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Effect of resistive exercise on insomnia and sleep quality in postmenopausal women: a randomized controlled trial

Esraa F. Massoud[1], Abeer M. ElDeeb[2], Sameh H. Samir[3] and Mai M. A. Shehata[2*]

Abstract

Background Sleep disorders are common in postmenopausal women and are linked to poor physical and mental health, which affect quality of life. Therefore, this study aimed to investigate the effect of resistive exercise on insomnia and sleep quality in postmenopausal women. Fifty-six postmenopausal women suffering from sleep disturbance and insomnia participated in this study. Their age ranged from 50–65 years, and their body mass index (BMI) was 25–29.5 kg/m^2. They were randomly distributed into two groups of an equal number. Control group received self-care and lifestyle advice, while study group received the same advice in addition to resistive exercises for 20–30 min per session for 4 weeks. Plasma estradiol levels were assessed, as well as the Pittsburgh Sleep Quality Index and Insomnia Severity Index, which were used to evaluate sleep quality and insomnia pre- and post-treatment.

Results Control group revealed a significant decrease ($p < 0.001$) in Pittsburgh sleep quality index and insomnia severity index and a non-significant difference ($p = 0.059$) in plasma estradiol level post-treatment. However, study group showed a significant decrease ($p < 0.001$) in Pittsburgh sleep quality index and insomnia severity index, as well as a significant increase ($p = 0.001$) in plasma estradiol level. Compared to control group, study group showed a significant decrease ($p = 0.000$) in insomnia and sleep quality, as well as a non-significant difference ($p = 0.179$) in estradiol level post-treatment. Also, there was a negative correlation between plasma estradiol level and insomnia severity score in the study group post-treatment.

Conclusion Resistive exercise is an effective modality for postmenopausal women suffering from sleep disorders as it improves insomnia, sleep quality, which in turn affects the quality of life. Increased estradiol level is an important factor that helps improve insomnia in postmenopausal women.

Keywords Resistive exercise, Insomnia, Sleep quality, Post menopause

Background

Insomnia is one of the most common sleep disturbances in postmenopausal women, with a prevalence of 40–60% [1, 2]. Insomnia is described as a problem with sleep initiation, maintenance, duration, or quality that impairs daily functioning despite appropriate sleep opportunities and circumstances [3].

Symptoms of insomnia include problems with sleeping at night, waking up in the middle of the night, and finding trouble falling back asleep, or waking up too early in the morning. These symptoms have negative impacts on postmenopausal women at home and at work as

*Correspondence:
Mai M. A. Shehata
mai_shehata@cu.edu.eg
[1] Department of Physical Therapy, El Hussein University Hospital, Cairo, Egypt
[2] Department of Physical Therapy for Women's Health, Faculty of Physical Therapy, Cairo University, Giza, Egypt
[3] Department of Obstetrics and Gynecology, National Research Center, Giza, Egypt

they result in exhaustion, reduced awareness, and mood swings such as irritability and dysphoria [3, 4].

The specific causes of insomnia are still unknown. However, various biosocial, psychological, genetic, and behavioral risk factors have been proposed [5]. Also, menopausal insomnia has been linked to estrogen deficiency that results in decreasing spinal cord density and forming new synapses in the brain. This, in turn, produces a drop in cholinergic and serotonergic hormone levels, which have a direct impact on cognitive ability [6].

Unseasonal and ineffective treatments of insomnia could constitute a risk factor for physical and mental illness, accidents, and even mortality [7]. Currently, the treatments for insomnia include pharmacological and non-pharmacological measures. Although widely used, pharmacotherapy is recommended for short-term use only due to potential risks concerning hazardous side effects. These effects include fatigue, mental impairment, tolerance, and dependency with long-term use [8].

On the other hand, physiotherapy exercises are recommended as a non-pharmaceutical, safe, and inexpensive intervention to improve sleep [3]. In previous studies, resistive exercises showed improvement in chronic insomnia and sleep quality [3, 9, 10]. Also, Kovacevic et al. reported that resistive exercises decreased anxiety and depression and improved sleep in young and elderly men and women [11].

To the authors' knowledge, there are only a few studies showed the effect of resistive exercises on postmenopausal women with sleep disorders [3], and no study has investigated the effect of resistive exercises on Egyptian postmenopausal women with sleep disorders. Also, although of the linking between estrogen deficiency and sleep disorders [6], no studies have showed the effect of resistive exercises on estradiol level and its relationship to insomnia and sleep quality in postmenopausal women. So, this study aimed to determine the effect of resistive exercise on estradiol level, insomnia, and sleep quality, as well as their relationships in postmenopausal women with sleep disorders. The hypothesis of the study was that resistive exercise would be effective on insomnia, sleep quality, and estradiol levels in postmenopausal women.

Methods

Study design

It was a randomized controlled trial.

Sample size calculation

The sample size was calculated based on pre- and post-treatment sleep quality score measured by the Pittsburgh Sleep Quality Scale [12]. A sample size of 28 per group was sufficient to produce a medium effect size of 0.77 at a power equal to 80% and an alpha level of 0.05 (two-tailed). The sample size was calculated using G*Power software (version 3.0.10).

Participants

Fifty-six sedentary postmenopausal women participated in this study. They were diagnosed with insomnia, with a total score of 5 or greater on the Pittsburgh sleep quality index and a score greater than 8 on the insomnia severity index [13, 14]. Their age ranged from 50 to 65 years, and their BMI was 25–29.5 kg/m^2.

Postmenopausal women were excluded if they were smokers, had thyroid problems, osteoporosis, or any medical problems that led to sleep disturbance or insomnia, such as cancer, Parkinson's disease, depression, or obstructive sleep apnea. Also, they were excluded if they were on hormone replacement therapy or taking drugs that caused sleep disorders as a side effect.

Enrollment

Sixty-six participants were enrolled to join the study. Ten of them were excluded because they didn't meet the inclusion criteria: three women refused to sign the consent form, one had thyroid problems, one had osteoporosis, and the other five refused to participate in the study for personal reasons. Consequently, fifty-six of the sixty-six postmenopausal women met the requirements for incorporation. They were randomly assigned into two equal groups (control and study) using a computer-based randomization program by an independent researcher. The control group received lifestyle advice, while the study group received the same advice in addition to resistive exercises. No dropping out of subjects from the study was reported after randomization (Fig. 1).

All postmenopausal women were informed about the study purpose and benefits, the right to refuse or withdraw at any time, and the confidentiality of any obtained data. They were given a full explanation of the study assessment and treatment procedures; a consent form had been signed by each participant at the start of the study.

Outcome measures

Plasma estradiol level measurement

A biochemical examination of estradiol level was done using the COBAS method with a HPLC tool. All blood samples were taken from each patient in both control and study groups at 9–11 a.m. following overnight fasting and rest to avoid diurnal variation in plasma estradiol levels. After a 12-h fast, a 3 mL blood sample was drawn from the brachial vein and placed in EDTA tubes with heparin. It had been kept at room temperature (27 °C) for 1 h before being chilled to -8 °C [15]. The reference range of

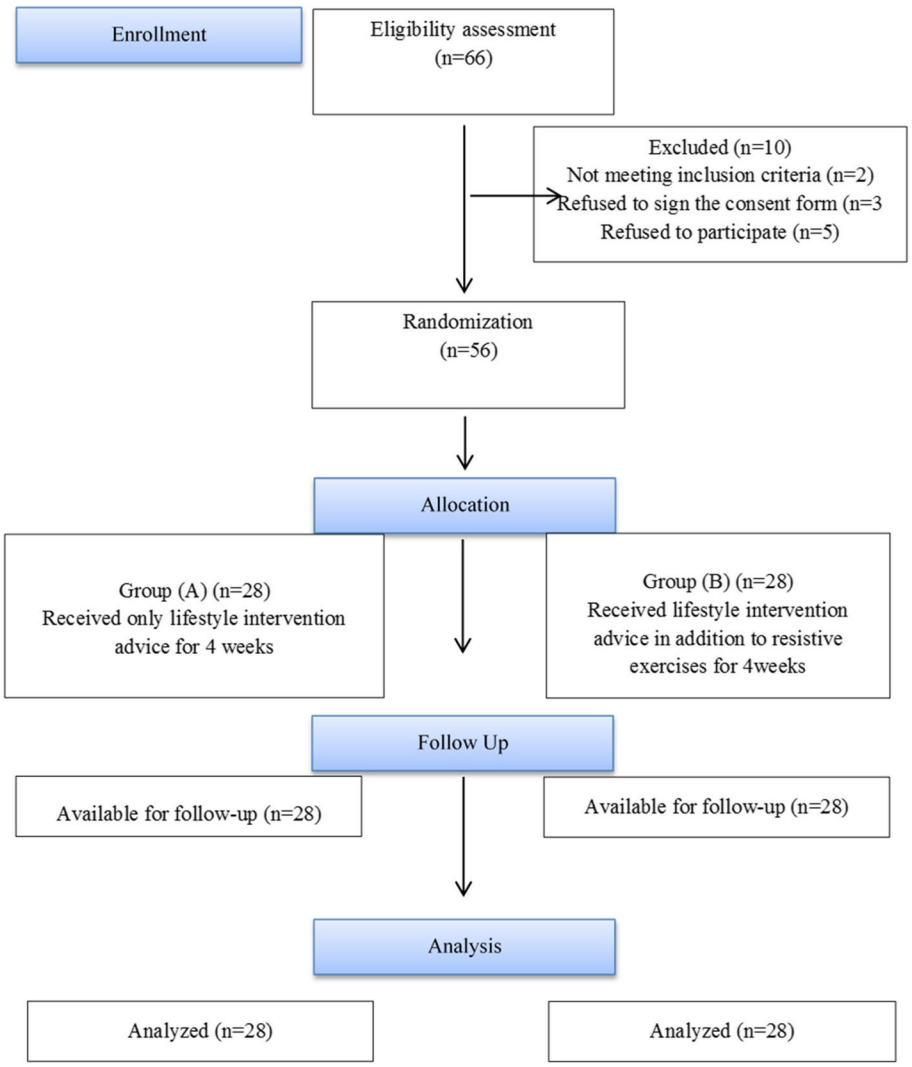

Fig. 1 Flow diagram of the study

morning estradiol (from 9 a.m. to noon) for normal menopause is 5–54.7 pg/mL [16].

Sleep quality assessment

The Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep quality for each patient in both the control and study groups. It is a valid and reliable tool used to diagnose sleep disturbances and is currently the most common measure of sleep quality. It assesses different aspects of sleep quality in the past month [17]. It is made up of seven parts that combine to create a total of 19 questions, including subjective sleep quality, sleep latency, sleep length, normal sleep efficiency, sleep interruptions, usage of sleep medicine, and daytime dysfunction. Each question is graded from zero to three. Zero indicates good sleep quality, and 3 indicates poor sleep quality. The seven component scores are also summed together to produce a global Pittsburgh Sleep Quality Index score ranging from 0 to 21. Higher scores indicate poorer sleep quality, with a value of 5 indicating patients with sleep disturbance [15, 18].

Insomnia assessment

Insomnia severity index (ISI) was used to assess insomnia for each patient in both control and study groups. It is a brief, reliable, and valid instrument for measuring patients' perception of insomnia in general practice and is sensitive to treatment response [19, 20]. It is a seven-item self-report questionnaire about insomnia symptoms in the last two weeks. The first three items address issues with falling asleep, staying asleep, and waking up early in the morning. The last four address sleep dissatisfaction,

sleep-related impairments in daily performance, noticeability of the condition, and insomnia-related misery. On a 5-point Likert scale, patients rate each item from "none" to "extremely severe" for items 1 to 3, " very satisfied "to "very dissatisfied "for item 4, and "not at all" to "very much" for items 5 to 7. The overall score, which ranges from 0 to 28, is calculated by adding the seven items together, with higher values indicating more severe insomnia [21].

Each patient in both the control and study groups was carefully instructed about the PSQI and ISI, and appropriate time was given to fulfil them. All evaluative measures were done at the start and after the end of the study course.

Interventions

Lifestyle intervention advice

Each patient in both groups was instructed to follow lifestyle intervention advice. The advice included avoiding eating or drinking before going to bed [4], and increasing consumption of a whole diet rich in fruit, vegetables, carbohydrates, and legumes [22, 23]. Moreover, advice included preparing for sleep by mentally calming down at night and avoiding afternoon naps, making sure the bedroom was comfortable, warm, calm, and dark [24], avoiding sleeping near a light source [25], going to bed when feeling tired, getting up when unable to sleep, and rising at the same time every morning [26].

Resistive exercises program

The program consisted of a warm-up phase, an active phase, and a cool-down phase. A warm-up phase took around 10 min and involved spotting at a slow pace. A cool-down phase included gently active stretching each of the main muscle groups for 10 min to restore their length, which could help bring their mind and body back to a resting state. The active phase consisted of closed-chain exercises such as modified push-ups, forward, backward, and sideways lunges, calf lifts, bridging, marching, and chair sit-ups.

In modified push-ups exercise, each patient was in a prone kneeling position and was asked to tuck her toes under, tighten abdominals, and bend elbows to lower her chest towards the floor, keeping her eyes looking at her fingertips, and raise the chest back up to the starting position. In forward and backward lunges, she was instructed to step from a standing position into a forward lunge, push into and come to stand, and immediately step into a reverse lunge. In sideways lunges, she was asked to take a wide step sideways with one leg, bending her knee as she stepped outward with her hips back, pushing off the foot to return to the starting position, and repeating for the other leg. In calf raises, she was asked to slowly raise her heels from a standing position, keeping her knees extended, and lower her heels back to the ground. In bridging, she was asked to raise the pelvis upward from crock lying and return to the starting position. In marching, she marched in place, lifting her knees high towards the ceiling. In chair sit-ups, she was in crock lying position and was asked to lift her legs, so her knees were directly above her hips, making a 90-degree angle. Then, she was asked to slowly curl her knees towards her chest and return to the starting position. At each exercise, each patient held the position for a few seconds, which graduated from five seconds in the first two weeks to ten seconds in the 3rd and 4th weeks.

Exercise duration was gradually increased from 20 min in the first two weeks to 30 min in the third and fourth weeks. Each exercise was repeated 10–15 times and performed for 1 set in the 1st week, 2 sets in the 2nd week, and 3 sets in the 3rd and 4th weeks, with a rest interval of 3–5 min. The resistive exercise program was described according to Karandikar-Agashe and Agrawal, 2020 [3].

Statistical analysis

Statistical analysis was conducted using SPSS for Windows, version 25 (IBM, Chicago, Illinois, USA). Initially, the Shapiro–Wilk test was used to examine whether the data were normally distributed. Normally distributed data were expressed as mean ± standard deviation (SD), while not-normally distributed data were expressed as median (interquartile range; 25th percentile–75th percentile). Independent sample t-test and Mann–Whitney U-test were used to compare between groups for normally distributed and not-normally distributed data, respectively. Also, the Wilcoxon signed-rank test was used to compare within groups for not-normally distributed data. Finally, Spearman's rank correlation coefficient (r) was used to study the correlation between plasma estradiol level and both insomnia and sleep quality post-treatment in both groups. A p-value < 0.05 was considered statistically significant.

Results

Independent sample t-test revealed no significant difference ($p > 0.05$) between both groups in baseline characteristics, including age, BMI, and menopausal years, as shown in Table 1.

Wilcoxon signed-rank test showed a significant decrease ($p < 0.001$) in Pittsburgh sleep quality score of the control and study groups with a percentage of change equal to 33.33% and 45.45% respectively. It also, showed a significant decrease ($p < 0.001$) in insomnia severity score of the control and study groups with a percentage of change equal to 7.65% and 37.50% respectively. In addition, it showed non-significant difference

Table 1 Baseline characteristics of the postmenopausal women

Variables	Control group (*N* = 28)	Study group (*N* = 28)	t-value	*P*-value
Age (years)	55.64 ± 5.06	57.39 ± 5.04	-1.296	0.201 NS
BMI (kg/m²)	27.50 ± 1.46	27.64 ± 1.40	-0.355	0.724 NS
Menopausal years	5.43 ± 2.52	5.61 ± 2.48	-0.297	0.766 NS

Data are expressed as mean ± SD

BMI Body mass index, *NS* Non-significant

P-value < 0.05 considered significant

Table 3 Correlation between plasma estradiol level and Pittsburgh sleep quality and insomnia severity score post-treatment in control and study groups

	Control group		Study group	
	R	*P*-value	R	*P*-value
Pittsburgh sleep quality	0.101	0.608 NS	0.125	0.528 NS
Insomnia severity score	-0.012	0.950 NS	-0.381	0.045 *

NS non-significant

* Significant; $p < 0.05$ considered significant

($p = 0.059$) and a significant increase ($p = 0.001$) in the estradiol level of the control and study groups with a percentage of change equal to 0% and 4.50% respectively.

Mann–Whitney U-test showed a significant decrease in Pittsburgh sleep quality score ($p = 0.001$). and insomnia severity score ($p = 0.021$), and non-significant difference in estradiol level ($p = 0.179$) between the control and study groups post-treatment as shown in Table 2.

Table 3 showed correlation between improvement of plasma estradiol level and Pittsburgh sleep quality and Insomnia severity post-intervention in both groups. In control group, there was no significant correlation between plasma estradiol level and Pittsburgh sleep quality ($p = 0.608$), as well as between plasma estradiol level and insomnia severity score post-treatment ($r = -0.012$ and $p = 0.950$) post-treatment.

In study group, there was no significant correlation between plasma estradiol level and Pittsburgh sleep quality post-treatment ($p = 0.528$). In contrast, a negative correlation was observed between plasma estradiol level and insomnia severity score post-treatment ($r = -0.381$ and ($p = 0.045$).

Discussion

Insomnia is a common sleep disturbance that usually occurs during menopause and is linked to menopause-specific characteristics, including psychosocial variables [27]. Sleep disturbances can cause daytime fatigue,

Table 2 Comparison of Pittsburgh sleep quality, insomnia severity score, and plasma estradiol level pre- and post-treatment in control and study groups

	(Control group) (*N* = 28)	(Study group) (*N* = 28)	Z	*P* –value
Pittsburgh sleep quality score (Median (IQR)				
Pre-treatment	12.00 (10.25–14.00)	11.00 (10.00–13.75)	0.746 NS	-0.324 b
Post-treatment	8.00(7.00–9.00)	6.00 (5.00–7.00)	0.001*	-3.396 b
P value	< 0.001*	< 0.001*		
Z-Score	-4.666 a	-4.651 a		
Insomnia severity score				
Pre-treatment	17.00 (15.25–22.00)	20.00 (16.00–22.75)	0.489 NS	-0.691 b
Post-treatment	14.00 (12.25–19.00)	12.50 (10.00–16.00)	0.021*	-2.315 b
P value	< 0.001*	< 0.001*		
Z-Score	-4.678 a	-4.646 a		
Plasma Estradiol level (pg/ml)				
Pre-treatment	8.95 (6.55–10.88)	7.15 (5.35–9.90)	-1.600b	0.110 NS
Post-treatment	8.95 (6.55–10.95)	7.50 (5.40–9.98)	-1.345b	0.179 NS
P value	0.059 NS	0.001*		
Z-Score	-1.890a	-3.436a		

Data presented as Median (IQR)

NS Non-significant

a Mann–Whitney U-test

b Wilcoxon's sign rank test

* Significant at $p < 0.05$

exhaustion, impaired concentration, attention, and memory, anxiety, depression, and behavioral problems such as impulsivity and aggression, therefore affecting quality of life [26, 28]. So, this study aimed to investigate the effect of resistive exercises on insomnia and sleep quality in postmenopausal women. Findings revealed that postmenopausal women received resistive exercise showed more improvement in insomnia, sleep quality and estradiol level than their controls.

In line with our findings, a supervised resistive exercise program showed significant improvements in sleep quality in elderly persons aged over 60 with depression [29, 30], and postmenopausal women [3] as well as in women with fibromyalgia [31] and generalized anxiety disorder [32]. It also improved sleep, mood, and quality of life in chronic insomnia patients in their 30 s and 50 s [9, 33].

The study findings can be supported by previous studies, which have reported that exercise can raise core temperature, serotonin release, or metabolic rate in a manner that promote sleep quality. Exercise is considered as a thermogenic stimulus to improve sleep as increasing temperature is linked to the regulation of sleep by the anterior hypothalamus [34]. Exercise may reduce resting plasma concentrations of pro-inflammatory cytokines, which are linked to sleep disruption and fragmentation [35]. Also, it may increase anti-inflammatory cytokines, consequently improving the quality of sleep [33]. In addition, exercise can trigger body's sleep cycle, which is regulated by the peripheral clock. The circadian clock controls melatonin production and release, which simultaneously regulates sleep and brings the body's temperature down [3]. Moreover, exercise stimulates the release of growth hormone and growth hormone-releasing hormone, which in turn results in improving sleep quality [36]. Furthermore, exercise can distract from intrusive thoughts, and yield positive thoughts improving sleep quality [37].

The present study showed improvement of the estradiol level in postmenopausal women receiving resistive exercise more than their controls. This finding was in line with previous studies that reported the same result [38–40]. In contrast, Yoon et al., revealed that resistive exercise is not effective in inducing changes in the estrogen secretion in obese postmenopausal women. This difference may be due to different inclusion criteria and duration of the exercise program as our study was on overweight postmenopausal women not obese [41]. The exact mechanism by which resistive exercise increases estradiol levels is still unknown. Son et al. suggested that increased estradiol levels may be related to decreasing fat mass and increasing muscle mass that are associated with resistive exercise [42]. However, they are not investigated in present study and further studies are warranted to prove this suggestion in postmenopausal women with sleep disorders.

In addition, results of this study revealed a negative correlation between estradiol level and insomnia severity index post-treatment in women receiving resistive exercise. This finding was supported by Baker et al., who reported that insomnia was associated with menopausal stage and changes in follicle-stimulating hormone and estradiol [43]. Also, low dose oral estradiol found to have a modestly better effect on quality of sleep and insomnia symptoms in postmenopausal women when compared to placebo [18]. Moreover, increased estradiol improved sleep during the menopausal transition [44]. As well, a previous study showed a negative relation between estradiol levels and movement arousal during sleep in postmenopausal women [45]. This relationship was explained by the presence of estrogen receptors in various brain areas, including those associated with sleep regulation [46].

Our results showed that lifestyle modification advice had a significant positive effect on sleep quality and insomnia severity with no significant effect on estradiol level. Previous studies showed the same findings; they reported that lifestyle modification and behavioral treatment improved sleep quality [47] and insomnia [48, 49] as participating in educational programs dramatically lowered sleep and stress issues. Also, previous studies suggested avoiding sleeping next to a light source since it might suppress melatonin and interfere with sleep [25, 50].

To avoid the effect of exercise timing on sleep [51], all exercise sessions in the current study were scheduled in the morning. That is because morning exercise is associated with longer sleep duration, greater improvement in sleep quality, and more slow-wave sleep than evening exercise. Also, program used in the present study was effective, easy, and safe to apply with no risk to postmenopausal women.

Limitations

The scope of this study was limited to evaluating insomnia using a questionnaire that was given to participants in their second language. However, to ensure accurate replies to the questionnaire items, comprehensive instructions were provided to every participant. Also, the underlying mechanisms underlying the improvement in sleep quality and insomnia needs further investigations. Therefore, more research is required to determine the effect of resistive exercise on serotonin level and growth hormones in postmenopausal women with sleep disturbance. Additionally, level of physical fitness and nutritional components of postmenopausal women were not evaluated in this study. So that, further research is

required to evaluate the effect of both exercise and nutrition on chronic insomnia in postmenopausal women. Finally, research with a longer duration and follow-up is required to fully understand the long-term impact of resistive exercise on insomnia in postmenopausal women.

Conclusion

Resistive exercise is recommended for postmenopausal women with sleep disturbance to improve estradiol level, insomnia, and sleep quality. So that postmenopausal women should be educated about how to change their lifestyle to improve and optimize their sleep quality.

Abbreviations

BMI	Body Mass Index
PSQI	Pittsburgh Sleep Quality Index
ISI	Insomnia severity index
Pg./ml	Pico grams per milliliter

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Not applicable.

Authors' contributions

EM, EA, MS made the concept and design of the research. EM, EA, MS contributed to literature search, clinical part, data acquisition, data analysis, statistical analysis, manuscript preparation, editing, and review. EA, MS, SS made the critical revision of the manuscript. All authors have read and approved the final manuscript.

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Availability of data and materials

Available on reasonable request.

Declarations

Ethics approval and consent to participate

It was approved by the Ethical Committee at the Faculty of Physical Therapy, Cairo University (No: P.T.REC/012/003873) and registered in the Clinical Trials Registry (Registry ID: NCT05556317). The study design, assignment, and intervention followed the CONSORT statement. A written consent form was signed by each participant after testing their eligibility for the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interest.

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