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Breathing Interventions Improve Autonomic Function, Respiratory Efficiency and Stress in Dysfunctional Breathing: A Randomised Controlled Trial

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Abstract

Background: Dysfunctional breathing patterns can impair autonomic regulation and increase perceived stress. Breathing interventions, particularly those incorporating guided exercises and supportive tools, may offer non-pharmacological benefits. **Methods**: In this parallel two-arm randomized controlled trial, 14 women aged 35–45 years with signs of dysfunctional breathing and without comorbidities were recruited from a fitness club. Participants were randomly assigned (1:1) using a computer-generated sequence to an intervention group (n=7) or a control group (n=7). Blinding was not applied. Both groups followed a 6-week program of guided breathing exercises using the iBreathe app; the intervention group additionally used mouth tape during sleep. The primary outcomes were heart rate variability indices (RMSSD, HF component). Secondary outcomes included respiratory rate, Hencho test performance, and perceived stress (PSS-10, VAS). All participants were included in the final analysis (no loss to follow-up). **Results**: The intervention group showed a significant increase in the HF component of HRV ($p=0.018$) and improved Hencho test performance ($p=0.018$). Both groups demonstrated significant reductions in respiratory rate ($p<0.05$) and PSS scores ($p<0.05$). Between-group differences were not significant for RMSSD or perceived stress. No adverse events were reported. **Conclusions**: A 6-week breathing intervention improved respiratory efficiency and reduced stress in women with dysfunctional breathing. Mouth taping at night provided additional benefits for HRV and respiratory control. Larger, longer trials are needed to confirm these findings.

Keywords: heart rate variability; breathing interventions; dysfunctional breathing; stress reduction; biofeedback

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Introduction

Breathing is a fundamental physiological function that ensures the body's metabolic demands are met, but it also reflects emotional and psychological states. Although breathing occurs automatically, it can be consciously regulated, thereby influencing both physical and mental health, as well as rehabilitation outcomes. In physiotherapy practice, dysfunctional breathing has become an increasingly relevant clinical target because it may compromise postural stability, movement control, and functional capacity. Dysfunctional breathing is characterized by inefficient patterns [1], such as overly rapid, shallow, or mouth breathing [2], which can lead to autonomic nervous system imbalance, elevated stress levels, and disturbances in homeostasis [3].

Heart rate variability (HRV) is a key indicator of autonomic nervous system activity and reflects the body's ability to adapt to internal and external stimuli. Low HRV is associated with chronic stress, anxiety, burnout, and reduced resilience to disease [4], and has also been linked to poorer functional performance and slower rehabilitation progress. Dysfunctional breathing can negatively affect HRV by reducing physiological flexibility and emotional stability [5], thereby creating challenges for physiotherapists seeking to optimize both physical and psychophysiological recovery.

Given these effects, breathing therapy has been increasingly applied in clinical and rehabilitation practice. Methods such as slow breathing, HRV biofeedback, nasal strips, and mobile applications with guided breathing are used to correct dysfunctional patterns and enhance parasympathetic activity [6]. Among these, HRV biofeedback is particularly noteworthy, as it allows individuals to monitor their HRV in real time and regulate it through controlled breathing. Evidence indicates that HRV biofeedback can significantly reduce symptoms of anxiety and stress, improve sleep quality, and increase HRV metrics [7,8].

Despite the growing number of studies on specific techniques, there is still a lack of research comparing the effects of complex breathing interventions—particularly those combining biofeedback with supportive tools—on HRV, respiratory function, and stress levels in individuals with dysfunctional breathing. Addressing this gap is essential for physiotherapy, as integrating such interventions could provide a non-pharmacological, evidence-based strategy to improve functional outcomes and quality of life.

The aim of this study was to evaluate the effectiveness of comprehensive breathing correction methods in individuals exhibiting signs of dysfunctional breathing. Specifically, the study analyzed the effects of various interventions—including breathing exercises, nasal strips, guided mobile applications, and HRV biofeedback—on HRV components, respiratory function indicators, and perceived stress. By focusing on these outcomes, this work contributes to the evidence base for physiotherapy-led breathing interventions and their role in supporting both rehabilitation and psychophysiological health.

Research Methodology

Research Methods

Trial Design

This study was designed as a randomized, parallel-group exploratory trial with a 1:1 allocation ratio, conducted within a superiority framework. All trial procedures, outcomes, and analyses were conducted according to the original study plan, with no post hoc modifications. The trial was conducted in a community fitness club setting in Klaipėda, Lithuania. All assessments (HRV, respiratory function, and stress measures) were performed in a controlled environment within the same institution to ensure consistency of testing conditions. The random allocation sequence was generated using a computer-based random number generator. To ensure allocation concealment and prevent selection bias, group assignments were placed in sequentially numbered, opaque, sealed envelopes prepared by a researcher not involved in participant recruitment or data collection. The envelopes were identical, tamper-proof, and stored in a secure location. After a participant provided informed consent and met eligibility criteria, the next envelope in sequence was opened by the study coordinator, thereby revealing the group assignment. This procedure ensured that the allocation sequence remained concealed until the moment of intervention assignment.

Details of Patient or Public Involvement

Patients or members of the public were not directly involved in the design, conduct, reporting, or dissemination of this trial. The decision not to involve them was based on the exploratory and methodological focus of the study, which primarily aimed to evaluate the physiological and psychological effects of breathing interventions in a controlled setting. However, participants were fully informed about the procedures, risks, and benefits, and their feedback during the intervention period was monitored to ensure safety and adherence. Future studies with larger samples may benefit from incorporating patient perspectives in shaping research questions, intervention design, and dissemination strategies.

Participant Characteristics and Sample Size

From the initial sample of 20 participants, 14 women aged 35–45 years who met the inclusion criteria and had no comorbidities were included in the final analysis. Participants were recruited using convenience sampling at a fitness club. They were randomly assigned to either the control or intervention group. The intervention group additionally used mouth tape during sleep. The study was conducted as a pilot trial; therefore, no formal sample size calculation was performed. The final sample consisted of 14 participants who met the eligibility criteria. All randomized participants (n = 14) completed the baseline and post-intervention assessments. Therefore, no imputation methods were required and all analyses were conducted on complete case data.

Eligibility Criteria for Participants

Women aged 35–45 years, generally healthy, non-smokers, and demonstrating signs of dysfunctional breathing (as assessed by Hi-Lo and breath-hold tests) were eligible. Exclusion criteria included the presence of comorbidities, chronic medical conditions affecting respiratory or autonomic function, or current psychological or pharmacological treatment for stress or anxiety.

No specific eligibility criteria were applied to study sites or to individuals delivering the interventions, as the program consisted of self-administered breathing exercises guided by a mobile application and nocturnal mouth taping, requiring no specialist involvement.

Blinding Procedure

Due to the nature of the intervention (breathing exercises with or without mouth taping), participants and care providers could not be blinded. However, outcome assessors and data analysts were blinded to group allocation to minimize bias in measurement and analysis.

Blinding of participants and care providers was not feasible because of the visible nature of the intervention (mouth taping during sleep). To reduce potential bias, outcome assessors and data analysts were blinded to group allocation. Data files were coded, and group labels were concealed until the completion of statistical analysis. Since the interventions were not visually or procedurally similar, no additional steps to mimic similarity were implemented.

Testing Procedures

Physiological and psychological parameters were systematically evaluated both before and after the 6-week intervention program to assess its effectiveness. Each testing session was conducted under similar conditions, at approximately the same time of day, to minimize circadian influences on physiological data. The procedures included a combination of objective measurements and validated self-report instruments:

Heart Rate Variability (HRV) was used as a primary indicator of autonomic nervous system regulation, particularly parasympathetic (vagal) activity. It was measured using the Polar H10 chest strap [9], which is widely recognized for its high accuracy and reliability in capturing interbeat intervals (IBI). Data were collected through the Elite HRV mobile application, which computed time-domain and frequency-domain parameters, including:

- RMSSD (Root Mean Square of Successive Differences): reflecting short-term HRV and parasympathetic nervous system activity.
- HF (High Frequency) Power Component: representing vagal modulation of heart rate associated with respiration, typically in the 0.15–0.40 Hz range.

Respiratory Rate. This parameter served as an indicator of breathing pattern efficiency. Participants' breathing rates were observed manually while they were seated in a relaxed state, and the number of breaths per minute was recorded over a one-minute period. This process was repeated three times to ensure accuracy, and the average was used for analysis. A decrease in respiratory rate is considered indicative of improved respiratory efficiency and autonomic balance.

Hencho Test (Breath-Holding Time) was used to assess respiratory control and tolerance to carbon dioxide accumulation. Participants were instructed to take a normal breath in and out, and then hold their breath after a passive exhalation. The duration (in seconds) from the start of the breath-hold to the first involuntary urge to breathe was recorded. This measure reflects the functional breathing reserve and is sensitive to improvements in respiratory fitness and chemoreflex sensitivity.

Perceived Stress Scale (PSS-10). Psychological stress was measured using the 10-item version of the Perceived Stress Scale developed by Cohen et al. The PSS-10 evaluates the degree to which participants perceive situations in their life as stressful, unpredictable, and uncontrollable over the past month. Each item is rated on a 5-point Likert scale, and total scores range from 0 to 40. Higher scores indicate greater perceived stress.

Visual Analogue Scale (VAS) for Stress. Subjective stress perception at the moment of testing was quantified using a 100-mm Visual Analogue Scale. Participants were asked to mark a point on a horizontal line representing their current stress level, ranging from 0 (no stress at all) to 100 (maximum imaginable stress). The score was determined by measuring the distance in millimeters from the start of the line to the participant's mark. The VAS is a quick and sensitive tool for capturing momentary emotional states.

All assessments were administered by the same trained researcher to ensure consistency, and participants were provided with standardized instructions before each test to reduce variability and bias.

Statistical Methods

Data analysis was performed using IBM SPSS Statistics 24.0. Descriptive statistics (mean ±SD) were calculated for all variables. Normality was tested with the Shapiro–Wilk test. Due to the small sample size and some non-normal distributions, non-parametric tests were used: the Wilcoxon signed-rank test for within-group comparisons (pre- vs. post-intervention) and the Mann–Whitney U test for between-group comparisons. A p-value < 0.05 was considered statistically significant. Effect sizes were calculated using Cohen's *d*. Adverse events (harms) were monitored descriptively, and no statistical comparisons were necessary as none occurred.

All randomized participants who completed both baseline and post-intervention assessments were included in the final analysis (n = 14). Participants were analyzed in the groups to which they were originally assigned (intervention: n = 7; control: n = 7). No participants were excluded after randomization. No subgroup or sensitivity analyses were prespecified or performed due to the small sample size. All analyses were limited to the primary and secondary outcomes as outlined in the study protocol.

Intervention Procedure

Participants were recruited between February and April 2025. Follow-up for outcomes of benefits and harms was completed at the end of the 6-week intervention period. The intervention program was conducted over a period of six consecutive weeks, during which participants in both the intervention and control groups followed a structured breathing protocol designed to enhance respiratory function and autonomic regulation.

Breathing Exercises

All participants, regardless of group assignment, were instructed to perform twice-daily guided breathing sessions using the iBreathe mobile application. The app provided auditory and visual cues to assist in timing and consistency. Each daily routine consisted of the following components:

Box Breathing [10] (5 minutes):

This technique involves equal-duration phases of inhalation, breath-holding, exhalation, and post-exhalation hold (e.g., 4–4–4–4 seconds). Box breathing is known to activate the parasympathetic nervous system and improve focus and stress regulation.

LSD (Long Slow Deep) Breathing (10 minutes):

This method emphasizes prolonged inhalations and exhalations (typically 6–8 breaths per minute), which helps promote vagal tone and respiratory efficiency. It is particularly effective in reducing breathing rate and increasing heart rate variability (HRV).

Participants were encouraged to complete both sessions daily—ideally once in the morning and once in the evening—in a calm environment while seated comfortably. A daily log was provided to track adherence, and weekly check-ins via phone or text were conducted to reinforce compliance.

Additional Component for the Intervention Group

Participants in the intervention group received additional instructions to use mouth tape during sleep for the full six-week duration. This intervention was introduced to encourage nasal breathing at night, which is hypothesized to improve oxygen exchange efficiency, reduce sympathetic nervous system activation, and support more coherent breathing patterns. Commercially available hypoallergenic mouth tape was provided, along with written guidelines and a demonstration of safe application.

Participants were advised to discontinue use if any discomfort, sleep disturbances, or respiratory difficulties occurred. No adverse effects were reported during the study period.

Testing and Monitoring

All participants underwent baseline testing (week 0) and post-intervention testing (week 6). Assessments included physiological (HRV, respiratory rate, Hencho test) and psychological (PSS-10, VAS) measurements. Testing was performed in a controlled environment and scheduled at similar times for each participant to reduce variability due to diurnal fluctuations in physiological parameters.

To ensure protocol fidelity, participants received printed instructions and support throughout the study. While objective adherence monitoring was not employed (e.g., wearable trackers), self-reported compliance indicated a high level of engagement across both groups.

Harms

No adverse events were reported. Potential harms (e.g., discomfort, sleep disturbance, respiratory difficulties) were monitored through weekly check-ins and self-report. Participants were advised to discontinue intervention if any issues occurred.

Research Ethics

This study was conducted in accordance with the fundamental principles of research ethics, including respect for human dignity, autonomy, beneficence, non-maleficence, and justice. All procedures were designed and implemented to ensure the safety, well-being, and rights of the participants.

Prior to the commencement of the study, ethical approval was obtained from the Bioethics Committee XXX). The study protocol, informed consent form, and all related materials were reviewed to ensure compliance with institutional and international ethical guidelines for research involving human participants.

Participants were fully informed about the aims, procedures, and potential risks and benefits of the study. Each participant received an informed consent form, which they signed prior to

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enrollment. They were made aware of their right to withdraw from the study at any time without penalty and with no effect on their access to services or support.

To maintain confidentiality and protect personal data, all participant information was anonymized. Data were stored in password-protected digital files, accessible only to the research team. No identifying information was used in data analysis, reporting, or publication.

The study involved non-invasive interventions (breathing exercises and mouth tape usage) that posed minimal risk to participants. To monitor participant safety, weekly contact was maintained to assess well-being and gather feedback. Participants in the intervention group were specifically instructed on safe use of mouth tape during sleep and were encouraged to discontinue use immediately if any discomfort, breathing difficulties, or sleep disruptions occurred. No adverse events were reported during the study.

The research followed the Declaration of Helsinki guidelines and aligned with the ethical standards outlined by the Committee on Publication Ethics (COPE).

Results

Demographic Statistics

A total of 14 participants were included in the final analysis, with 7 participants assigned to the intervention group and 7 to the control group. All participants were female, aged between 35 and 45 years. The random allocation ensured a balanced distribution between the two groups.

The mean age of the intervention group was 38.57 ± 3.26 years, while the control group had a mean age of 39.29 ± 3.50 years. Statistical comparison using the Mann–Whitney U test revealed no significant age difference between the groups (U = 21.5, p = 0.653), indicating effective randomization and demographic comparability at baseline.

No participants reported comorbidities or chronic medical conditions that could affect respiratory or autonomic function, and all were non-smokers. Inclusion criteria required participants to demonstrate signs of dysfunctional breathing (as determined by Hi-Lo and breath-hold tests [11]), be generally healthy, and not currently undergoing psychological or pharmacological treatment for stress or anxiety.

The demographic homogeneity of the sample helps minimize confounding variables related to age, gender, and health status, strengthening the internal validity of the intervention's observed effects.

Descriptive demographic indicators are summarized in Table 1.

Table 1. Demographic Characteristics of Participants.

Indicator	**Intervention Group (M ± SD)**	**Control Group (M ± SD)**	**p-value**
Age (years)	38.57 ± 3.26	39.29 ± 3.50	0.653

Note. M – mean; SD – standard deviation.

Changes in Autonomic Nervous System Activity Based on HRV

The average heart rate variability (HRV) in the intervention group increased from 40.14 ± 5.43 before the intervention to 45.29 ± 6.97 after the intervention. Although the mean change was +5.14 ± 8.45, this improvement did not reach statistical significance (Z = -1.612; p = 0.107). In the control group, HRV increased from 53.29 ± 8.48 to 58.14 ± 6.07 (mean change: +4.86 ± 8.63), which was also not statistically significant (Z = -1.270; p = 0.204). Between-group comparison of the HRV change revealed no significant difference (U = 24; p = 0.949). These findings are illustrated in Table 2.

RMSSD results. The root mean square of successive differences (RMSSD) in the intervention group increased from 14.93 ± 4.58 ms to 16.11 ± 5.19 ms, with a mean difference of +1.18 ± 1.75 ms, which was not statistically significant (Z = -1.352; p = 0.176). In the control group, RMSSD decreased slightly from 35.79 ± 17.63 ms to 34.52 ± 11.02 ms (mean change: –1.28 ± 9.58 ms), also not statistically significant. Between-group differences in RMSSD changes were non-significant (U = 20; p = 0.565). Results are presented in Table 2.

HF component results. The high-frequency (HF) component of HRV in the intervention group showed a statistically significant increase from 0.26 ± 0.08 Hz to 0.28 ± 0.08 Hz (Z = -2.366; p = 0.018). In contrast, the HF component in the control group slightly decreased from 0.29 ± 0.09 Hz to 0.27 ± 0.11 Hz, without statistical significance (Z = -0.338; p = 0.735). The between-group comparison of changes in HF power was not statistically significant (U = 18; p = 0.406). Full results are detailed in Table 2.

Table 2. Changes in Heart Rate Variability (HRV) and Respiratory Function.

Variable	Group	Pre (M ± SD)	Post (M ± SD)	p value	Cohen's d
HRV (ms)	Intervencinė	40.14 ± 5.43	45.29 ± 6.97	0.107	0.82
HRV (ms)	Kontrolinė	53.29 ± 8.48	58.14 ± 6.07	0.204	0.66
RMSSD (ms)	Intervencinė	14.93 ± 4.58	16.11 ± 5.19	0.176	0.51
RMSSD (ms)	Kontrolinė	35.79 ± 17.63	34.52 ± 11.02	0.753	0.08
HF (Hz)	Intervencinė	0.26 ± 0.08	0.28 ± 0.08	0.018*	0.75
HF (Hz)	Kontrolinė	0.29 ± 0.09	0.27 ± 0.11	0.735	0.21

Notes: M – mean; SD – standard deviation; * statistically significant ($p < 0.05$). p values calculated with Wilcoxon signed-rank test; Cohen's d calculated for paired samples.

Respiratory Function Outcomes

To assess respiratory system adaptation, two key functional parameters were analyzed: respiratory rate and Hench test duration. These measures provided insight into both breathing efficiency at rest and the functional respiratory reserve, specifically the body's capacity for oxygen retention.

Respiratory Rate

At baseline, the intervention group exhibited an average respiratory rate of 21.00 ± 3.92 breaths per minute, which decreased to 17.43 ± 2.64 breaths per minute after six weeks of intervention. This reduction was statistically significant (Z = --1.992; p = 0.046). The control group also experienced a significant decrease in respiratory rate, from 20.57 ± 2.23 to 16.00 ± 3.00 breaths per minute (Z = --2.388; p = 0.017). However, the between-group comparison of changes in respiratory rate did not reach statistical significance (U = 20; p = 0.561). These findings are illustrated in Table 3.

Table 3. Respiratory Function Outcomes.

Indicator	Group	Pre-Intervention (M ± SD)	Post-Intervention (M ± SD)	p-value (within group)	Cohen's d
Respiratory Rate (breaths/min)	Intervention	21.00 ± 3.92	17.43 ± 2.64	0.046*	0.96
Respiratory Rate (breaths/min)	Control	20.57 ± 2.23	16.00 ± 3.00	0.017*	1.18
Hencho Test (seconds)	Intervention	17.71 ± 4.22	20.70 ± 4.07	0.018*	0.71

Hencho Test (seconds)	Control	20.37 ± 1.36	20.65 ± 1.53	0.612	0.19

Note. Values are presented as means ± standard deviations. *Statistically significant at $p < 0.05$ (Wilcoxon signed-rank test). Cohen's d effect sizes are interpreted as: 0.2 = small, 0.5 = medium, 0.8 = large.

Hench Test

In the intervention group, the average duration of the Hench test increased significantly from 17.71 ± 4.22 seconds to 20.70 ± 4.07 seconds (Z = --2.366; p = 0.018), indicating improved breath-holding capacity. In contrast, the control group showed only a slight and non-significant improvement, from 20.37 ± 1.36 seconds to 20.65 ± 1.53 seconds (Z = --0.507; p = 0.612). The between-group comparison revealed a statistically significant difference (U = 7; p = 0.025), suggesting that the intervention yielded a more pronounced improvement in respiratory reserve. Full results are presented in Table 3.

Subjective Perceived Stress Outcomes

Perceived Stress Scale (PSS-10)

In the intervention group, the mean score on the PSS-10 decreased significantly from 22.14 ± 4.98 to 14.43 ± 4.58(Z = --2.375; p = 0.018), representing a reduction of 7.71 ± 3.68 points. Prior to the intervention, five participants reported moderate stress and two reported high stress; following the intervention, four reported moderate stress and three reported low stress (Z = --2.236; p = 0.025).

In the control group, the PSS-10 mean score also significantly declined, from 23.14 ± 3.63 to 15.29 ± 3.15 (Z = --2.379; p = 0.017), with a mean reduction of 7.86 ± 2.54 points. Initially, six participants experienced moderate stress and one high stress; after the intervention, four reported moderate and three low stress (Z = --2.000; p = 0.046).

However, the between-group comparison revealed no statistically significant difference (U = 24; p = 0.949). These outcomes are visualized in Table 4.

Table 4. Changes in Subjective Perceived Stress Indicators Before and After the 6-Week Intervention.

Indicator	**Before Intervention Intervention Group**	**After Intervention Intervention Group**	**p[1] Intervention**	**Cohen's d Intervention**	**Before Intervention Control Group**	**After Intervention Control Group**	**p[1] Control**	**Cohen's d Control**
PSS (Perceived Stress Scale)	22.14 ± 4.98	14.43 ± 4.58	0.018*	1.69	23.14 ± 3.63	15.29 ± 3.15	0.017*	2.52
VAS (%)	55.71 ± 19.88	42.86 ± 4.88	0.109	0.82	58.57 ± 9.00	47.14 ± 4.88	0.066	1.47

[1] Wilcoxon signed-rank test. * $p < 0.05$ – statistically significant. Cohen's d: 0.2 – small effect; 0.5 – medium effect; ≥ 0.8 – large effect.

Visual Analogue Scale (VAS)

In the intervention group, the mean VAS score decreased from 55.71 ± 19.88% to 42.86 ± 4.88%, representing a non-significant change of 12.86 ± 17.04% (Z = --1.604; p = 0.109). Similarly, in the control group, VAS scores dropped from 58.57 ± 9.00% to 47.14 ± 4.88% (Z = --1.841; p = 0.066), with a mean reduction of 11.43 ± 12.15%.

The between-group comparison of VAS changes did not reach statistical significance (U = 24.5; p = 0.999). Before the intervention, 71.43% of participants reported high stress and 28.57% moderate stress. After the intervention, 57.14%reported moderate stress and 42.86% low stress. Detailed results are presented in Table 4.

Discussion

The results of this study demonstrated positive outcomes in both the intervention and control groups, although significant between-group differences were limited to specific variables. While the overall increase in HRV in the intervention group was not statistically significant, the improvement in the HF component reached significance, suggesting enhanced parasympathetic nervous system activity. This aligns with previous evidence indicating that breathing exercises, particularly those incorporating elements of biofeedback, can facilitate autonomic balance [12]. Such findings are of particular importance in physiotherapy, where interventions targeting autonomic regulation are increasingly integrated into rehabilitation strategies.

The significant reduction in respiratory rate observed in both groups supports earlier reports that slow and conscious breathing enhances ventilatory efficiency and stimulates vagal tone [13]. Importantly, only the intervention group demonstrated a significant increase in Hencho test duration, indicating improved oxygen utilization and respiratory control. This outcome may be linked to the application of mouth taping during sleep, which encourages nasal breathing patterns and has been suggested to promote more efficient respiratory mechanics [14]. From a physiotherapy perspective, these results underscore the potential of adjunctive tools to optimize functional breathing retraining.

Changes in perceived stress, as measured by the PSS, were significant in both groups, reinforcing the effectiveness of guided breathing in improving emotional well-being [5]. Although VAS scores did not reach statistical significance, the downward trend suggests clinically meaningful benefits for stress reduction. These results are consistent with the findings of Jerath et al. [6] and Shaffer [7], who emphasized the psychological and physiological benefits of breathing-based interventions. In the context of physiotherapy practice, stress management is increasingly recognized as an integral component of holistic rehabilitation, further supporting the relevance of these findings.

Overall, this study supports the effectiveness of structured breathing interventions—particularly when combined with supportive strategies such as mouth taping—in improving both physiological and psychological parameters in women with dysfunctional breathing. However, the small sample size necessitates cautious interpretation. Larger-scale trials are required to confirm these preliminary results and to establish clear evidence-based guidelines for clinical application.

This study has several limitations. The small sample size (n=14) reduces the generalizability of the findings, and the relatively short intervention period (6 weeks) may not have been sufficient to detect longer-term effects or stabilize breathing habits. Adherence to the intervention was self-reported, and there was no objective monitoring of mouth tape use, which introduces the possibility of deviations from the protocol. Moreover, no interim analyses were conducted due to the exploratory nature of the trial, although weekly monitoring ensured participant safety and no adverse events were reported. Future studies should include larger, more diverse samples, longer intervention periods, and objective adherence monitoring to validate and extend these preliminary findings.

Conclusions

Both groups experienced significant reductions in respiratory rate and perceived stress, indicating the general efficacy of guided breathing exercises in promoting emotional and physiological well-being [5]. The intervention group additionally demonstrated improvements in the HF component of HRV and in Hencho test performance, suggesting that nocturnal mouth taping may further enhance autonomic regulation and respiratory control. However, between-group differences were limited, underscoring the need for cautious interpretation and larger trials to confirm these results.

Implications for Physiotherapy Practice

This study highlights several key implications for physiotherapy and rehabilitation:

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1. **Integration into practice.** Structured breathing interventions, particularly those delivered through mobile applications, can be feasibly incorporated into physiotherapy programs to address dysfunctional breathing patterns and support holistic patient care.
2. **Adjunctive strategies.** The addition of simple, low-cost supportive tools such as mouth taping may enhance the effectiveness of breathing retraining, improving HRV and respiratory control beyond guided exercises alone.
3. **Holistic outcomes.** Improvements in Hencho test performance and reductions in stress highlight the dual benefits of breathing interventions—addressing both physiological function and psychological resilience. This aligns with the holistic framework increasingly adopted in physiotherapy practice.
4. **Clinical application.** Although the study was limited in scale, the findings provide a rationale for physiotherapists to integrate breathing-based interventions into rehabilitation, wellness, and stress management programs. Future research will be crucial in establishing long-term effectiveness, identifying optimal protocols, and developing evidence-based clinical guidelines.

Limitations and Strengths

This pilot study has several limitations. The small sample size and short intervention duration reduce the generalisability of findings and limit conclusions about long-term effects. In addition, adherence to the intervention, including mouth tape use, was self-reported, which may have introduced bias.

Despite these limitations, the study also has notable strengths. It employed a randomized controlled design, used objective physiological and functional outcomes, and tested a novel combination of breathing interventions with supportive adjuncts. These features provide a valuable foundation for future large-scale studies in physiotherapy and complementary practice.

Clinical Relevance Statement

Structured breathing interventions, supplemented by simple adjuncts such as mouth taping, may provide physiotherapists with an accessible, low-cost strategy to improve respiratory function, autonomic regulation, and stress management in patients with dysfunctional breathing.

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Institutional Review Board Statement: All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments. Ethical approval was obtained from the institutional ethics committee. All participants provided written informed consent.

Data Availability Statement: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. No custom code was used in the analysis.

Conflicts of Interest: The authors declare no conflicts of interest related to this work.

Permission to Reproduce Material from Other Sources: No copyrighted or previously published materials were reproduced in this manuscript.

Clinical Trial Registration: This study was not a clinical trial and therefore was not registered.

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