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REVIEW

Can you breathe yourself to a better pelvic floor? A systematic review

Kari Bø[1,2] | Patricia Driusso[3] | Cristine Homsi Jorge[4]

[1]Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway

[2]Department of Obstetrics and Gynecology, Akershus University Hospital, Lørenskog, Norway

[3]Women's Health Research Laboratory, Physical Therapy Department, Universidade Federal de São Carlos, São Carlos, Brazil

[4]Departament of Health Science, Graduation Program in Rehabilitation and Functional Performance, Ribeirão Preto Medical School, Ribeirão Preto, Brazil

Correspondence
Kari Bø, Department of Sports Medicine, Norwegian School of Sport Sciences. PO Box 4014, Ullevål stadion, 0806 Oslo, Norway.
Email: kari.bo@nih.no

Abstract

Introduction: Some authors suggest that breathing exercises should be recommended instead of or in combination with pelvic floor muscle training (PFMT) to prevent and treat urinary incontinence (UI) and pelvic organ prolapse (POP).

Aims: The primary aim of the present study was to investigate the evidence for breathing as an intervention alone or in addition to PFM contraction in treatment of UI and POP.

Materials & Methods: This systematic review included short-term experimental studies and randomize controlled trials (RCTs) indexed on PubMed, EMBASE, and PEDro database. A form was used to extract data that was analyzed qualitatively due to the heterogeneity in interventions and outcome measures of the included studies. The individual methodological quality of RCTs was analyzed using the PEDro scale.

Results: A total of 18 studies were included, 374 participants from short-term experimental studies and 765 from nine RCTs. PEDro score varied from 4 to 8. Activation of the PFM during expiration was significantly less than during a PFM contraction. In general, the RCTs showed that training the PFM is significantly more effective to improve PFM variables and UI and POP than breathing exercises, and that adding breathing exercises to PFMT have no additional effect.

Conclusion: This systematic review indicates that the evidence for incorporating breathing exercise in clinical practice in addition to or instead of PFMT is scant or non-existing, both based on short-term experimental studies and small RCTs.

KEYWORDS

breathing, diaphragm, expiration, incontinence, inspiration, pelvic floor, pelvic organ prolapse, physiotherapy, respiration, women's health

1 | INTRODUCTION

Pelvic floor muscle training (PFMT) has Level 1 evidence/recommendation A to treat stress- and mixed urinary incontinence (UI) and pelvic organ prolapse (POP) in women, and there is international consensus that PFMT should be first-line treatment for these conditions.[1–4] Because of its anatomical location at the bottom of the abdominal canister and directly surrounding the pelvic orifices (urethra, vagina, and rectum), the pelvic floor muscles (PFM) and connective tissue of the pelvic floor yield structural support to resist gravity, rise in intra-abdominal pressure (IAP) and ground reaction forces that may lead to excessive downward movement and opening of the levator hiatus.[5] Regular and supervised PFMT increases PFM strength and endurance, lifts the bladder neck and rectal ampulla, narrows the levator hiatus area, shortens the PFM, and increases PFM cross-sectional area, thereby having a direct effect factors causing UI, especially stress UI (SUI) and POP.[6]

Due to its location at the lower part of the abdominal canister, it has been suggested that the PFM works in orchestra with abdominal muscles and the thoracic diaphragm.[7,8] Based on this some authors have suggested that "nonoptimal strategies for posture, movement, and/or breathing create failed load transfer which can lead to UI."[9] Likewise, some authors claim that the PFM is important for breathing function,[7,10,11] and that holding the breath in an inspiratory pattern during exertion stresses the PFM and may cause pelvic floor dysfunction (PFD).[8] In addition, it was suggested that "an expiratory motor pattern during body work-outs and strenuous efforts is likely to protect and even train the cocontracted PFMs and lower abdominal muscles."[8] Furthermore, Toprak et al.[12] hypothesized that pelvic floor function can be improved by performing diaphragmatic breathing exercises, indirectly via what they claimed to be a facial connection between the diaphragm and PFM, and that incontinence could be reduced.

Two systematic reviews of evidence for alternative exercises to PFMT for UI[1,13] did not find any randomized controlled trials (RCTs) to support the view that breathing exercises should be recommended instead of or in combination with PFMT. As there seems to be a continuous interest in adding deep respiration to PFM contraction in prevention and treatment of PFD, the aim of the present review is to investigate whether there is evidence for deep breathing as an intervention alone or in addition to PFM contraction in treatment of UI and POP. In addition to RCTs, we also report results from short-term experimental studies on a possible immediate effect of inspiration and expiration on PFM response and function.

2 | MATERIALS & METHODS

This systematic review followed the Prisma 2020 statement: an updated guideline for reporting systematic review.[14] The review protocol was registered in Research Registry in December 2022 (review registry1493).

2.1 | Eligibility criteria

Inclusion criteria were short-term experimental studies and RCTs with full-text publications available, with no language restriction, including only women, not pregnant or in the postpartum period, above 18 years old, investigating the impact of breathing on the PFM and/or pelvic floor support and the effectiveness of any breathing technique alone or added to PFM contraction/training on PFM response, UI, and/or POP. Exclusion criteria were studies that included breathing exercises, among other exercises for other purposes than affecting the PFM, in addition to PFMT given in exercise classes.[15]

2.2 | Information source and search strategies

The last search date for all databases was March 17, 2023. An open search strategy on PubMed used the terms (breathing OR respiration OR hypopressive) AND (pelvic floor OR urinary incontinence OR organ prolapse). The EMBASE/ELSEVIER was searched using the terms: "breathing"/mj AND ("pelvis floor"/mj OR "diaphragma pelvis" OR "pelvic diaphragm" OR "pelvic floor" OR "pelvic ground" OR "pelvis diaphragm" OR "pelvis diaphragma" OR "pelvis floor" OR "urine incontinence"/mj OR "bladder incontinence" OR "incontinence, urine" OR "incontinentia urinae" OR "involuntary urinary loss" OR "involuntary urination" OR "involuntary urine loss" OR "leak." In addition, the PEDro database was searched with the term "breathing exercise" and "urinary incontinence."

2.3 | Selection process

The titles and the abstract of the studies were assessed for eligibility by independent reviewers. All three reviewers then retrieved the remaining articles in full text and independently determined their eligibility. Disagreements were resolved by discussion till consensus was agreed.

TABLE 1 Short term experimental studies on the effect of breathing on the pelvic floor muscles.

Author/year	Design	Participants	Assessment of ability to contract PFM	Type of exercise/maneuver	Primary outcome measure	Results	Limitations
Bø et al.[16]	Cross sectional experimental	14 women with urodynamically proven stress urinary incontinence, mean age: 44.7 (range: 36–58) years	Yes, observation and vaginal palpation	*Maximum PFM contraction *Forced inspiration *Forced expiration *Contraction of gluteals, hip adductors, abdominals via pelvic tilt and total contraction of all muscle groups Supine position	Manometer (Camtech AS) assessing "response" of forced inspiration and expiration at the level of the PFM in the vagina	Median PFM contraction: 11.5 cm H_2O (95% CI: 10–15) *Forced inspiration: 15 cm H_2O (95% CI: 7–27) *Forced expiration: 5.5 cm H_2O (95% CI: 4–11)	Not possible to separate rise in IAP or PFM response. Forced inspiration likely due to increase in IAP.
Hodges et al.[10]	Cross sectional experimental	1 male and 6 healthy females, mean age females 45.7 (range: 35–63) years	No	*Single repetitions of shoulder flexion or extension in response of the PFM to a light *Repetitive movement *Repetitive movement increasing frequency *Quiet breathing *Increased deadspace breathing *Repetitive movement with breathing	Vaginal sEMG. IAP assessed in in one male and one female	During quiet respiration: PFM sEMG activity was recorded during both inspiration and expiration, but was greater during expiration Vaginal sEMG increased to 19.1 (11.0) % MVC during expiration and 12.8 (7.1) % MVC during inspiration ($p < 0.03$).	Cross talks from other muscles, therefore reported as vaginal sEMG rather than PFM.
Talasz et al.[7]	Pilot cross sectional experimental	8 healthy nulliparous women mean age 25 (SD 6) years	Vaginal palpation. Modified Oxford grading	Participants asked to breathe and cough	Real time dynamic MRI, 1.5-T, whole body MRI-scanner of respiratory diaphragm and PFM movement	Mean amplitudes of cranio-caudal movement of the right and left diaphragmatic cupolae were 15 (SD 6) and 9 (SD 7) mm during quiet breathing; 32 (SD 15) and 28 (SD 16) mm during forceful breathing; and 32 (SD 13) and 28 (SD 7) mm during coughing. Both diaphragm and pelvic floor moved caudally during inspiration and	No MRI measurement during voluntary PFM contraction.

(Continues)

TABLE 1 (Continued)

Author/year	Design	Participants	Assessment of ability to contract PFM	Type of exercise/maneuver	Primary outcome measure	Results	Limitations
						cranially during expiration- PFM movement significant less than diaphragmatic movement.	
Stüpp et al.[17]	Cross sectional experi-mental	36 nullipara, healthy female physiotherapists mean age 28.1 (SD 6) years	Yes, observation and vaginal palpation	*Maximum PFMc *HT (excessive breathing out with abdominal indrawing) *PFMc + HT Supine position	sEMG	*HT: 47.1 (SD 31.1) µV sign higher than resting tone 22.9 (SD 11) µV, $p < 0.001$. *HT sign less effective than PFM (101.1 (SD 44.2) µV). *HT + PFM: 104.8 (SD 50.6) µV, not different from PFM alone $p < 0.001$. *HT activated TrA more than PFM, but adding PFM to HT sign increased TrA.	
Resende et al.[18]	Cross sectional experi-mental	17 healthy, nullipara women, mean age 24 (SD 5.9) years	Yes, 4D ultrasonog-raphy	*Maximum PFMc *HT *HT + PFMc	4D ultrasonography of LH area	Narrowing of LH area: Maximum PFMc: 1.8 cm^2 HT: 0.5 cm^2 (not statistically sign from rest) HT + PFMc: 2.0 $cm.^2$ No significant narrowing of LH area in healthy nulliparous women by HT.	
Ithamar et al.[34]	Cross sectional experi-mental	30 healthy, nulliparous women, mean age 25.8 (SD 3.3) years	sEMG	Random order contraction of rectus abdominis, external oblique, transversus abdominal/	Response of abdominal and PFM during hypopressive exercise. Semg normalized sEMG	In supine position sEMG during PFM MVC was median 40.25 (IQ: 25–75: 30.42–61.07).	Only sEMG to assess correct contraction.

TABLE 1 (Continued)

Author/year	Design	Participants	Assessment of ability to contract PFM	Type of exercise/maneuver	Primary outcome measure	Results	Limitations
				internal oblique (TrA/IO), and PFM assessment in supine, quadruped, and upright standing positions during abdominal hypopressive gymnastics	data (% EMG of each muscle group's maximal contraction) during hypopressive	During hypopressive median PFM sEMG was 7.57 (IQ: 25–75: 4.52–12.77). TrA/IO and PFM showed higher % sEMG in all the positions assessed, followed by the external oblique and rectus abdominis.	
Kruger et al.[19]	Cross sectional experimental	21 healthy physiotherapists, mean age 43 (SD 11) years	Yes, observation	*Maximum PFMc then random order of: internal hip rotation, external hip rotation, hip abduction, hip adduction, contraction of the gluteal muscles, pelvic tilt, indrawing, abdominal crunch, deep inspiration, and deep expiration Supine position	FemFit® prototype pressure sensor array with 8 evenly spaced pressure sensors, 9 mm apart. Sensor 7–8 positioned in the posterior fornix to measure IAP	*PFMc: 16.3 ± 12.2 mmHg IAP: 3.4 mmHg (SD 2.2). *Inspiration: difference from PFMc −10.8 (95% CI: 2.1–21.1) $p < 0.001$ IAP: 5.5 (SD 3.1). *Expiration −10.1 (95% CI: 11.1–20.4) $p < 0.001$ IAP: 6.12 mmHg (SD 4.9). Only PFMc and contraction of internal rotators and gluteals had significantly higher vaginal pressure rise than simultaneous rise in IAP ($p < 0.001$) PFMc sign better than the other maneuvers to active the PFM.	FemFit® not commercially available.
Aljuraifani et al.[20]	Cross sectional experimental	12 healthy women, mean age 34 (SD 10) years	No	*Maximum PFMc *Dead-space breathing *Cough in sitting and standing position	Custom made vaginal sEMG positioned on superficial and deep PFM	As breathing demand increased, the deep PFM layer sEMG had greater coherence with	Possible cross talk from other muscles. No other assessment than

(Continues)

TABLE 1 (Continued)

Author/ year	Design	Participants	Assessment of ability to contract PFM	Type of exercise/ maneuver	Primary outcome measure	Results	Limitations
				* Maximal inspiratory and expiratory pressure *Submaximal inspiratory and expiratory pressure Long sitting back rest of 45% in reclined position		respiratory airflow at the frequency of respiration than the superficial PFM. Deep maximal inspiratory pressure 0.28 (SD 0.23) ($p = 0.04$). During cough, the superficial PFM activated earlier than the deep PFM in the sitting position ($p = 0.04$). During maximal and submaximal inspiratory and expiratory efforts, the superficial PFM sEMG was greater than that for the deep PFM. Deep maximal expiratory pressure: -0.36 ± 0.24 ($p = 0.01$).	sEMG to ensure correct contraction. No reliability or validity study of the method.
Talasz et al.[8]	Retrospective chart data analysis	177 elderly inpatients with urinary incontinence, mean age 78 (SD 7), range 65–94	Yes, observation and vaginal palpation	*Voluntary PFM contraction strength *PFM activation *displacement of the PF and abdominal wall during forced exhalation and coughing	Observation and digital vaginal palpation	Independent of voluntary PFM contraction strength, most patients ($n = 168$) demonstrated bulging of the abdominal wall and PF during forced exhalation and coughing instead of contracting the PFMs and lifting the PF (in accordance with physiological breathing synergies).	

TABLE 1 (Continued)

Author/year	Design	Participants	Assessment of ability to contract PFM	Type of exercise/maneuver	Primary outcome measure	Results	Limitations
						None of the nine women who reflexively contracted the PFM in accordance with expiratory breathing pattern complained of symptoms of SUI alone.	

Abbreviations: CI, confidence interval; D, dimensional; HT, hypopressive technique; IAP, intra-abdominal pressure; IO, internal oblique abdominal muscle; IQ, interquartile; LH, levator hiatus; MRI, magnetic resonance imaging; MVC, maximal voluntary contraction; PFM, pelvic floor muscle; PFMc, pelvic floor muscle contraction; SD, standard deviation; sEMG, surface electromyography assessment; TrA, transverse abdominal muscle.

2.4 | Data extraction

Data from all studies were collected by the three researchers independently. For the short-term experimental studies the following items were reported in Table 1: Author/year of publication, design, participants, whether assessment of ability to perform a correct PFM contraction was conducted, description of the maneuver/exercise performed, outcome measures, results, and limitation of the study. For the RCTs the items reported were author/year of publication, design, participants, training program, drop-out and adherence, primary and secondary outcome measures, results, and PEDro score (Table 2).

2.5 | Study risk of bias assessment

The PEDro rating scale was used to grade the methodological quality of the RCTs.[28,29] Total PEDro scores of 0–3 are considered "poor," 4–5 "fair," 6–8 "good," and 9–10 "excellent."[30] For trials evaluating complex interventions (e.g., exercise), a total PEDro score of 8/10 is optimal as it is considered impossible to blind the therapist and the participants.[30] The PEDro scale is a reliable and valid tool to evaluate the risk of bias in clinical trials.[29,31,32]

2.6 | Synthesis methods

Due to the heterogeneity in terms of subjects involved, interventions, and outcome measures, it was not possible to perform a subgroup analysis or meta-analysis. Data was qualitatively synthesized and presented in tables.

3 | RESULTS

The PRISMA flow diagram with the number of studies identified, screened, and selected is presented in Figure 1. A total of 18 full-text articles were included in this review.

Tables 1 and 2 present the characteristics of the included studies. A total of 374 participants were included in the short-term experimental studies and 765 participants in the RCTs. The studies were published from 1990 to 2022.[16,27,33] In relation to study design, nine were short-term experimental studies[7,10,16–20,33,34] while nine were RCTs.[12,21–27,35]

3.1 | Short-term experimental studies

Table 1 describes the short-term experimental studies. The studies had sample sizes ranging from 6[10] to 177[33]

TABLE 2 Results of randomized controlled trials (RCT) using breathing as intervention for urinary incontinence in women.

Author/year	Design	Participants	Training program	Drop out/adherence	Primary outcome measure	Secondary outcome	Results	PEDro score 0–10
Hung et al.[21]	Assessor blinded 2-arm parallel group RCT	70 women with SUI or MUI randomized to 4 months of: *Training ($n = 35$) mean age 48.6 (SD 6.4) years *Control ($n = 35$) mean age: 48.9 (SD 6.4) years	Assessment of correct PFM contraction: vaginal palpation Both groups taught in PF anatomy and ability to contract the PFM *Training group: met with PT twice a week for 4 months for assessment and progression to further of these stages: – Diaphragmatic breathing (Week 1–4) – Tonic activation of TrA and PFM (Week 2–5) – Muscle strengthening of TrA and PFM and internal obliques (Week 6–16) – Functional expiratory pattern like coughing and sneezing (Week 8–16) – Impact activities such as running and jumping (Week 10–16)*Control: oral instruction and information of UI, PFM exercise, and bladder hygiene	Drop out *Training: 11.4% *Control: 5.7% Adherence 26 participants in the training group (84%) participated in 8, the others in 7 individual visits No information of home exercise adherence	Self-reported improvement on a 4-point Likert-scale	*20 min pad-test with standardized bladder volume. *Three-day voiding diary. *PFM squeeze pressure and holding time by Peritron manometer. *QoL.	Sign more women in training group reported cured or improved symptoms (96.7% vs. 66.6%), $p = 0.002$. No difference between groups in amount or number of leaks, but none of participants had any leakage. No difference in change of maximum vaginal pressure or holding time. Only the training group had sign reduction in number of activities affected and avoiding activity due to needing a toilet. More women in the intervention group had UUI than in the PFMT group.	8/10

TABLE 2 (Continued)

Author/ year	Design	Participants	Training program	Drop out/adherence	Primary outcome measure	Secondary outcome	Results	PEDro score 0–10
Bernardes et al.[22] Resende et al.[23]	Assessor blinded 3-arm parallel group RCT	58 women with POP stage II randomized to: *PFMT ($n = 21$) *PFMT + hypopressive technique ($n = 21$) *Control with lifestyle advice only ($n = 16$)	Assessment of correct PFM contraction: vaginal palpation 12 weeks intervention with three individual sessions of group training in intervention 1 and 2 **1.** PFMT **2.** Hypopressive 10 repetitions of hypopressive exercise in association with voluntary PFM contractions **3.** Control: single visit with PT, learned to contract the PFM, asked to do the “Knack”Home training for the study period with 3 sets of 8–12 maximal PFM contractions per day, similar time in group 1 and 2 with two monthly visits with PT. Standard lifestyle advice for all three groups	Drop-out: $n = 5$; 7.9% in the control group Adherence (exercise diary) PFMT: 71.4% Hypopressive + PFM contraction: 76.2% performed all exercises	*Manometer for PFM strength *Ultrasonography for CSA	None	Change in CSA between both treatment groups compared to control. No difference between group 1 and 2. Improvement in PFMT: 50% Improvement in Hypopressive + PFMT: 20% Both exercise groups superior to control group in strength, endurance, and activation. PFMT alone superior to hypopressive + PFM contractions in endurance. No effect of adding hypopressive technique regarding PFM strength, endurance, CSA.	Bernardes et al.: 4/10 Resende et al.: 6/10

(Continues)

TABLE 2 (Continued)

Author/ year	Design	Participants	Training program	Drop out/adherence	Primary outcome measure	Secondary outcome	Results	PEDro score 0–10
Resende et al.[35]	Assessor blinded 2-arm parallel group RCT	70 women, mean age 55.7 (SD 5.2) with symptomatic stage II POP (POP-Q) randomized to: *PFMT ($n = 35$) *Hypopressive exercise ($n = 35$)	Assessment of correct PFM contraction: visual observation Three individual sessions with physiotherapist to learn each of the techniques. Three months of home training	Drop out: 4 in hypopressive, 5 in PFMT Adherence (exercise diary): Hypopressive: 89% PFMT: 84%	*P-QoL	*POP symptoms. *POP-Q. *PFM strength (Oxford grading). *PFM sEMG.	PFMT sign better results in symptoms and P-QoL, POP-Q, PFM function (Oxford grading and sEMG).	6/10
Huang et al.[24]	Assessor blinded 2-arm parallel group RCT	161 women with moderate to severe OAB syndrome with mean 6.9 (SD 3.4) episodes per day randomized to *Paced respiration ($n = 82$), mean age 60.4 years (SD 11.4) *Control ($n = 79$), mean age 61.7 (SD 10.9)	12 weeks of 15 min/day: 1. Intervention: portable biofeedback device to practice daily slow guided breathing exercise 2. Control: identical-appearing device reprogrammed to play music without guided breathing	Drop-out discontinuation 1. Intervention: drop out: 0, discontinued intervention: 5 2. Control: drop out: 2. Discontinued intervention: 4Results analyzed as ITT and per protocol Adherence: 1. Intervention group: average 4.8 days/week practice, average 16.8 min/day 2. Control: 5.5 days/ week, average 16.4 min/day	Three-day voiding diary with OAB composite score OAB-Q, USIQ, PPBC, PSS Primary: 12 weeks change in frequency of voiding or incontinence episodes associated with at least modest urgency	Secondary: 12 weeks change in frequency of voiding or incontinence associated with severe urgency, urgency type incontinence, daytime and night-time voiding, OAB symptom composite score, and OAB-Q, USIQ, and PPBC scores. Additional measures: STAI, HADS electrocardiography-derived heart rate variability was used to measure resting cardiac	Modest within group decreases in frequency of OAB symptoms, no differences between groups. Women assigned to intervention with paced respiration statistically significant greater improvements in PSS scores, but not on any other difference in change in anxiety. No significant difference in automatic function. No difference in ITT or per protocol assessments.	8/10

TABLE 2 (Continued)

Author/year	Design	Participants	Training program	Drop out/adherence	Primary outcome measure	Secondary outcome	Results	PEDro score 0–10
						automatic function. PEP to measure sympathetic autonomic activity. Adverse events.		
Jose-Vaz et al.[25]	Assessor blinded 2-arm parallel group RCT	90 women with SUI PFMT group ($n = 45$): mean age 53.4 (SD 11.6) Hypopressive ($n = 45$): mean age 56.9 (SD 11.5)	No assessment of correct PFM contraction 12 weeks of 24 50 min classes with either *PFMT *Hypopressive exercise	Drop out PFMT: 8 (17.8%) Hypopressive: 9 (20%) Adherence: not reported	*Seven days leakage episodes *ICIQ-total score	*Manometry of PFM strength.	All outcome in favor of PFMT: *Seven days leakage episodes: effect size 0.94 *ICIQ-total score: effect size: 1.04 *PFM strength: effect size: 1.15.	6/10
Navarro-Brazalez et al.[26]	Assessor blinded 3-arm parallel group RCT	94 women with PFD (SUI, MUI, and/or POP (stage I or II), mean age 47 (SD 10) randomized to *PFMT ($n = 32$) *Hypopressive exercise ($n = 31$) *PFMT + hypopressive exercise ($n = 31$)	Assessment of ability of correct PFM contraction: vaginal palpation. All participants had instruction in ability to contract the PFM and instruction in "the Knack" Hypopressive exercise was without voluntary PFMc 8 weeks of 2 visits of 45 min each week of: 1. PFMT+ el.stim. if score <3). 10 maximal contractions + rapid,	Drop out: 2 + 3 for follow-up Adherence (asked by PT) to home exercise: 1. PFMT: 71.9% 2. Hypopressive: 61.3% 3. PFMT + hypopressive: 67.7%Adherence fell below 60% in all groups at 6 months with no difference between groups. Knack incorporated into activities of daily living in 85% during the intervention, no diff between groups Use of Knack at 12 months:	*PFDI-20 *PFIQ-7	*POP. *Manometry of PFM strength. *Pelvic floor basal tone using dynamometry.	No difference between groups in any variables. Long-term at 6 and 12 months after cessation of the intervention: effects within groups reported to be maintained, no difference between groups Adverse effects: low back pain in some postures by 1 woman in PFMT + hypopressive and in 5 in hypopressive group.	7/10

(Continues)

TABLE 2 (Continued)

Author/ year	Design	Participants	Training program	Drop out/adherence	Primary outcome measure	Secondary outcome	Results	PEDro score 0–10
			holding time 10 s. Home exercise 2–3 sets of 5–10 PFMc/day **2.** Hypopressive + home hypopressive **3.** PFMT + hypopressive	PFMT: 68.8% Hypopressive: 83.9% PFMT + hypopressive: 80.6%				
Toprak et al.[12]	Pilot non-blinded 2-arm parallel group RCT	40 Caucasian women complaining of urinary leakage, mean age 39.3 (SD 6.8) years randomized to: *Group 1: PFMT ($n = 20$) *Group 2: Diaphragmatic respiration (breathing) ($n = 20$)	Assessment of correct PFM contraction: vaginal palpation 1 set of 30 repetitions per day of each of the two exercises for 6 weeks. Hold every contraction at the maximal level for 5–10 s and then to relax 5–10 s in both groups. Taught by PT (vaginal palpation of PFMT group, abdominal palpation during diaphragmatic respiration) but exercised at home	Drop-out. 0 All women in both groups completed the study. Adherence: not reported	*IIQ-7 *UDI-6 *I-QOL *OAB-V3	Adverse events.	UDI-6 urge symptoms decreased statistically significantly only in the diaphragmatic respiration group (p 0.05). Mean decrease in the total UDI-6 score was statistically significantly higher in the diaphragmatic respiration group than in the PFMT No significant difference between groups in any other scores. No adverse effects reported.	6/10
Molina-Torres et al.[27]	Assessor blinded 2-arm paral-lell group RCT	124 women with PFD symptomatology lasting >6 months, mean age 45.6 (SD 8.9) randomized to: *Hypopressive exercise ($n = 64$)	Hypopressive exercise: 8-week, 20 min twice a week group training of 10–12 participants including initial training in "breathing patterns, rib cage proprioception, apnea familiarization, and abdominal vacum"	Drop out: Hypopressive group: 2 Control group: 5 Adherence: not reported	Modified Oxford Scale PFDI-20 PFIQ-7 ICIQ-UI-SF		Improvement in the hypopressive group in PFM strength; $F(1117) = 89.514$, $p < 0.001$ A significantly lower score for the PFIQ-7 total score, $t(112) = 28.895$,	6/10

TABLE 2 (Continued)

Author/year	Design	Participants	Training program	Drop out/adherence	Primary outcome measure	Secondary outcome	Results	PEDro score 0–10
		*Control ($n = 60$)	Control group no intervention				$p < 0.001$ and FPDI-20 t (112) = 7.037, $p < 0.001$. Improvement in ICIQ-UI-SF values compared to control group.	

Abbreviations: CSA, cross sectional area; el.stim, electrostimulation; HADS, hospital anxiety and depression scale; ICIQ, International consultation on incontinence questionnaire; IIQ-7, incontinence impact questionnaire; I-QOL, incontinence quality of life; ITT, intention to treat; MUI, mixed urinary incontinence; OAB, overactive bladder; OAB-Q, overactive bladder questionnaire; OAB-V3, overactive bladder version 3; PEP, pre-ejection period; PFD, pelvic floor dysfunction; PFDI-20, pelvic floor distress inventory short form; PFIQ-7, the pelvic floor impact questionnaire short form; PFM, pelvic floor muscles; PFMc, pelvic floor muscle contraction; PFMT, pelvic floor muscle training; POP, pelvic organ prolapse; PPBC, patient perception of bladder condition; P-QoL, prolapse quality of life; PSS, Cohen perceived stress scale; PT, physical therapist; QoL, quality of life; SD, standard deviation; sEMG, surface electromyography; STAI, Spielberger state trait anxiety inventory; SUI, stress urinary incontinence; TrA, transverse abdominal muscle; UDI-6, urogenital distress inventory; UI, urinary incontinence; USIQ, urgency severity and impact questionnaire; UUI, urgency urinary incontinence.

and used surface electromyography (sEMG), manometer, ultrasound, or magnetic resonance imaging (MRI) to assess response from the PFM during respiration. Most studies included healthy participants, while two studies were assessing women with SUI or UI.[16,33] Three studies did not use methods to control for correct contraction of the PFM.[10,20,34] Table 1 lists the limitations of the measurement methods used in assessment of PFM response.

Three studies evaluated hypopressive technique (combination of excessive expiration and abdominal contraction).[17,18,34] These studies applied different measurement methods (ultrasonography and sEMG) and all showed that PFM contraction was significantly more effective in activating the PFM compared to the hypopressive technique. Stupp et al.[17] found that the hypopressive technique gave a statistically significant increase over resting PFM tone measured with sEMG while Resende et al.[18] found no significant reduction of the levator hiatus area during the hypopressive technique measured with ultrasonography. Kruger et al.[19] was the only group that measured IAP simultaneously with contraction of the PFM and other muscle groups and during inspiration and expiration in all participants. They showed that PFM contraction was superior to all other muscle groups and breathing to activate the PFM, and that only contraction of the PFM, the internal hip rotators and gluteal muscles increased PFM activity significantly more than the simultaneous increase in IAP.

3.2 | RCTs

Table 2 shows the characteristics of the RCTs. The trials were published between 2010 and 2022 and the sample size in the comparison arms varied between 20[12] and 82.[24] Three studies included women with different forms of UI,[12,21,25] three studies were on women with POP,[22,23,35] two studies included women with different PFD,[18,27] and one study included women with overactive bladder syndrome (OAB).[24] There was a huge heterogeneity in outcome measures and interventions between studies.

3.3 | Risk of bias

Table 2 shows the risk of bias assessment of the RCTs. The PEDro score of the RCTs varied from 4[22] to 8.[21,24] No study had blind participants or instructors, but the majority had blind assessors. Duration of the training period varied between 6 weeks[12] to 4 months[21] and

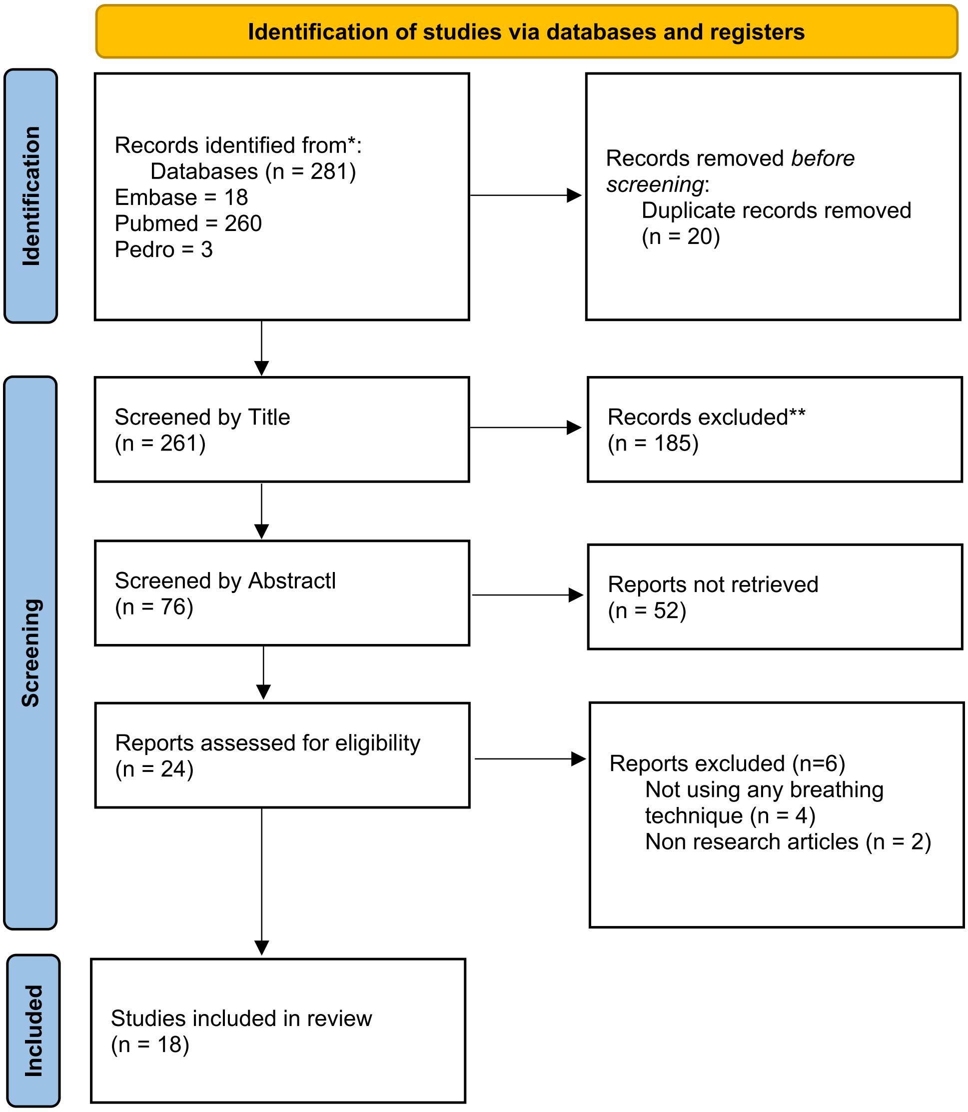

FIGURE 1 PRISMA flow diagram for included studies.

included a plethoria of exercise programs (Table 2). Dropout was generally low and adherence to the programs between 61.3%[26] and 84%.[21] In three studies, adherence was not reported.[12,25,27] Assessment of correct PFM contraction was performed in all studies that applied PFMT in one comparison arm, except one.[25] Teaching and assessment of a correct PFM contraction was also conducted in the comparison groups. Most studies included supervised training combined with home exercise (Table 2).

Six of the RCTs evaluated the effect of hypopressive exercise.[22,23,25–27,35] Four of the studies found no additional effect of adding hypopressive exercise (a combination of excessive expiration and abdominal contraction) to PFMT or that PFMT was more effective than hypopressive exercise for either POP, SUI, MUI, and PFM variables (Table 2). Molina-Torres et al.[27] found statistically significantly better results in all outcome measures in the hypopressive group compared with the group no intervention.

Two RCTs compared an intervention containing breathing exercises only with either a control group with no breathing[24] or PFMT.[12] Hung et al.[24] found no differences between groups randomized to either slow-guided breathing exercise compared with an identical-appearing control device programmed to play music without guided breathing on the primary outcome: frequency of voiding or incontinence associated with moderate to severe urgency. The breathing group demonstrated greater improvements in perceived stress (Table 2). Toprak et al.[12] compared diaphragmatic breathing with PFMT in a 6 weeks intervention period and did not show any differences in change between groups in any other outcome than the sub-item score of

UDI-6 urge symptom, which was only significantly reduced in the breathing group.

4 | DISCUSSION

We found limited information about the relationship between respiration and the PFM from short-term experimental studies and RCTs to support the theories that breathing can positively affect PFM function or PFD. The studies included a plethoria of outcome measures, exercise programs and breathing techniques, and meta-analyses could therefore not be conducted. In general, short-term experimental studies have shown that the PFM can be activated and moved cranially during expiration. However, the activation during expiration is significantly less than during a voluntary PFM contraction. The RCTs showed that training the PFM is significantly more effective to improve PFM variables and PFD than breathing exercises, and that adding breathing exercises to PFM does not have any additional effect to PFMT.

4.1 | Short-term experimental studies

The short-term experimental studies were conducted during one single breathing exercise. All exercises and studies were done differently; therefore, the results are difficult to compare across studies. Our decision to include hypopressive exercise as a form of breathing exercise in this review can be discussed. Hypopressive exercise, although it includes deep expiration, is always combined with abdominal indrawing, mostly involving contraction of the transverse abdominal muscle (TrA) and internal obliques.[36] Former short-term experimental studies have found that contraction of the TrA can open the levator hiatus and also depress the PFM.[37,38] Hence this may counteract a possible positive effect of expiration alone.

The results of the included short-term experimental studies of the present review on PFM response to a single hypopressive maneuver are somewhat contradictive. Stupp et al.[17] and Ithamar et al.[34] found an increased muscle activation over rest with hypopressive technique measured with sEMG. In contrast, Resende et al.[18] using ultrasonography found that the hypopressive maneuver did not significantly change the levator hiatus area. Furthermore, these three studies found that contraction of the PFM was significantly more effective than the hypopressive technique.

It has been argued that many women are not able to contract the PFM, and therefore, other muscle groups should be used to elicit a co-contraction of the PFM. Toprak et al.[12] concluded that breathing exercises could be an alternative for women with UI, particularly those who cannot perform PFM exercise. They also claimed that breathing exercise are easier to perform compared to PFM exercise, and that breathing exercise may be a good alternative for patients with poor pelvic floor awareness. We cannot see any evidence from that study for this conclusion. Whether a measurable, but small, statistically significant activation of the PFM is clinically meaningful and can have a trainable effect on PFM function or PFD needs further investigation. This also applies to the MRI finding that the PFM is moving in a cranial direction with expiration.[7] Ultrasound may be feasible for future clinical studies and is a responsive, reliable, and valid measurement tool to assess whether inspiration or expiration can significantly narrow the levator hiatus or lift the pelvic floor. Furthermore, whether a possible co-contraction of the PFM during expiration can actually be sensed by the women and thereby give improved awareness needs further clinical studies. However, studies have reported that more than 54% of women may be unable to contract the PFM correctly during the first week postpartum, but 70% of them were able to learn by simple teaching by a trained physiotherapist.[39] Other studies support that women with SUI can learn a correct contraction by verbal instruction, vaginal palpation, and electrical stimulation.[40,41]

5 | RCTS

As for the short-term experimental studies, most of the included RCTs inserted breathing exercises as part of a hypopressive exercise program, involving abdominal muscle contraction with breathing. However, former published RCTs have found that adding TrA or other abdominal muscles to PFMT did not yield any additional effect on SUI,[13,42–44] POP,[45] or PFM variables.[45] In the present systematic review, only one of five RCTs using hypopressive technique in one arm showed a positive effect on a PFD condition. Molina-Torres et al.[27] compared hypopressive exercise with an untreated control group, and found a significant effect on SUI and urgency incontinence, bowel problems, and POP. However, it is not possible to conclude whether the effect was due to the breathing or other components of the program. In the other RCTs, PFMT was superior to hypopressive training for SUI[25] and POP.[22,23,35]

Molina-Torres et al.[27] found that their program also improved PFM strength assessed by vaginal palpation classifying strength according to the modified Oxford grading scale. The responsiveness and interrater reliability of vaginal palpation have been questioned.[46,47] The other RCTs included in this systematic review found that PFMT was more effective than hypopressive in improving PFM activation measured by sEMG,[35] strength by vaginal palpation[35] or manometry,[23,25] and CSA assessed by ultrasonography.[22] Three of the RCTs used other exercise programs than hypopressive to compare either breathing as part of a PFMT program to act on the PFM and SUI,[21] breathing as the sole intervention compared with PFMT[12] and breathing exercise compared with sham to treat OAB.[24] There are limitations in the study of Hung et al.[21] as there was a huge difference in dosage of training and attention of the physiotherapist in favor of the intervention including breathing, and the groups were not homogeneous at baseline with more women in the breathing group reporting urgency symptoms. In addition, number of leaks and amount of leakage were actually 0 at baseline. Given this flaws of the study and the fact that it is not possible to separate any effect from other components of the intervention, this study cannot yield any valid information about the effect of breathing exercise.

The above discussion leaves two RCTs that can be considered valid when it comes to show effect of breathing exercises alone on the PFM or/and and PFD. The RCT of Huang et al.[24] included women with OAB syndrome and had an excellent design to rule out the effect on breathing as a single intervention as it had a sham control group with the same amount of time dedicated to listening to music without breathing. They found no differences in change between the two groups in any measured variable except for a difference in change of Cohen perceived stress scale. Hence, this study indicates that breathing may improve stress but not OAB symptoms. The other RCT used solely breathing exercises and compared these with PFMT in a group with urinary leakage.[12] This trial had the same amount of exercises and attention in both groups and found that breathing exercises had a statistically significant better effect on only OAB variables than PFMT. PFM variables were not assessed. It is important, when appracing these two RCTs, to highlight that the trials had the same dosage and attention by the therapist and included women with OAB. OAB has been associated with psychiatric conditions such as depression and anxiety and breathing exercises can potentially reduce stress.[48,49] None of these studies showed convincing effects on OAB symptoms in women.

The rationale for suggesting breathing exercises into PFMT programs is the belief that there is a facial connections between the respiratory diaphragm and the pelvic floor.[7,8,12,21] Tim and Mazur-Bialy[50] claimed that PFM are linked by myofascial connections with the respiratory diaphragm, TrA, intercostal muscles, oblique abdominal muscles, and thoracolumbar fascia. This suggestion needs to be substantiated with evidence from basic cadaver and imaging studies of anatomy. If there are facial connections with the PFM, biomechanical and anatomical studies on how breathing may contribute to make a PFM contraction is warranted in addition to blinded RCTs comparing breathing with no intervention or PFMT using the same dosage for each arm of the trial. Mechanisms for how PFMT may work was addressed in a review in 2004.[51] In a recent systematic review by Sheng et al.,[52] the conclusion was that there was no evidence that strengthened core muscles is effective in the treatment of UI, the same conclusion that was given in an older systematic review.[51] Sheng et al.[52] recommend that future studies should specifically state and report statistical analysis that relates the theorized mechanisms to the training outcomes observed.

Our review indicates that the evidence for incorporating breathing exercise in clinical practice in addition to or instead of PFMT is scant or non-existing, both based on short-term experimental studies and RCTs. Neither the Cochrane reviews, nor the ICI or the NICE guidelines have recommended breathing as an exercise to be included in a PFMT program.[1–3] Given the lack of evidence, or the effect of adding breathing exercises to PFMT to be marginal, focus on breathing may take time and resources away from evidence-based PFMT for SUI/MUI and POP. It is of most importance that conservative treatment of these prevalent and bothersome conditions follow protocols that have been shown to be effective and have solid rationale for the mechanisms of how it works.[4,6,15,51]

Strengths of the present review is the extensive review of databases with no language limitations and inclusion of both short term experimental studies and RCTs. Limitations are the limited number of high quality RCTs and heterogeneity of outcome measures and interventions not allowing for performance of a meta-analysis.

6 | CONCLUSION

This systematic review indicates that the evidence for incorporating breathing exercise in clinical practice in addition to or instead of PFMT is scant or non-existing. Clinical practice for SUI/MUI and POP should follow protocols from high quality RCTs.

AUTHOR CONTRIBUTIONS

Kari Bø: Idea of study, first search, analysis, and draft of manuscript. **Patricia Driusso**: Second search, analysis, and draft of manuscript. **Cristine Homsi Jorge**: Second search, analysis of results, and draft of manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ORCID

Kari Bø http://orcid.org/0000-0003-1176-9272
Patricia Driusso http://orcid.org/0000-0001-8067-9786
Cristine Homsi Jorge http://orcid.org/0000-0002-4956-4611

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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