from the unpaired t-test (df = 58). PSQI, Pittsburgh Sleep Quality Index; PSS-10, Perceived Stress Scale-10; FVC, forced vital capacity; FEV₁, forced expiratory volume in 1 s; PEFR, peak expiratory flow rate.

Sleep quality and perceived stress

The PSQI global score decreased significantly in the relaxed breathing group (from 8.7 ± 1.7 to 5.6 ± 2.2; p < 0.001) and in the deep breathing group (from 9.1 ± 1.7 to 4.6 ± 2.2; p < 0.001). The reduction was significantly greater with deep breathing (p < 0.001) (Table 2). PSS-10 scores decreased from 20.0 ± 3.7 to 16.2 ± 3.6 in the relaxed group and from 20.3 ± 3.1 to 15.0 ± 3.6 in the deep breathing group (both p < 0.001), with a significantly greater reduction in the deep breathing group (p < 0.001) (Table 2).

Table 2. Primary outcome (PSQI) and perceived stress (PSS-10): within-group and between-group comparisons

Outcome	Group	Pre (mean ± SD)	Post (mean ± SD)	Paired t	Paired p	Unpaired t	Unpaired p
PSQI global score (0–21)	Relaxed	8.7 ± 1.7	5.6 ± 2.2	-17.68	<0.001	-4.12	<0.001
	Deep	9.1 ± 1.7	4.6 ± 2.2	-17.19	<0.001		
PSS-10 score (0–40)	Relaxed	20.0 ± 3.7	16.2 ± 3.6	-13.91	<0.001	-3.57	<0.001
	Deep	20.3 ± 3.1	15.0 ± 3.6	-15.88	<0.001		

Pulmonary function, heart rate and blood pressure

FVC, FEV₁ and PEFR increased significantly in both groups, with larger increases in the deep breathing group, whereas FEV₁/FVC did not change significantly in either group (Table 3). The between-group comparison was significant for FVC, FEV₁ and PEFR (all p < 0.001) but not for FEV₁/FVC (p = 0.117). Resting heart rate and systolic and diastolic blood pressure decreased significantly in both groups, with significantly greater reductions in the deep breathing group: heart rate (p = 0.003), systolic blood pressure (p = 0.002) and diastolic blood pressure (p = 0.001) (Table 3).

Table 3. Pulmonary function, heart rate and blood pressure: within-group and between-group comparisons

Outcome	Group	Pre (mean ± SD)	Post (mean ± SD)	Paired t	Paired p	Unpaired t	Unpaired p
FVC (L)	Relaxed	2.67 ± 0.44	2.75 ± 0.44	4.90	<0.001	5.80	<0.001
	Deep	2.68 ± 0.33	2.89 ± 0.31	12.79	<0.001		
FEV ₁ (L)	Relaxed	2.19 ± 0.39	2.24 ± 0.40	4.02	<0.001	5.80	<0.001
	Deep	2.24 ± 0.34	2.40 ± 0.36	11.25	<0.001		
FEV ₁ /FVC (%)	Relaxed	81.9 ± 4.4	81.3 ± 5.6	-0.91	0.368	1.59	0.117
	Deep	83.3 ± 5.4	84.1 ± 6.4	1.37	0.183		
PEFR (L/s)	Relaxed	5.24 ± 0.82	5.35 ± 0.86	2.34	0.027	4.63	<0.001
	Deep	5.23 ± 0.95	5.65 ± 0.84	9.13	<0.001		
Heart rate (beats/min)	Relaxed	78.5 ± 8.4	74.4 ± 9.0	-15.53	<0.001	-3.07	0.003
	Deep	79.2 ± 7.7	73.8 ± 7.9	-15.83	<0.001		
Systolic BP (mmHg)	Relaxed	123.4 ± 10.9	118.8 ± 11.9	-9.56	<0.001	-3.22	0.002
	Deep	120.2 ± 8.9	113.4 ± 8.8	-13.60	<0.001		
Diastolic BP (mmHg)	Relaxed	79.8 ± 5.8	77.4 ± 6.2	-7.94	<0.001	-3.39	0.001
	Deep	81.0 ± 6.3	77.0 ± 6.4	-10.68	<0.001		

Discussion

This randomised controlled trial compared relaxed breathing and deep breathing exercises in middle-aged women with poor sleep quality and moderate stress. Both groups showed significant within-group improvements in sleep quality (PSQI) and perceived stress. Deep breathing produced a significantly greater

improvement in PSQI than relaxed breathing ($p < 0.001$) and significantly greater improvements in PSS-10, FVC, FEV₁, PEFR, heart rate and blood pressure, whereas FEV₁/FVC did not differ between groups.

Sleep quality

The improvement in PSQI in both groups is consistent with earlier reports that slow, paced breathing improves sleep onset, sleep efficiency and subjective sleep quality^{17,18}. Slow breathing is thought to act by increasing cardiac vagal activity and reducing sympathetic arousal before sleep^{12,13,15}, and autonomic dysfunction, particularly reduced vagal activity, has been demonstrated in people with insomnia¹⁷. The relaxation component common to both of our interventions, including attentional focus on the breath, reduced rumination and release of muscular tension, may further contribute to improvements in sleep-onset latency and sleep disturbance^{6,34}. The significantly greater improvement with deep breathing may reflect the added physiological component of slow, volitional diaphragmatic breathing at about 6 breaths per minute, a rate associated with increased vagal activity and baroreflex gain^{12,13,15}, whereas relaxed breathing involved no pacing or depth target. Nevertheless, a well-matched breathing placebo can produce comparable improvements, implying that non-specific effects such as attention, expectation and routine may account for part of the benefit in both arms²⁰. Because there was no control group, the large pre-post changes in both arms cannot be attributed to the breathing techniques alone; regression to the mean and non-specific effects are plausible contributors, particularly as participants were selected for poor sleep.

Perceived stress

Reductions in perceived stress in both groups agree with meta-analytic evidence that breathwork has a small-to-medium effect on stress¹⁹, and with studies of diaphragmatic and yogic breathing in healthy adults and students^{22–24,27,29}. Reduced sympathetic activity and enhanced parasympathetic control, as proposed in neurovisceral integration models, offer a plausible pathway through which breathing practices influence appraisal of stress^{7,14}. The reduction was greater with deep breathing ($p < 0.001$), although a substantial part of the stress reduction was seen with both techniques. Stress reduction may have contributed to the improvement in sleep, since perceived stress and sleep quality are closely linked, but mediation was not tested.

Pulmonary function

The greater effect of deep breathing on FVC, FEV₁ and PEFR may reflect greater diaphragmatic excursion, improved respiratory muscle strength and endurance, and increased chest wall compliance with repeated practice, mechanisms described for pranayama and related breathing training in healthy young adults and women^{31–33}. Because relaxed breathing does not involve volitional deep inspiration or expiratory effort, a smaller effect on ventilatory capacity would be expected¹². The unchanged FEV₁/FVC ratio in both groups is compatible with a change in lung volumes and respiratory effort rather than airway calibre in healthy women. Spirometry is effort-dependent, and the between-group FVC difference (0.13 L) is of similar size to the within-session repeatability criterion of the ATS/ERS standard^{37,38}, so a learning or effort effect cannot be excluded.

Heart rate and blood pressure

Slow breathing is known to increase baroreflex sensitivity and reduce sympathetic outflow, which can lower heart rate and blood pressure^{12,15,26,28}. Immediate and short-term reductions in blood pressure and heart rate have also been reported with slow-paced yogic breathing^{29,30}. In our trial, heart rate and systolic and diastolic blood pressure fell significantly in both groups, with greater reductions in the deep breathing group (all $p < 0.01$). Because participants had no known hypertension and most were normotensive at baseline, the absolute changes were modest and their clinical relevance should be interpreted cautiously.

Clinical implications and future research

Breathing exercises are inexpensive, safe, easily taught and suitable for home practice, making them attractive for primary care and community physiotherapy for stressed women with sleep complaints. Future trials should include an attention-control arm, objective sleep and heart rate variability measures, longer follow-up and a more diverse sample, and should examine dose-response and adherence.

Conclusion

Relaxed breathing and deep breathing exercises both improved sleep quality and perceived stress in middle-aged women with poor sleep and moderate stress, but deep breathing produced significantly greater improvements in sleep quality (PSQI), perceived stress, FVC, FEV₁, PEFR, heart rate and blood pressure, whereas

FEV₁/FVC did not change. In the absence of a control group, non-specific effects cannot be excluded, and larger controlled trials with objective sleep measures are needed.

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