Trials

STUDY PROTOCOL

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Effectiveness of breathing exercises on urinary symptoms, muscle activity, and strength in women with multiple sclerosis and urinary incontinence—a study protocol for a randomized controlled trial study

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Abstract

Background Urinary incontinence (UI) is a common and debilitating condition among people with multiple sclerosis (MS) and is more prevalent among women. Over the past decade, numerous studies have investigated the effects of pelvic floor muscle training (PFMT) as a treatment for UI in people with MS. MS negatively impacts pulmonary function even in the early stages of the disease and people with MS may experience respiratory muscle weakness. Considering the synergy between the pelvic floor muscle (PFM) and respiratory muscles, this trial will evaluate the effects of PFMT and breathing exercises on PFM activity and strength, diaphragm activity, and urinary symptoms in women with MS who experience UI.

Methods Fifty women with MS and UI will participate in this parallel randomized controlled trial, comprising 32 treatment sessions. The intervention group consists of PFMT and breathing exercises, and the control group includes PFMT. The severity of UI symptoms, PFM activity, diaphragm activity, and PFM strength will be evaluated using the International Consultation on Incontinence Questionnaire–Urinary Incontinence Short Form, ultrasound imaging, and modified Oxford grading scale, respectively before and after the intervention.

Discussion The current trial is designed to examine the effects of a combined exercise program for UI in women with MS. It is hypothesized that using breathing exercises in conjunction with PFM exercises will improve patient symptoms compared to PFMT alone.

Trial registration The trial was registered in the Iranian Registry of Clinical Trials with code IRCT20180916041051N3 and was approved on 23 May 2024.

Keywords Multiple sclerosis, Urinary incontinence, Pelvic floor muscle, Exercise, Breathing exercise, Physiotherapy, Women, Randomized controlled trial

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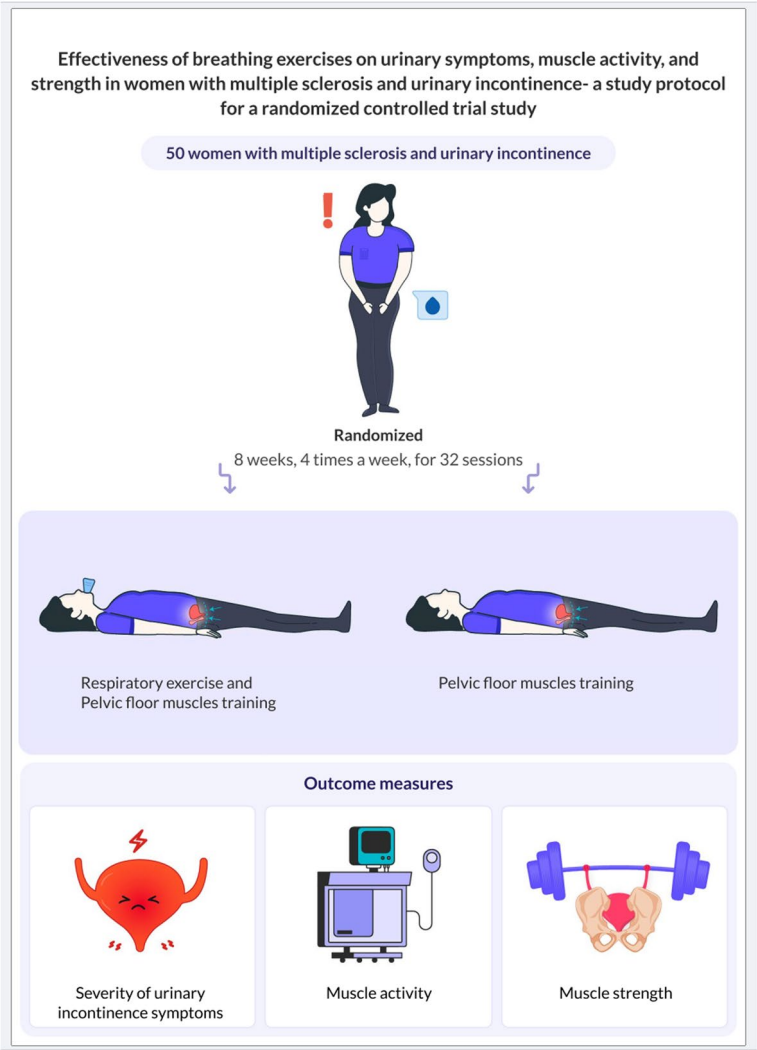
Graphical Abstract



Background and rationale {6a}

Multiple sclerosis (MS) is an autoimmune disease characterized by a chronic and progressive central nervous system disorder. As a global health concern, the prevalence of MS is on the rise worldwide, with a rate of 35.9 cases per 100,000 people [1]. Studies suggest that women are more susceptible than men with a rate of 2:1 [1, 2]. There are various symptoms associated with MS, depending on which nerve fibers are affected, such as numbness or weakness in the limbs, fatigue, loss of vision, and pelvic floor muscle (PFM) dysfunctions including urinary incontinence (UI) [3, 4].

The prevalence of UI, which is defined as a complaint of involuntary urine loss, is reported to be 19–80% among people with MS [5, 6]. It is more prevalent in women [4]. UI can cause significant physical and psychological distress for people with MS, resulting in low self-esteem, social withdrawal, and limitations in their activities. Even though UI is not life-threatening, it significantly impacts their quality of life (QOL) [7]. World Health Organization (WHO) has identified UI as a critical health concern, emphasizing its significant influence on patients' lives [8, 9].

Hyperreflexia, hyporeflexia, and dyssynergia of the detrusor-sphincter are the most common bladder dysfunctions among MS patients that can increase the risk of urinary incontinence [4, 10]. Management of these dysfunctions, and improving the overall urinary

system health, are crucial to treating MS. There are several approaches for UI management, including medications, hormone therapy, surgical methods, and pelvic floor muscle training (PFMT) [11]. Several oral drugs including anticholinergics and sphincter muscle relaxants are available to treat hyper-reflexic bladder and detrusor-sphincter dyssynergia. Antimuscarinic drugs can also be prescribed to relieve urinary urgency, improve continence, increase bladder capacity, and improve the QOL of patients suffering from bladder dysfunction [11]. However, it is important to consider the potential adverse effects of the pharmacotherapy method such as central nervous system depression [11–13], constipation, dizziness, urinary retention, and skin rash [14, 15]. Surgical methods may cause urinary incontinence relapse and have high costs. Furthermore, findings from the EMAS clinical guideline indicate that hormone therapy exacerbates urinary incontinence in postmenopausal women [16].

PFMT is a non-pharmacological and non-invasive method recommended for UI treatment, and there is an international consensus that should be the first-line treatment [17–19]. The regular and supervised use of PFMT increases PFM strength and endurance, lifts the bladder neck and the rectal ampulla, narrows the levator hiatus, shortens the PFM, and increases PFM cross-sectional area, thereby directly affecting factors that cause UI [20–22].

According to previous studies, MS affects pulmonary function even during the early stages [23, 24]. It was reported that 64% of people with MS and a low to medium disability had respiratory muscle weakness [25]. Also, a study showed that pulmonary function is associated with UI in people with MS [26]. The diaphragm, intercostal muscles, PFM, abdominal muscles, and myofascial connections with the thoracolumbar fascia work in synergy, thus, alteration in one of these muscle groups can affect the function of the other [22, 27, 28]. As a result, it has been suggested that nonoptimal breathing can result in a failed load transfer, resulting in UI [27, 29, 30].

Toprak et al. hypothesized that breathing exercises would improve pelvic floor function, indirectly via a facial connection between the diaphragm and the PFM, thereby reducing UI [31]. The results of a systematic review have shown that PFMT alternative exercises such as hypopressive, and diaphragmatic breathing exercises are ineffective for improving UI by themselves [22]. Of the studies included in this systematic review, only one randomized control trial (RCT) added breathing exercises to PFMT to treat UI and reported no additional effect over PFMT [32]. Previous research that assessed the impact of adding breathing exercises to PFMT on improving UI, included subjects without a history of neurological diseases. No study has evaluated the effects of these exercises on people with MS and UI.

Objectives {7}

Regarding respiratory muscle problems in people with MS and the relationship between respiratory muscles and PFM and UI, this protocol study aims to investigate the effect of PFMT and breathing exercises on PFM activity and strength, diaphragm activity, and urinary symptoms in women with MS and UI.

Trial design {8}

The current project is a two-parallel armed, superiority RCT, designed to investigate and compare the effects of PFMT and breathing exercises on PFM activity, diaphragm activity, and urinary symptoms in women with MS and UI. This RCT employs a one-to-one allocation method across two parallel groups. The intervention group receives PFMT with synchronous breathing exercises, while the control group is assigned to PFMT alone.

The primary outcome is the severity of UI symptoms, and the secondary outcomes are PFM activity, strength, and diaphragm activity, which will be evaluated before and after interventions. The trial process includes an initial assessment at baseline and a final assessment after the last treatment session. A physiotherapist will assess all outcome measures.

Methods: participants, interventions, and outcomes

Study setting {9}

Patients diagnosed with MS and UI will be referred by a neurologist from the Iran MS Society or contacted from the previous files available. Assessments and treatments will be conducted in the physiotherapy department laboratory of the Iran University of Medical Sciences in Tehran, Iran. A physiotherapist will provide all participants with rehabilitation treatments, including PFMT and breathing exercises, according to the trial's requirements and ethical guidelines.

Eligibility criteria {10}

The following are the inclusion criteria:

- Women aged 18–50 years, diagnosed with relapsing–remitting MS [33] and UI [34].
- An Expanded Disability Status Scale score (EDSS) of 0–3.5 [35].
- Mini-Mental State Examination (MMSE) score > 24 [36].

The following are the exclusion criteria:

- Other neurological disorders (in addition to relapsing–remitting MS), cardiovascular diseases, kidney diseases, rheumatoid arthritis, visceral diseases, and malignancy [37].
- MS clinical relapse within 90 days before enrollment.
- Pregnancy or being in the first 6 months post-partum.
- Surgical treatment for UI.
- Pelvic organ prolapses above grade 2.
- Receiving prior physiotherapy for UI within the past 30 days before enrollment.
- Body mass index (BMI) > 30 kg/m.^{2}
- Very severe UI as indicated by the International Consultation on Incontinence Questionnaire–Urinary Incontinence Short Form (ICIQ-UI SF) score of 19–21 [38].
- MS plaques in the medulla (due to the presence of respiratory control areas) based on magnetic resonance imaging (MRI) findings [39].
- Changes in UI medication dosage over the month before the study (if taking any) or using diuretic and/or anti-hypertensive medications [40].
- Declining to participate in the study.

Who will take informed consent? {26a}

The informed consent form will be developed based on the Ethics Committee of Iran University of Medical Sciences guidelines. At the baseline visit, a trial staff member will obtain written informed consent from eligible participants. The interventions and possible adverse effects will be fully explained to all eligible participants before they sign the consent form. For details regarding the consent form, please refer to Supplemental File 1.

Additional consent provisions for collection and use of participant data and biological specimens {26b}

Not applicable—It is not planned to collect or store biological specimens.

Interventions

Explanation for the choice of comparators {6b}

This trial consists of two arms:

(1) Intervention arm: PFMT plus breathing exercises.
(2) Control arm: PFMT.

In both groups, exercise sessions will be conducted over 8 weeks, 4 times a week, for 32 sessions under a physiotherapist's supervision. Each treatment session is estimated to take 15–20 min. A make-up session can be scheduled if a session is missed.

Intervention description {11a}

PFMT

A preliminary education session will be held for both groups to provide an overview of PFM function, the benefits of PFMT, and how to perform PFM exercises. Participants will be instructed to lift their PFM up and inward and squeeze the anal sphincter vagina and urethra, with maximal voluntary contraction for 8 to 10 s before relaxing the muscles [41, 42].

PFMT will be performed based on the protocol developed in previous studies [41–43]:

- Positions: supine lying, kneeling, sitting, standing, and walking (for each position, one series of exercises will be done)
- Repetitions: 8–10 sustained contractions with 8–10 s of holding contraction
- Muscle relaxation time after contraction: 8–10 s
- Four fast contractions are added after repetitions of sustained contractions
- Intensity: maximal voluntary contraction

In both groups, the PFMT protocol will be performed four times a week under the supervision of a physiotherapist. Participants in both groups will also be instructed to perform the protocol daily at home without supervision.

Breathing exercise

The intervention group will perform breathing exercises simultaneously with the PFMT program. Breathing exercises will be done using a specific Inspiratory Muscle Training (Power Breathe classic device; POWERbreathe International Ltd, England). This device strengthens the respiratory muscles by creating appropriate pressure (10–15 mmHg). In the first session, participants in the intervention group will be instructed to use the device under the supervision of a physiotherapist. During the intervention, respiratory resistance will be controlled to keep the participants' perceived force (based on Ratings of perceived exertion (RPE)) below 14 [44, 45]. The exercises will be performed in supine lying, kneeling, sitting, standing, and walking, simultaneously with the PFMT. Participants will be asked to perform 5 repetitions of breathing exercises in each position. Participants will be asked to perform breathing exercises in 2 sets of 25 repetitions ((5 repetitions in 5 positions) * 2 sets = 50 repetitions in each session). The breathing exercises in the intervention group will be performed for 8 weeks, 4 times a week, with a physiotherapist's supervision. The duration of rest periods between each exercise set is tailored to the individual's condition. Participants will be advised to stop exercising if they experience a lack of energy or

symptoms of fatigue, as these factors are particularly significant for people with MS. Also, participants will be trained to stop the intervention immediately if dizziness or dyspnea occurs during the intervention.

Criteria for discontinuing or modifying allocated interventions {11b}

There will be no changes to the medical recommendations of individuals, such as drug treatments. Participants can withdraw from the study for any reason without consequences.

Strategies to improve adherence to interventions {11c}

The rehabilitation protocol will be provided completely free of charge to enhance patients' motivation. Also, a physiotherapist will closely supervise participants with feedback on each treatment session.

Relevant concomitant care permitted or prohibited during the trial {11d}

The protocol allows medical consultations and the intake of pre-existing medications, except for modifications to the dosage of UI medications within the month before the study. All participants in the study will be required to refrain from participating in any other PFMT programs during the study period.

Provisions for post-trial care {30}

No harm is anticipated, and compensation is not applicable for trial participation or post-trial care.

Outcomes {12}

A physiotherapist will measure all outcomes at baseline and after the final treatment session (after 8 weeks).

Primary outcome

The primary outcome is the severity of UI symptoms, which will be assessed using the Persian version of the self-reported ICIQ-UI SF [46]. This questionnaire is developed to assess the severity of symptoms, determine the type of UI, and assess the impact on QOL. The score ranges between 0 and 21, with higher values representing greater UI severity. The UI severity could be divided into four categories: slight (1–5 points), moderate (6–12 points), severe (13–18 points), and very severe (19–21 points) [38].

Secondary outcomes

Secondary outcomes are PFM activity, diaphragm activity, and PFM strength.

PFM activity and diaphragm activity (excursion) will be assessed using an ultrasound unit (SONOACE R7; Samsung Medison, Korea) with a bandwidth frequency of 5–8 MHz (penetration frequency).

PFM activity

Bladder base displacement will be considered to measure PFM activity. Because the urethra, bladder neck, and bladder are anatomically located in the pelvic floor area, the PFM activity causes the bladder base to be displaced [47]. Before the test, participants were asked to consume 600 ml of water to ensure clear images of the bladder base. Participants will lie in crook-lying with about 60° hip and knee flexion and neutral lumbar spine position. Transabdominal ultrasound will be performed in motion mode (M-mode) with the convex probe inserted transversely on the midline of the suprapubic region. The inferior border of the bladder will be used as a reference (indicated by the end of the anechoic margin) and the start of the hyperechoic line representing the pelvic floor deep plane (indicated by the anechoic margin end and the hyperechoic line representing the pelvic floor deep plane) [48, 49]. Then, the participants will be asked to perform one maximum voluntary cough, and the vertical distance of bladder base displacement (the difference between the maximum displacement of the bladder base during maximum voluntary cough and the initial position of the bladder base with the PFM at rest) will be considered a PFM activity.

Diaphragm activity (excursion)

Participants will be positioned supine and diaphragm excursions will be recorded in the M-mode using a convex probe. The probe will be placed between the midclavicular and anterior axillary lines, with a medial, cranial, and dorsal orientation to facilitate visualization of the posterior third of the right diaphragm. In M-mode imaging, the diaphragm appears as an echogenic line and moves freely during inspiration and expiration. The diaphragmatic excursion will be determined by positioning calipers at the top and bottom of the diaphragmatic slope between the end of expiration during quiet breathing and the end of inspiration during coughing [50, 51]. All ultrasound measurements will be conducted three times, and the analysis will be based on the average values derived from these three repetitions.

PFM strength

PFM strength assessment will be performed by vaginal palpation and will be graded using the modified Oxford grading scale. First, the participant received instructions on how to perform a PFM contraction correctly. The following verbal command will be given to induce voluntary contractions of the PFM: "Squeeze the PFM as hard as you can". The scores will be as follows: 0 = no

contractions; 1: flicker; 2: weak; 3: moderate (with lift); 4: good (with lift); and 5: strong (with lift) [52].

Project timeline {13}

The timeline is presented in Fig. 1.

Sample size {14}

This study is the first to compare the effects of PFMT and breathing exercises against PFMT alone in people with MS. Due to the lack of previous studies, the Cohen standardized effect size for comparing means of two independent groups was used to calculate the sample size. The sample size was calculated using G*Power, version 3.1.9.2. Considering a power of 0.90, an α level of 0.05, Cohen's f of 0.25, and using an F-test family (ANOVA: Repeated measures, within-between interaction), the required sample size is 46. With an estimated attrition rate of 10%, fifty women with MS and UI will be included, with 25 participants assigned to each group. Another power calculation will be conducted at the end of the trial to ensure the adequacy of the sample size.

Recruitment {15}

Participants will be recruited from the Iran MS Society in Tehran, Iran. Additionally, recruitment efforts will extend to advertisements disseminated within MS social media groups identified by the Iran MS Society. A physiotherapist will assess patients for eligibility, evaluate outcome measures, and determine their final eligibility status. The treatment course will be outlined to the patients, and those who consent to participate in the study will be included.

Assignment of interventions: allocation

Sequence generation {16a}

Participants will be randomly allocated to one of the two arms (the experimental group or the control group) in a 1:1 ratio using the balanced block randomization method. The freely accessible online platform randomizer.org will be utilized for this purpose.

Concealment mechanism {16b}

Sealed envelopes are employed to store the randomization results for each participant securely. These envelopes are opened just before the intervention of the study investigator.

Implementation {16c}

The study investigator enrolls participants and accesses the website using a personal Identity Document (ID) and password, thereby being aware of the intervention assigned to each participant.

	Enrolment	Allocation	Intervention							
TIMEPOINT	$-t_1$	0	t_1= Week 1	t_2= Week 2	t_3= Week 3	t_4= Week 4	t_5= Week 5	t_6= Week 6	t_7= Week 7	t_8= Week 8
ENROLMENT:										
Eligibility screen	X									
Informed consent	X									
Allocation		X								
INTERVENTIONS:										
PFMT plus breathing exercises (Intervention group)			♦—	—	—	—	—	—	—	—♦
PFMT (Control group)			♦—	—	—	—	—	—	—	—♦
ASSESSMENTS:										
Severity of UI		X								X
PFM activity		X								X
Diaphragm excursion		X								X
PFM strength		X								X

Fig. 1 Schedule of enrollment, intervention, and assessments. PFM: Pelvic Floor, PFMT: Pelvic Floor Muscle Training, UI: Urinary Incontinence

Assignment of interventions: Blinding

Who will be blinded {17a}

Due to the nature of the intervention, enrolled participants will not be blinded to their study assignment, nor will the physiotherapist perform the interventions. The data analyzer will be blinded to the assignment of study arms.

Procedure for unblinding if needed {17b}

As the design is open-label, unblinding is not applicable.

Data collection and management

Plans for assessment and collection of outcomes {18a}

Outcomes are assessed at two time points: at baseline and following the treatment sessions, by a physiotherapist with sufficient experience and expertise in the assessment process. In addition, a staff member will collect demographic information in the first session. Detailed descriptions of outcomes and assessments are presented in the "Outcomes {12}" section.

Plans to promote participant retention and complete follow-up {18b}

At the first session, all potential participants are informed of the importance of attending all treatment sessions until the end of the trial to ensure that only those capable of committing to the entire protocol are enrolled. The importance of adherence to the treatment will also be emphasized. Data regarding patients who withdraw from a study are counted as dropouts.

Data management {19}

Data will be collected on paper and stored in folders in an office in the physiotherapy department laboratory of Iran University of Medical Sciences. Participants will be identified by their inclusion number, the initial letter of their family, and their given name. Data will be entered twice into Excel software by the research staff.

Confidentiality {27}

Participants identifying data (full name, date of birth, written informed consent, contact details), their medical history, and identification code, will be recorded in a document maintained by the corresponding investigator. Access to the document key is restricted to the research team. Participants' private data will not be disclosed in the publication.

Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in this trial/future use {33}

Not applicable, as no biological samples will be collected during this trial.

Statistical methods

Statistical methods for primary and secondary outcomes {20a}

The calculation and reporting of data summary will follow the criteria of the Consolidated Standards of Reporting Trials (CONSORT) [53]. Throughout the trial, various factors may contribute to patient dropout and loss; therefore, an intention-to-treat analysis will be implemented to guarantee the inclusion of all randomized participants. Participants will be analyzed according to their assigned groups, irrespective of their adherence to the intervention protocol. Multiple imputation will be used if this method proves impractical.

Data analysis will be conducted using SPSS version 24. The data's normality will be evaluated using a combination of the Shapiro–Wilk test, histograms, and assessment of skewness and kurtosis. Continuous variables (e.g., age, BMI, ultrasound measurement values, ICIQ-UI SF, and modified Oxford grading scale scores) will be summarized as mean ± standard deviation for normally distributed data and median ± interquartile range for non-normally distributed data. If the trial results satisfy the assumptions of normality, a two-factor, two-level repeated measures analysis of variance (group*time) is employed; otherwise, Friedman's test is implemented. Effect sizes will be reported with 95% confidence intervals, and a two-sided P-value < 0.05 will be considered significant.

Interim analyses {21b}

No interim analyses will be performed, considering that the designed interventions are non-invasive, cost-free, and not classified as expensive.

Methods for additional analyses (e.g., subgroup analyses) {20b}

No subgroup analyses are planned.

Methods in analysis to handle protocol non-adherence and any statistical methods to handle missing data {20c}

An intention-to-treat analysis will assess the primary and secondary outcomes, and missing data will be accounted for using multiple imputation.

Plans to give access to the full protocol, participant-level data, and statistical code {31c}

The corresponding author can be contacted for reasonable access to the full protocol, participant-level dataset, and statistical code.

Oversight and monitoring

Composition of the coordinating center and trial steering committee {5d}

The coordinating center for this study is the specialized neurologic physiotherapy rehabilitation center within the School of Rehabilitation Sciences. The center's administrative secretary is responsible for daily patient contact and appointment scheduling.

The members of the trial steering committee include the corresponding investigator, the physiotherapist (PhD candidate), other authors of this study (MD, IE, HM, LAM), and the statistician, who are all affiliated with the Department of Physiotherapy of the Iran University of Medical Sciences and University of Social Welfare and Rehabilitation Sciences. The corresponding investigator will be responsible for the study and its management. Steering committee members will provide organizational support and manage the trial day-to-day. There will be meetings every 2 weeks where all authors will discuss the study's progress and strategies to improve the trial management.

Composition of the data monitoring committee, its role and reporting structure {21a}

It is a short-term trial with minimal known risks, so there will be no data monitoring committee.

Adverse event reporting and harms {22}

Although this study involves minimal known risks, participants must promptly inform the physiotherapist responsible for interventions if any adverse or serious events occur. Participants may experience tiredness, dizziness, or fatigue following the protocol; however, the literature does not report any serious side effects associated with this type of intervention. The corresponding investigator will report any harm to the institution's research ethics committee.

Frequency and plans for auditing trial conduct {23}

The Trial Steering Committee audits the trial and meets every 2 weeks. The Steering Committee reviews the recruitment table, informed consent, adherence to the study protocol, and any reported adverse events.

Plans for communicating important protocol amendments to relevant parties (e.g., trial participants, ethical committees) {25}

Any modifications to the study protocol must receive approval from the Ethical Committee of Iran University of Medical Sciences and modified in the Iranian Registry of Clinical Trials.

Dissemination plans {31a}

The trial results will be published in relevant journals and presented at physiotherapy, neurology, and urology conferences.

Discussion

The present study will investigate the effect of breathing exercises and PFMT compared to PFMT alone on PFM activity and strength, diaphragm activity, and urinary symptoms in women with MS and UI.

UI is a common complication among people with MS [9]. Conservative interventions, which encompass treatments that do not involve pharmacological or surgical approaches, are regarded as the primary method for managing UI symptoms in the general population [54, 55]. However, clinical practice guidelines consequently advocate pharmacological treatments for UI management in neurological patients, due to the limited number of studies addressing conservative interventions [56, 57]. Nevertheless, patient concerns regarding adverse effects may result in non-adherence to treatment [58].

PFMT is considered a conservative technique with Level A evidence for UI management [18, 19]. The rationale for incorporating breathing exercises into the PFMT program is based on the hypothesis that there is a fascial connection between the diaphragm and the PFMs [22, 32]. The diaphragm constitutes the superior boundary of the abdominopelvic cavity, while the PFMs serve as its inferior boundary. These two structures, which are shaped like opposing concave and convex domes, consist of striated muscle tissue interposed between layers of fascia [59]. It is suggested that non-optimal breathing strategies result in ineffective load transfer, potentially contributing to the development of incontinence and/ or respiratory disorders [29]. Given the association between respiratory muscle strength, pulmonary function, and urinary function in patients with MS [26], it is hypothesized that incorporating breathing exercises alongside PFM exercises would yield more improvement in patient's symptoms compared to PFMT alone.

Some potential implications result from the findings of this study. First, the findings of this RCT will contribute to establishing an evidence base for the use and effectiveness of breathing exercises in improving urinary symptoms, PFM activity, strength, and diaphragm activity in women with MS and UI.

Second, antimuscarinics and anticholinergics which are frequently prescribed for UI management [11], are often effective in the short-term, and long-term outcomes tend to be suboptimal due to a range of side effects and issues

related to medication adherence [60]. An alternative to pharmacological treatment for UI might be conservative treatment such as exercise therapy. These conservative approaches are generally safe, and more cost-effective [61]. The exercises described in this study are simple and have a low incidence of adverse effects, which increases their acceptability among women with MS and UI.

Third, if PFMT combined with breathing exercises is found to be more effective than PFMT alone, this trial could have a beneficial impact on continence care and potentially reduce the reliance on more invasive UI interventions, such as medication and surgery, for women with MS and UI.

Finally, a notable strength of this study is using ultrasound as a valid and reliable instrument to measure PFM and diaphragm activity [62–64]. Electromyographic measurements are commonly utilized to assess muscle activity. However, accurate evaluation of deep muscle activity, including that of the PFMs, necessitates the insertion of fine-wire electrodes into the muscles [65]. This procedure often causes discomfort for subjects, particularly during movement [66]. In recent years, several studies have used ultrasound imaging to measure changes in muscle thickness to assess muscle activity indirectly [63, 67, 68]. This method is convenient since it does not require exposing intimate parts of the body and is fast, noninvasive, and easy to use in the clinical setting.

The results of this RCT will provide evidence for the rehabilitation management of women with MS and UI. If the program proves effective, the findings will provide physiotherapists, clinical decision-makers, and administrative stakeholders with a solid evidence base for making treatment decisions for women with MS and UI. Also, the findings will have implications for the organization and administration of continence care services for women with MS.

Limitations

The current study has some limitations. In this study, only women with relapsing–remitting MS and UI will be recruited. Also, those with an EDSS score greater than 3.5 and individuals with a MMSE score lower than 24 will be excluded, which limits the generalizability of findings. More research could be done to explore the effects of breathing exercises in male populations, individuals with other MS types, and subjects with higher levels of disability and cognitive impairments. Moreover, due to the effects of menopause on the PFMs [69], women between 18 and 50 years of age will be included. Consequently, the findings derived from this study can only be generalized to female patients within the same age range. Future studies could consider other age groups to enhance the generalizability of the findings. Finally, due to the nature of the interventions, blinding investigators and participants to group allocations is not feasible, which may introduce bias in the study results.

Trial status

This current protocol represents protocol version 1.0. Recruitment for the trial commenced on May 21, 2024, and is anticipated to be completed in November 2025.

Abbreviations

BMI	Body mass index
EDSS	Expanded Disability Status Scale score
ICIQ-UI SF	International Consultation on Incontinence Questionnaire–Urinary Incontinence Short Form
ID	Identity document
M-mode	Motion mode
MMSE	Mini-Mental State Examination
MRI	Magnetic resonance imaging
MS	Multiple sclerosis
PFM	Pelvic floor muscle
PFMT	Pelvic floor muscle training
QOL	Quality of life
RCT	Randomized controlled trial
RPE	Ratings of perceived exertion
UI	Urinary incontinence
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13063-025-08721-0.

Supplementary Material 1.

Acknowledgements

Not applicable.

Authors' contributions

Concept and design: SSA, MD, IET, HM, and LAM. Data collection: AN. Data analysis and interpretation: SSA, MD. Manuscript preparation: AN, SSA, MD, IET, HM, and LAM. All authors read and approved the final manuscript.

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All authors declare that they did not receive any funding for this protocol.

Data availability

The final trial dataset will be available upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate

The Human Research Ethics Committee of the Iran University of Medical Sciences (IR.IUMS.REC.1403.027) reviewed and approved this study. All participants signed an informed consent form.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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