REABILITACIJOS MOKSLAI
Slauga, kineziterapija, ergoterapija
LITHUANIAN SPORTS UNIVERSITY

Reabilitacijos mokslai: slauga, kineziterapija, ergoterapija, *2*(33) 2025, 13–22, eISSN 2538-8673; DOI: https://doi.org/10.33607/rmske.v2i33.1734

A Randomised Study of Vocal and Breathing Exercises on Pulmonary Function and Trunk Stability in Female Adults

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Abstract

Background. The effects of breathing exercises and vocal exercises on respiratory function and trunk stability in women remain unclear.

Aim. To compare the effects of vocal exercises and breathing exercises on respiratory function and core stability in women.

Methods. Fifty women participated in this randomised study. Respiratory function was assessed using thoracic excursion (Th3–4, Th7–8, Th11–12), breath-holding tests, and spirometry (PEF, FVC, FEV1). Trunk stability was evaluated using dynamic neuromuscular stabilisation (DNS) tests and trunk stability assessments with the Stabilizer Pressure Biofeedback device. Participants were randomly assigned to a breathing exercise group or a vocal exercise group.

Results. In the breathing exercise group, statistically significant improvements were observed in breath-hold duration, thoracic excursion at Th3–4, Th7–8, and Th11–12, PEF, DNS head, neck, and trunk flexion tests, and trunk stability with right-leg flexion using the Stabilizer device. In the vocal exercise group, significant improvements were observed in thoracic excursion, spirometry parameters (PEF, FVC, FEV1), breath-holding tests, DNS assessments, and trunk stability with left-leg flexion using the Stabilizer device. Between-group comparisons indicated that the vocal exercise group achieved significantly greater improvements in FVC, FEV1, and trunk stability with left-leg flexion.

Conclusions. Vocal exercises improved respiratory function, enhanced respiratory muscle strength and endurance, and supported trunk stability in women. Breathing exercises also improved respiratory function, muscle strength, and endurance. While vocal exercises demonstrated a superior effect on lung function (FVC and FEV1) compared to breathing exercises, both interventions had comparable effects on respiratory muscle strength, endurance, and trunk stability.

ClinicalTrials.gov Identifier: NCT07175844

Keywords: breathing exercises; vocal exercises; respiratory system; core stability

1. INTRODUCTION

Respiratory rehabilitation is a fundamental component of physical rehabilitation, aiming to enhance pulmonary function and overall well-being (Kim et al., 2023). Breathing exercises have been shown to improve lung function, respiratory muscle strength, physical capacity, and quality of life (Lu et al., 2020); however, conventional programmes are often too brief to maintain these benefits over time (Balban et al., 2023).

Holistic breathing techniques, such as Pranayama, have long been used to support both emotional and respiratory health. Systematic reviews have demonstrated their anti-inflammatory effects and benefits for individuals with cardiovascular, respiratory, and oncological conditions (Rao et al., 2024; Shah et al., 2022). Singing, particularly when combined with controlled breathing, has emerged as a cost-effective and accessible adjunct to pulmonary rehabilitation. It has been shown to improve respiratory muscle strength, lung function, and quality of life across diverse populations, including individuals with Parkinson's disease, cerebral palsy, asthma, and chronic obstructive pulmonary disease (COPD) (Ganzoni et al., 2020; Kim et al., 2023).

Although the biomechanics of breathing and vocalisation differ, with vocalisation involving greater abdominal muscle engagement and rib cage movement (Salomoni et al., 2016), few studies have investigated their comparative effects on trunk stability, which is closely associated with balance and the prevention of low back pain (Cavaggioni et al., 2015). While Pranayama has been shown to outperform singing in certain outcomes related to quality of life (Kaasgaard et al., 2022), no studies to date have directly compared breathing exercises and vocal training as separate interventions for respiratory function and trunk stability.

The diaphragm is one of the most important muscles involved in breathing (Hamasaki et al., 2020). It accounts for 60–80% of the work of respiration (Neumann, 2017) and plays a central role in chest movement. This dome-shaped muscle separates the thoracic and lumbar regions (Kocjan et al., 2017) and is also critical for phonation, vocalisation, and swallowing (Hamasaki et al., 2020). Diaphragm movement during respiration directly and indirectly influences the sympathetic and parasympathetic systems, modulates intra-abdominal pressure, and contributes to postural stability, bowel and bladder function, and childbirth (Kocjan et al., 2017). Additionally, the diaphragm affects metabolic balance, cardiovascular function, and the intraperitoneal lymphatic system (Ganzoni et al., 2020; Hamasaki et al., 2020).

Given the diaphragm's dual role in voice modulation and trunk stabilisation, we hypothesised that vocal training would be at least as effective as static breathing exercises in improving respiratory function and trunk stability in women. The aim of this study was to compare the effectiveness of these two interventions on respiratory and core outcomes in a healthy female population.

2. METHODS

Study design

Ethical approval for this study was obtained (Approval No.: 2024 12 09 MNL-KIN (M)-2024-726), and the trial was prospectively registered on ClinicalTrials.gov (Identifier: NCT07175844). The study was conducted in accordance with the principles of the Declaration of Helsinki. Participants were recruited through social media and invited to complete an online screening questionnaire. Eligible individuals received detailed information regarding the study procedures and provided written informed consent, confirming voluntary participation.

A total of 50 healthy female adult participants were randomly assigned to one of two intervention groups: a breathing exercise (BE) group or a vocal exercise (VE) group. Two in-person assessments were conducted for all participants: the first at baseline, prior to the intervention, and the second at the conclusion of the six-week intervention period. Both interventions were administered over six weeks. All participants were provided access to a dedicated closed social media group, which included instructional videos and supporting materials to facilitate home practice.

Participants

Fifty women aged 18–65 years were enrolled. Inclusion criteria were: female sex; age 18–65 years; no engagement in breathing exercises or vocal training for at least six months; and absence of acute or chronic respiratory infections. Participants who did not meet these criteria were excluded. Baseline characteristics, including age, height, weight, and body mass index (BMI), were comparable between groups (Table 1).

Table 1. **Distribution of participants by age, weight, height, and body mass index (BMI)**

Variable	Vocal exercise group (VE, n = 25)	Breathing exercise group (BE, n = 25)	p between groups
Age (years ± SD)	45.64 ± 10.45	44.28 ± 9.80	0.62
Weight (kg ± SD)	68.80 ± 10.38	66.80 ± 10.36	0.48
Height (cm ± SD)	166.44 ± 5.49	168.88 ± 10.36	0.31
BMI (kg/m² ± SD)	24.85 ± 3.91	23.22 ± 3.46	0.21

Randomisation

Participants were randomised in a 1:1 ratio using a computer-generated sequence to either the vocal exercise (VE) group (n = 25) or the breathing exercise (BE) group (n = 25).

Outcome measures

Assessments were conducted individually before and after the six-week intervention. Chest expansion (CE) was measured at three thoracic levels (Th3–4, Th7–8, Th11–12) using a tape measure. Participants performed maximal inhalation and exhalation in a standing position. Each measurement was repeated three times, and the mean value was used.

Spirometry

Pulmonary function was evaluated using the Contec SP80B Spirometer. Parameters recorded included forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), and peak expiratory flow (PEF). Three trials were performed per participant, with the mean used for analysis.

Breath-holding tests

The Stange test (breath-hold after maximal inhalation) and Genchi test (breath-hold after maximal exhalation) were performed in a seated position. Participants were instructed to breathe calmly before testing, and breath-hold duration was recorded with a stopwatch.

Dynamic neuromuscular stabilisation (DNS)

Three DNS functional tests were selected: the diaphragm test, head/neck/trunk flexion test, and head/neck/trunk extension test (Kobesova et al., 2020). Tests were scored on a 4-point scale (1 = failed, 4 = excellent) based on muscle activation, symmetry, posture, and compensatory movements.

Trunk stability tests

Trunk stability was assessed using the Stabilizer Pressure Biofeedback device. Four tests were conducted: prone activation, supine activation, bent-leg lift, and straight-leg lift. Pressure changes during abdominal muscle activation were recorded, with three repetitions per test and mean values calculated (Herrington & Davies, 2005; von Garnier et al., 2009).

Interventions

Breathing exercise group

Participants in the breathing exercise group were given access to a 30-minute instructional video, in which a licensed physiotherapist demonstrated how to perform the exercises. Participants were instructed to complete the exercises twice per week at a time convenient for them. They could reflect on the exercises and submit questions to the physiotherapist within a closed social media group. Two weeks after the start of the intervention, participants were advised to increase the intensity of the exercises: lengthening inhalation, exhalation, and breath-holding during square breathing, and increasing the number of exhalations during Kapalabhati breathing from 20 to 60 per series, while respecting individual comfort and tolerance.

Vocal exercise group

Participants performed six weekly sessions of 30 minutes, guided by videos focusing on diaphragmatic breathing and contemporary singing techniques. Initial exercises (weeks 1–2) included sustained ‘s’ sounds, lip trills, humming, melodic vowel sequences, and ‘Ja’ exercises. Weeks 3–6 included advanced solo exercises such as short and long ‘S’, humming variations, ‘mum’ vocalisations, rhythmic patterns (‘cha-cha-cha’), melodic sequences (‘Niemak 1–3’), and counting exercises. Exercises were performed standing, preferably in front of a mirror.

Statistical analysis

Data were analysed using IBM SPSS Statistics version 29.0.2.0. Normality of the data was assessed with the Shapiro–Wilk test ($p > 0.05$). Within-group comparisons were performed using paired-samples *t*-tests, and between-group comparisons were conducted using independent-samples *t*-tests. Statistical significance was set at $p < 0.05$. Effect sizes (Cohen’s *d*) were interpreted as follows: 0–0.20 = no effect, 0.21–0.50 = small, 0.51–0.80 = medium, 0.81–1.30 = large, and >1.30 = very large. All results are presented as mean ± standard deviation (SD).

3. RESULTS

At baseline, no significant differences were observed between groups in terms of age, weight, height, or BMI.

Table 2 summarises the effects of six weeks of vocal (VE) and breathing (BE) exercises on respiratory outcomes. Both interventions led to significant improvements within groups in chest excursion, pulmonary function, and endurance-based tests. Between-group comparisons showed that VE produced greater improvements than BE in upper thoracic chest excursion and FEV1, while other measures did not differ significantly (Table 2).

Table 2. **Breathing capacity related outcome measures before and after vocal (VE, n = 25) and breathing (BE, n = 25) exercises**

Outcome measures	Group	Pre (Mean ± SD)	Post (Mean ± SD)	Cohen’s *d*	p-value (within groups)	p-value (between groups, post)
Chest excursion Th3–4 (cm)	VE	4.72 ± 2.05	6.32 ± 1.77	–1.209	<0.001	0.03
	BE	4.36 ± 1.38	5.48 ± 1.63	–1.063	<0.001	
Chest excursion Th7–8 (cm)	VE	4.48 ± 1.87	5.80 ± 2.00	–0.959	<0.001	0.01
	BE	3.84 ± 1.54	4.92 ± 1.28	–0.910	<0.001	

Outcome measures	Group	Pre (Mean ± SD)	Post (Mean ± SD)	Cohen's *d*	p-value (within groups)	p-value (between groups, post)
Chest excursion Th11–12 (cm)	VE	4.69 ± 2.30	5.60 ± 2.08	–0.799	<0.001	0.62
	BE	5.00 ± 2.10	5.76 ± 1.92	–0.751	<0.001	
Hench test (s)	VE	29.04 ± 7.83	35.56 ± 9.45	–0.829	<0.001	0.54
	BE	28.01 ± 9.47	34.13 ± 9.19	–1.492	<0.001	
Stange test (s)	VE	43.95 ± 11.71	50.98 ± 12.71	–1.069	<0.001	0.85
	BE	41.09 ± 12.04	51.63 ± 16.12	–0.885	<0.001	
FVC (L)	VE	3.34 ± 0.59	3.61 ± 0.56	–0.895	<0.001	0.08
	BE	3.12 ± 0.72	3.23 ± 0.47	–0.285	0.167	
FEV1 (L)	VE	3.07 ± 0.52	3.36 ± 0.49	–1.190	<0.001	0.03
	BE	2.79 ± 0.63	2.99 ± 0.49	–0.521	0.016	
PEF (L/s)	VE	6.83 ± 1.72	7.21 ± 1.52	–0.368	0.078	0.56
	BE	5.52 ± 1.83	6.96 ± 1.77	–0.927	<0.001	
FVC (%)	VE	98.60 ± 16.08	106.68 ± 16.96	–0.861	<0.001	0.09
	BE	91.09 ± 26.49	99.00 ± 14.45	–0.356	0.088	
FEV1 (%)	VE	105.24 ± 17.10	115.52 ± 18.49	–1.126	<0.001	0.19
	BE	98.84 ± 21.07	103.96 ± 23.64	–0.561	0.010	
PEF (%)	VE	100.84 ± 23.69	105.60 ± 20.37	–0.315	0.128	0.85
	BE	82.36 ± 25.70	106.32 ± 15.19	–0.979	<0.001	

Table 3 summarises trunk stability outcomes before and after six weeks of vocal (VE) and breathing (BE) exercises. Both interventions resulted in improvements in several stability tests, particularly in supine and leg-flexed positions. Within-group changes were generally significant, while prone and leg-extended positions showed minimal changes. Between-group comparisons did not reveal statistically significant differences, indicating that both interventions had similar effects on trunk stability.

Table 3. **Trunk stability tests' results before and after vocal (VE, n = 25) and breathing (BE, n = 25) exercises**

Trunk stability tests	Group	Pre (Mean ± SD)	Post (Mean ± SD)	Cohen's *d*	p-value (within groups)	p-value (between groups, post)
Prone (mmHg)	VE	12.19 ± 12.36	12.58 ± 9.86	–0.033	0.870	0.18
	BE	7.71 ± 8.70	8.77 ± 9.86	–0.139	0.493	
Supine (mmHg)	VE	16.42 ± 15.76	11.06 ± 11.38	0.547	0.012	0.86
	BE	13.07 ± 11.79	10.55 ± 9.61	0.439	0.038	
Left leg flexed (mmHg)	VE	11.41 ± 11.16	6.63 ± 4.95	0.589	0.007	0.13
	BE	16.91 ± 15.66	11.87 ± 15.96	1.011	<0.001	
Right leg flexed (mmHg)	VE	13.17 ± 15.21	5.62 ± 4.65	–0.176	0.007	0.05
	BE	18.34 ± 16.79	12.71 ± 16.64	0.706	0.002	
Right leg extended (mmHg)	VE	3.85 ± 4.37	4.02 ± 3.73	–0.052	0.387	0.55
	BE	5.54 ± 5.88	4.69 ± 4.03	0.242	0.239	
Left leg extended (mmHg)	VE	6.39 ± 4.41	7.45 ± 5.65	0.113	0.796	0.62
	BE	8.58 ± 5.72	8.23 ± 5.34	0.113	0.576	

Table 4 presents the results of dynamic neuromuscular stabilisation (DNS) tests before and after six weeks of vocal (VE) and breathing (BE) exercises. Both interventions led to significant within-group improvements across all tests, with VE generally showing larger effect sizes. Between-group comparisons after the intervention revealed no statistically significant differences for any of the DNS tests, indicating that both vocal and breathing exercises were similarly effective in enhancing diaphragm function and head/neck/trunk stability.

Table 4. **Dynamic neuromuscular stabilisation (DNS) test results before and after vocal (VE, n = 25) and breathing (BE, n = 25) exercises**

DNS test	Group	Pre (Mean ± SD)	Post (Mean ± SD)	Cohen's *d*	p-value (within groups)	p-value (between groups, post)
Diaphragm test (points)	VE	12.56 ± 4.64	15.52 ± 4.64	–1.488	<0.001	0.25
	BE	12.52 ± 5.22	13.88 ± 5.33	–0.534	0.013	
Head/neck/ trunk flexion test (points)	VE	10.88 ± 3.37	12.64 ± 2.99	–0.785	<0.001	0.22
	BE	9.69 ± 3.63	11.52 ± 3.42	–1.038	0.013	
Head/neck/trunk extension test (points)	VE	14.40 ± 4.51	16.64 ± 4.36	–1.094	<0.001	0.29
	BE	14.32 ± 5.32	15.33 ± 4.30	–0.385	0.066	

4. DISCUSSION

Recent studies suggest that both breathing exercises and vocal training positively influence respiratory function and trunk stability in women. The results of this study demonstrated that following both interventions, participants' breath-hold duration during inhalation and exhalation significantly increased, indicating improved respiratory muscle endurance. These findings align with previous research showing that diaphragmatic breathing exercises enhance respiratory function and vocal stamina in healthy singers (Chukwu et al., 2025).

Both interventions produced statistically significant improvements in chest expansion across all measured thoracic levels, confirming their effectiveness in enhancing thoracic mobility. This is consistent with the findings of Csepregi et al. (2022), which reported that breathing exercises significantly improve posture as well as spinal and thoracic mobility in healthy female students.

Spirometric outcomes further support the benefits of both interventions. Vocal exercises were more effective than breathing exercises in improving FVC and FEV1, suggesting a potential advantage of vocal training for specific aspects of pulmonary function. Conversely, PEF improved significantly only in the breathing exercise group, highlighting the role of breathing exercises in strengthening expiratory muscles. The positive effects of breathing exercises on FEV1 align with prior studies demonstrating that home-based breathing interventions can improve respiratory function in post-COVID-19 patients (Lu et al., 2020), emphasising the potential of remotely delivered programmes.

Regarding trunk stability, the vocal exercise (VE) group showed statistically significant improvements across all DNS tests, whereas the breathing exercise (BE) group exhibited significant changes only in the diaphragm and trunk/neck flexion tests. Improvements in diaphragm test results following both interventions indicate enhanced respiratory motor patterns, including reduced shoulder elevation and increased lower rib excursion. Positive outcomes in trunk and neck flexion tests suggest decreased compensatory activation of accessory respiratory muscles, indicating that both interventions improve appropriate respiratory muscle function. The trunk extension test confirmed the positive effect of vocal exercises on trunk stability; however, between-group comparisons of dynamic neuromuscular stabilisation revealed no statistically significant differences. Assessments using the Stabilizer device showed significant improvements in the BE group during the right-leg flexion test, while the VE group improved significantly in the left-leg flexion test. Between-group comparison revealed a significant difference only for the trunk stability test with flexed leg.

Overall, these findings suggest that both vocal training and breathing exercises positively affect trunk control, although intergroup differences were not statistically significant. This may be due to the short duration of the intervention and the study's remote design, which limited supervision and allowed participants to compensate using habitual respiratory patterns. Based on these results, we cannot conclusively state that vocal exercises are superior to breathing exercises in improving respiratory function, as only a few outcomes differed significantly between the groups. Nevertheless, both interventions are effective and can be incorporated into respiratory and pulmonary rehabilitation programmes. Vocal exercises, as a standalone tool, positively affect both respiratory function and trunk stability.

Several limitations should be considered. First, the six-week intervention may have been too short to observe maximal effects, particularly on trunk stability and pulmonary function. Second, the remote delivery limited supervision of exercise performance, which may have allowed compensatory movements or inconsistent technique. Third, the sample was homogeneous, including only healthy women of similar age, height, weight, and BMI, which limits generalisability to men, older adults, or clinical populations. Fourth, the vocal exercises focused solely on contemporary diaphragmatic singing; effects of other singing modalities remain unexplored. Fifth, adherence to the exercise protocol was self-reported, introducing potential bias. Finally, the sample size may have been insufficient to detect subtle between-group differences in some outcomes, particularly for trunk stability.

5. CONCLUSIONS AND PERSPECTIVES

Both vocal and breathing exercises effectively improve respiratory function, respiratory muscle endurance, and trunk stability in women. Vocal exercises may offer additional benefits for FVC and FEV1, while breathing exercises specifically enhance PEF. Future studies should investigate longer, in-person interventions with more diverse populations and explore different singing modalities to determine optimal approaches for respiratory and trunk control improvements. Despite its limitations, this study demonstrates that remotely delivered interventions can be a feasible and effective option for improving pulmonary function and trunk stability.

Author Contributions: Conceptualisation, E.K. and V.D.; methodology, E.K. and V.D.; software, V.O.; validation, E.K., V.O., and V.D.; formal analysis, V.D.; investigation, E.K.; data curation, V.D.; writing—original draft preparation, E.K.; writing—review and editing, V.D.; visualisation, V.O.; supervision, V.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgements: We sincerely thank all the study participants for their time and contribution.

Conflicts of Interest: The authors declare no conflict of interest.

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Vokalinių ir kvėpavimo pratimų poveikio moterų plaučių funkcijai ir liemens stabilumui atsitiktinių imčių tyrimas

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Santrauka

Tyrimo pagrindimas. Kvėpavimo ir vokalinių pratimų poveikis moterų kvėpavimo funkcijai ir liemens stabilumui yra nepakankamai ištirtas.

Tikslas. Palyginti vokalinių ir kvėpavimo pratimų poveikį moterų kvėpavimo funkcijai ir liemens stabilumui.

Metodai. Į šį atsitiktinių imčių tyrimą įtraukta 50 moterų. Kvėpavimo funkcija buvo vertinama pagal krūtinės išsiplėtimo rodiklius (Th3–4, Th7–8, Th11–12), kvėpavimo sulaikymo testų ir spirometrijos (PEF, FVC, FEV1) rezultatus. Liemens stabilumas vertintas pasitelkus dinaminės neuroraumeninės stabilizacijos (DNS) testus ir liemens stabilumo testus, naudojant biologinio grįžtamojo ryšio slėgio matavimo prietaisą „Stabilizer". Dalyvės buvo atsitiktinai suskirstytos į kvėpavimo pratimų arba vokalinių pratimų grupes.

Rezultatai. Kvėpavimo pratimų grupėje buvo nustatytas statistiškai reikšmingas kvėpavimo sulaikymo trukmės pailgėjimas, pagerėjo krūtinės išsiplėtimo rodikliai (Th3–4, Th7–8 ir Th11–12) ir PEF, DNS (atliekant galvos, kaklo ir liemens lenkimo testus) bei liemens stabilumo testų lenkiant dešinę koją (naudojant „Stabilizer" prietaisą) rezultatai. Vokalinių pratimų grupėje reikšmingai pagerėjo krūtinės išsiplėtimo rodikliai, spirometrijos (PEF, FVC, FEV1), kvėpavimo sulaikymo testų rezultatai ir DNS bei liemens stabilumo testų lenkiant kairę koją (naudojant „Stabilizer" prietaisą) rezultatai. Palyginus grupių rezultatus paaiškėjo, kad vokalinių pratimų grupė pasiekė reikšmingai didesnį FVC, FEV1 ir liemens stabilumo lenkiant kairę koją rodiklių pagerėjimą.

Išvados. Vokaliniai pratimai pagerino moterų kvėpavimo funkciją, sustiprino kvėpavimo raumenų jėgą ir ištvermę bei padėjo išlaikyti liemens stabilumą. Kvėpavimo pratimai taip pat pagerino moterų kvėpavimo funkciją, padidino raumenų jėgą ir ištvermę. Nors vokaliniai pratimai padarė didesnį poveikį plaučių funkcijai (FVC ir FEV1) palyginti su kvėpavimo pratimais, abi intervencijos turėjo panašią įtaką moterų kvėpavimo raumenų jėgai, ištvermei ir liemens stabilumui.

ClinicalTrials.gov identifikatorius: NCT07175844

Reikšminiai žodžiai: kvėpavimo pratimai; vokaliniai pratimai; kvėpavimo sistema; liemens stabilumas

Received 2025 07 01
Accepted 2025 09 30