

# Accepted Manuscript

Original article

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DOI: <https://doi.org/10.5114/areh.2024.136292>

To appear in: Advances in Rehabilitation

Received date: 29 January 2024

Accepted date:

Please cite this article as: Elgayar SL, Elgendy S, Youssef TM. Comparative Effects of Aerobic, Resistance, and Combined exercises on Depression and Sleep Quality in Women with Controlled Hypothyroidism. A Randomized Controlled Trial. Adv Rehab. (2024), <https://doi.org/10.5114/areh.2024.136292>

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# Comparative Effects of Aerobic, Resistance, and Combined exercises on Depression and Sleep Quality in Women with Controlled Hypothyroidism. A Randomized Controlled Trial

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## Abstract

### Introduction

Exercise has recently gained interest in managing hypothyroidism associated impairments. So, the objective of this research was to assess and contrast the effects of aerobic, resistance and a combination of both exercise regimens on depressive symptoms and sleep quality in women with managed hypothyroidism.

### Material and methods

A total of sixty women, ranging in age from 35 to 45, with controlled hypothyroidism associated with depression, and sleep problems were randomly assigned to four equally sized groups: aerobic exercise (AE), resistance exercise (RE), combined AE/RE, and a control group. They engaged in low to moderate intensity workouts, three times each week, during a span of 12 weeks, while also undergoing levothyroxine therapy. Outcome measures included depression assessed through Beck depression inventory II (BDI-II) and the sleep quality evaluated using Pittsburgh sleep quality index (PSQI).

### Results

The BDI-II and PSQI showed significant improvements in all exercise groups in comparison to the first measurements and the non-exercising group ( $p < 0.05$ ). Significantly, The AE/RE group demonstrated greater improvements in both outcomes as compared with the AE and RE groupings ( $p < 0.05$ ).

### Conclusions

In well-managed hypothyroid women, AE, RE, and combined AE/RE can improve depression and sleep quality. However, the combined AE/RE can induce the greatest improvements in both measures.

**Keywords:** Depression, Hypothyroidism, Sleep quality

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## **Introduction**

Hypothyroidism, characterized by insufficient production or impaired action of thyroid hormones, encompasses a spectrum of presentations. While some individuals remain asymptomatic, severe cases can culminate in life-threatening multi-organ dysfunction, occasionally progressing to a comatose state known as myxedema coma [1]. In instances with hypothyroidism, there is usually an increased level of thyroid-stimulating hormone (TSH) associated with a decrease in measures of free thyroxine (FT4) and triiodothyronine (FT3) [2]. Disruptions in thyroid hormone levels intricately intertwine with alterations in brain functions, both structural and physiological, leading to adverse impacts on neurocognitive abilities [3]. There's an undeniable link between hypothyroidism and depression. In 2017, Tayde et al. recognized this connection while examining patients with thyroid problems through observing a significant increase in "nerve strokes" [4]. Also, a reduction in thyroid hormone activity within the brain's metabolic pathways is considered a potential contributor to the development of depression in hypothyroidism [5,6]. Additionally, Hypothyroidism-related depression-like responses find potential underpinnings in the diminished concentrations of serotonin, dopamine, and brain-derived neurotrophic factor within the prefrontal cortex and hippocampus. [7,8].

Similarly, Thyroid disorders are frequently associated with sleep problems and impaired sleep quality [9]. Sleep can affect hormone secretion, and any disruption in endocrine function can likewise adversely affect sleep [10]. Hypothyroid patients exhibit dissociation between sleep quantity and quality, characterized by extended daytime napping without subjective feelings of refreshment or improved alertness upon awakening [11]. As a result, sleep disturbances exert a negative influence on both quality of life and health-related behaviors in such individuals [12].

Conventional treatment of hypothyroidism prioritizes normalization of serum TSH through levothyroxine adjustments, aiming to establish biochemical euthyroidism. [13]. Restoration of euthyroid state can demonstrably mitigate mood disorders such as sadness, depression, and disruptions in sleep patterns accompanied with thyroid hormone dysregulation [14]. While levothyroxine treatment ameliorates psychological symptoms in hypothyroid women, they remain significantly more susceptible to depression [15] and sleep disturbances [9] compared to non-affected individuals.

Hypothyroidism and its associated impairments have received less attention from researchers and clinicians in relation to exercise training than other chronic health disorders. Individuals suffering with clinical hypothyroidism have been the subject of certain studies investigating the potential therapeutic advantages of exercise training [16-18]. Two of these studies found exercises to induce enhancements in FT4 and FT3 accompanied by TSH reductions

in hypothyroid patients [16,17]. These effects were explained that physical activity modulates circulating TSH levels via its regulatory role on the hypothalamic-pituitary axis [19]. However, a recent review found that physical activity in hypothyroid patients doesn't affect thyroid function despite enhancing mental and physical health [18].

As supported by existing research, engaging in regular physical activity has been demonstrated to enhance mood, promote positive outlook, and potentially offer a means of managing depression and sleep impairment symptoms [20, 21]. Studies exploring the exercise benefits on hypothyroidism associated depression and sleep impairments are limited. Despite, various exercise training forms had shown therapeutic benefits in other different populations. Aerobic exercises (AE) alleviated anxiety, depression and improved sleep quality in perimenopausal women [22]. Similarly, resistance exercises (RE) minimized depressive symptoms [23] and enhanced sleep quality [24] among young adults. Also, obese women showed sleep quality and depressive symptoms improvements following combined aerobic and resistance exercises (AE/RE) [25].

In hypothyroidism, AE showed considerable declines in depressive symptoms [26, 27]. Compared to AE, resistance training was found to induce superior benefits on sleep in those with sleep disturbances [28] and more improvements in depression in depressed and non-depressed youths [29]. Furthermore, exercise programs that integrate both aerobic and resistance training have proven to be more advantageous for older persons who suffer from clinical depression [30]. Therefore, we hypothesized that all AE, RE and AE/RE would effectively improve depression and sleep quality in treated hypothyroid women with significant differences between the three training methods.

As far as we understand, identifying the most beneficial type of exercise for managing depression and sleep problems linked to hypothyroidism remains uncertain. Hence, this randomized controlled research was done with the objective of comparing the effect of aerobic, resistance, and mixed exercise forms on depression (as the main focus) and sleep quality (as secondary aspects) among women with controlled hypothyroidism. The intent behind this research is to provide guidance to clinicians or physiotherapists specializing in exercise therapy, enabling them to recommend more effective exercise regimens tailored for individuals dealing with these conditions.

## **Materials and methods**

This research has been documented in accordance with the prescribed requirements in the CONSORT 2010 Statement, which delineates the standards for reporting randomized controlled trials [31].

### *Settings*

The research was done as a prospective, randomized-controlled, parallel-group, and single-center research project, which took place from January 2022 to December 2022. The recruitment of participants occurred at the endocrine unit for outpatient care, with referrals facilitated by a psychiatrist. The exercise interventions were carried out at a privately-owned exercise center.

### *Ethical consideration*

The study protocol got an acceptance from the Ethics Committee of Human Scientific Research with an acceptance code of P.T.REC/012/003424 and registered in the Pan African Clinical Trial Registry (PACTR) with the registration number PACTR202305810673587. The study rigorously complied with the requirements outlined in the Helsinki Declaration. Patients actively participated in the study by providing signed consent forms, signifying their willingness to participate in this research.

### *Sample size determination*

Utilizing the G Power 3.1 software, the size of the sample was established in order to determine the optimal number of participants required for all groups. This calculation was guided by Rao et al.'s research [32], which utilized the Beck Depression Inventory II (BDI-II) score. The calculations considered an  $\alpha$  error probability of 5%, a 95% power and a 0.5 effect size. Consequently, the calculated sample size per group was 13 subjects. However, in an effort to minimize potential attrition effects and enhance the reliability of the outcomes, a sample size of 15 individuals was chosen for each group.

### *Randomization and concealed allocation*

Participant allocation to intervention groups was accomplished through a robust, computer-generated randomization sequence. Employing an equal allocation ratio (1:1:1:1) for aerobic, resistance, combined training, and control groups ensured balanced distribution and minimized selection bias. Occupied, opaque envelopes with sequential numbers concealed the allocation sequence, promoting participant and recruiter blinding throughout the recruitment process.

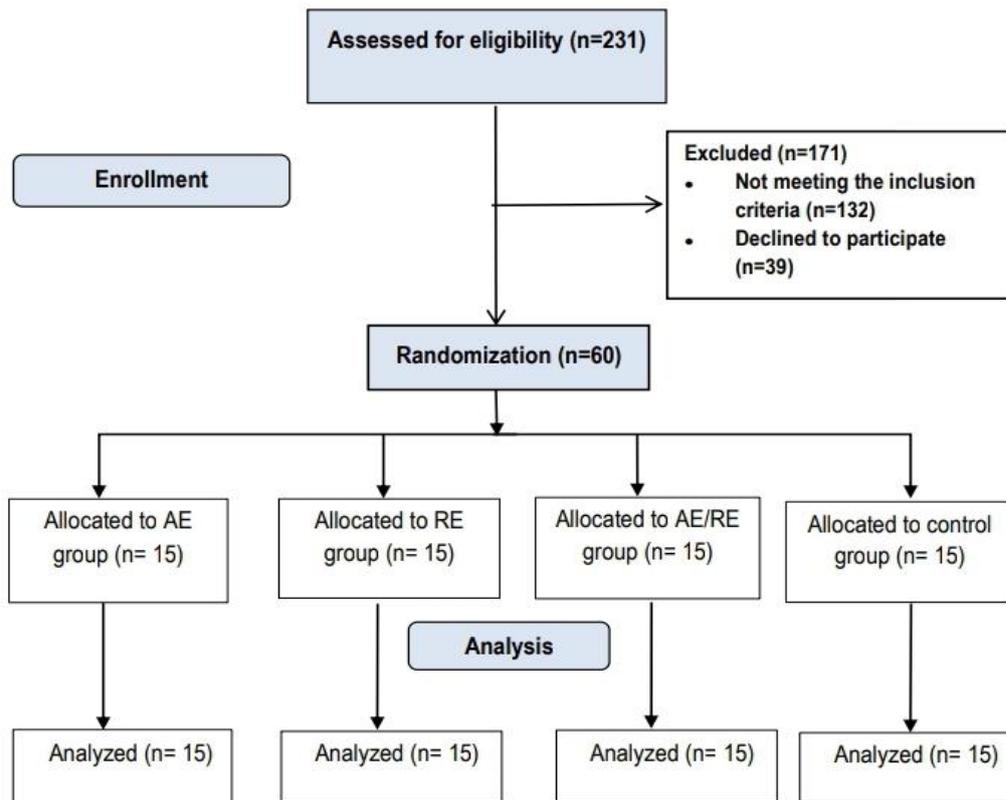
### *Blinding*

Due to the inherent characteristics of the implemented interventions (aerobic, resistance, and combined training), participant and exercise supervisor blinding was not achievable. However, to minimize potential bias, the physician prescribing medication and the assessor of depression and sleep quality were kept blinded to participants' group assignments.

### *Subjects*

The study recruited 60 female patients. Inclusion criteria involved a diagnosis of controlled primary hypothyroidism (TSH 0.4-5 mIU/L, FT4 0.7-1.78 ng/dL) [33] with associated mild-moderate depression (BDI-II score 14-28) [34] and sleep disturbance with Pittsburgh Sleep Quality Index (PSQI) score greater than 5 [35]. Participants were aged 30-50, had a body mass index (BMI) of 20-30 kg/m<sup>2</sup>, and were on stable levothyroxine therapy. Excluded were individuals with secondary or subclinical hypothyroidism, pituitary diseases, psychiatric disorders, unstable cardiovascular conditions, diabetes, chronic chest diseases, medications affecting muscle or thyroid function, musculoskeletal limitations, pregnancy/lactation, hypovitaminosis D/hypocalcemia, or contraindications to exercise testing.

The participating females were equitably distributed into equal four distinct groups including: AE, RE, AE/ RE and control group. The sequential progression of the patients throughout the research is thoroughly depicted in Figure 1.



**Fig. 1.** The sequence steps of the study

### *Assessment*

#### History and clinical evaluation

To ensure participant suitability, an experienced endocrinologist and psychiatrist conducted meticulous clinical examinations and medical history reviews. Demographic, anthropometric, and medication data were comprehensively documented for each participant. Using a digital weight/height scale (UGM-200, China), baseline body weight and height were precisely measured, serving as the basis for calculating individual BMI through a standardized formula by taking a person's height in meters squared and dividing it by their weight in kilograms [36].

#### Depression (Primary outcome)

Assessments of depression conducted before and after the intervention, utilized the Arabic version of the BDI-II. This self-report questionnaire, containing 21 items, offers a dependable and accurate assessment of the extent and intensity of depression symptoms [37]. The BDI-II employs a cumulative scoring system, where the aggregate of individual item scores, which range from 0 to

3, results in a total score that ranges from 0 to 63. Greater scores indicate greater degrees of depression severity. A standardized categorization system further interprets these scores as follows: 0-13 representing no depression, 14 to 19 showing mild depression, 20 to 28 indicating moderate depression, 29 to 36 indicating severe depression, and 37 or higher implying very severe depression [38]. Fawzi et al. provided compelling evidence for the robust psychometric features of the Arabic BDI-II, highlighting its excellent reliability and strong validity [39].

#### Sleep quality (Secondary outcome)

The PSQI Arabic version, validated by Suleiman et al. [40] was utilized to evaluate the sleep quality at baseline and after 12 weeks. This 19-item self-report instrument, encompassing seven subscales, yielded individual component scores (0-3) that were subsequently summed to create a global score (0-21), with greater scores suggest worse sleep [41].

#### *Interventions*

##### Hormonal therapy

All participants, regardless of their assigned intervention group, received ongoing levothyroxine therapy according to individual dosages meticulously prescribed by an endocrinologist as listed in Table 1.

##### Exercise training

An expert physiotherapist carefully created and supervised the training programs for the intervention groups based on the American College of Sports Medicine's FITT concept of Frequency, Intensity, Time, and Type [42].

##### Aerobic exercises (AE)

Over the course of 12 weeks, patients allocated to the AE group attended three training sessions weekly. Thirty to forty-five minutes of low-to-moderate intensity treadmill running made up each session, targeting an individualized exercise heart rate within the range of 50 to 70% of maximal heart rate (HRmax) which was derived from baseline maximal treadmill testing and corresponding less than 15 on a 20-point scale for perceived effort. The heart rate was continually monitored throughout the session using a Pulsox-304 pulse oximeter (Granzia, Italy) to ensure adherence to individual training zones. A 10-minute warm-up preceded each session, which concluded with a 3-minute cool-down. Exercise progression during the program followed a

structured approach. Between the first and the fourth week, training was performed at 50 to 55% of HRmax. In the middle 4 weeks, the intensity ranged between 55-60% of HRmax, while the highest intensity of 60-70% HRmax was targeted at the last 4 weeks. During each of these three stages, the duration of the session began with 30 minutes and gradually increased to 45 minutes with prioritizing the gradual increases in session duration before introducing intensity adjustments [43].

#### Resistance exercises (RE)

The RE group undertook a program consisting of twelve weeks of three sessions per week. Every session incorporated seven unique exercises: lateral pull downs, bench presses, biceps curls, abdominal crunches, leg presses, hip abductions, and calf raises, performed using a combination of free weights and gym machines. The training intensity remained within the low-to-moderate range, targeting 55 to 65% of each participant's individual one-repetition maximum (1RM) determined for every group of muscles prior to the program through assessments identifying the maximum weight manageable for a single complete repetition with proper form [44]. Each RE session was structured into three distinct phases: stretching and flexibility movements as part of a warm-up for ten minutes is succeeded by an active phase that extends for twenty to fifty minutes, and concluding with a 5-minute cool-down period involving further stretching. The active phase employed an individualized training protocol featuring 1-3 sets of 10-15 repetitions per exercise, separated by 5-10 seconds of passive rest within sets and 1-2 minutes of rest between sets (ensuring muscle relaxation exceeded contraction time). To progressively challenge participants throughout the program, adjustments were made on an individual basis. In the first four weeks, 55% of 1RM was targeted, raised up to 60% in the middle 4 weeks while completing the last stage at 65%. During each of these three stages, the count of sets was increased before introducing greater training load.

#### Combined aerobic and resistance exercises (AE/RE)

Participants assigned to the AE/RE grouping participated in a comprehensive 12-week training program encompassing both aerobic and resistance training modalities, delivered three times weekly. The program featured exercises that are mild to moderate in intensity, targeting 50-70% of individual peak heart rate for the aerobic component and 55-65% of 1RM for the resistance component. Each session commenced with flexibility exercises throughout a 10-minute warming up, followed by an active phase comprising 20-25 minutes of dedicated AE and 20-30 minutes of individualized resistance training protocols outlined previously for the respective AE and RE

groups. The sessions concluded with a 5-minute cool-down period involving further stretching exercises. As with the one type exercise groups, the AE/RE program incorporated gradual progression in response to individual participant tolerance throughout the study period.

### *Statistical analysis*

Prior to conducting statistical analysis, data exploration ensured normality and homogeneity of variance, fulfilling prerequisites for parametric tests. The Shapiro-Wilk test confirmed normality ( $p > 0.05$ ) and Levene's test established homogeneity of variances ( $p > 0.05$ ) across groups for all variables. Paired t-tests compared pre- and post-intervention means within each group, while one-way ANOVA examined differences between group means at baseline and post-intervention. In case of significant ANOVA results, pairwise comparisons were conducted using Fisher's LSD test to identify specific group differences. This study used SPSS version 22 for its statistical analysis.

## **Results**

All the sixty participants successfully completed the trial without incurring any losses and consistently engaged in all the recommended exercise sessions. Besides, the follow-up of the participants in the sessions was continuously monitored by an experienced well-trained physiotherapist who didn't report any adverse effects during the interventions.

### *At beginning*

Initially, there were no notable disparities identified across the groups in terms of patients' demographic characteristics, anthropometric measurements, thyroid function tests, and levothyroxine dosage ( $p > 0.05$ ) (Table 1). Furthermore, at the beginning of the trial, none of the outcome elements showed any significant differences between the groups ( $p > 0.05$ ) (Tables 2).

### *Within groups post-intervention*

Significant improvements were seen in all outcomes, BDI-II and PSQI, throughout all exercise groups (AE, RE, and AE/RE), when compared to the initial measurements ( $p < 0.05$ ) (Tables 2). While, no change from baseline was seen in any outcome measure in the control group ( $p > 0.05$ ) (Tables 2).

### *Between groups post-intervention*

After completing the trial, the analysis showed significant variations in the means of both outcomes across the groups ( $p < 0.05$ , Tables 2). Post-hoc testing revealed that all exercise groups had substantially better scores on all outcome measures in contrast to the control (Table 3). No notable disparities were seen between the AE and RE groups in relation to BDI-II and PSQI scores, as indicated in Table 3. Nevertheless, the AE/RE group had far more pronounced decreases in both BDI-II and PSQI scores in comparison to either the AE or RE groups alone ( $p < 0.05$ , Table 3).

**Tab. 1.** Baseline criteria

Variable	AE (mean±SD)	RE (mean±SD)	AE/RE (mean±SD)	Control (mean±SD)	p-value (mean±SD)
Age (years)	39.6 ± 2.8	41 ± 2.5	40 ± 2.7	40.2 ± 3	0.59
Weight (kg)	72.1 ± 6	72.2 ± 5.2	72.5 ± 6.1	70.8 ± 6.3	0.87
Height (cm)	162.6 ± 5.3	163.4 ± 5	163.2 ± 6.9	161.2 ± 6.8	0.75
BMI (kg/m <sup>2</sup> )	27.3 ± 1.7	27.2 ± 1.5	27.3 ± 1.2	27.3 ± 1.4	0.91
TSH (mIU/L)	3.28 ± 0.58	3.34 ± 0.56	3.4 ± 0.48	3.39 ± 0.52	0.13
FT4 (ng/dL)	1.25 ± 0.26	1.32 ± 0.26	1.34 ± 0.28	1.35 ± 0.26	0.77
Hypothyroidism duration (years)	3.66 ± 1.95	3.73 ± 2.1	4.92 ± 2.6	4.84 ± 2.7	0.33
Dose of Levothyroxine (mcg/day)	95.4±46	93.1±49	106.5±60.2	102.3±54.6	0.83

AE- aerobic exercises, BMI- body mass index, FT4- free thyroxine, RE- resistance exercises, TSH- thyroid stimulating hormone. The data are presented as means± standard deviations (SD). The one-way analysis of variance (ANOVA) was employed to examine the differences in continuous variables across many groups.

**Tab. 2.** Outcome measurements' findings both before and after the study

Outcome		AE	RE	AE/RE	Control group	p- value <sup>b</sup>
BDI-II	baseline	19.4± 3.64	18 ± 4.03	19.27± 5.1	18.8 ± 4.37	0.81
	Post	13.93± 4.3	14.13 ± 4.3	10.13± 4.79	18.2 ± 4.44	0.001**
	p-value <sup>a</sup>	0.001*	0.002*	0.001*	0.44	

	MD within group (95% CI)	-5.47 (3.3, 7.6)	-3.87 (1.7, 5.9)	-9.14 (6.5, 11.7)	-0.6 (-1, 2.2)	
	MD between-group compared to control group	-4.87	-3.27	-7.47		
PSQI	baseline	9.53± 2.5	8.86± 2.7	8.33± 2.16	9.73± 2.6	0.4
	Post	6.2 ± 1.8	6.06± 2.4	4.2± 2.4	9.33± 3	0.001**
	p-value <sup>a</sup>	0.001*	0.001*	0.001*	0.42	
	MD within group (95% CI)	-3.33 (2.1, 4.5)	-2.8 (1.7, 3.8)	-4.13 (2.4, 5.8)	-0.4 (-0.6, 1.4)	
	MD between-group compared to control group	-2.93	-2.4	-3.73		

AE- aerobic exercises, BDI-II- Beck Depression Inventory version II, PSQI- Pittsburgh Sleep Quality Index, RE- resistance exercises

p-values<sup>a</sup>: the data are presented as means ± standard deviation (SD) and mean difference (MD) with a 95% confidence interval (CI). These are the p-values obtained from the Paired t-test

p-value<sup>b</sup>: the p-value obtained from the one-way ANOVA test. A p-value less than 0.05 indicates statistical significance

**Tab. 3.** Pairwise comparisons of post-hoc test between groups.

Pairwise comparisons		BDI-II	PSQI
AE	RE	0.9	0.88
	AE/RE	0.02*	0.03*
	Control group	0.01*	0.01*
RE	AE/RE	0.01*	0.04*
	Control group	0.01*	0.001*
AE/RE	Control group	0.001*	0.001*

AE- aerobic exercises, BDI-II- Beck Depression Inventory version II, PSQI- Pittsburgh Sleep Quality Index, RE- resistance exercises. The data are represented in the form of p-values. A significant p-value of less than 0.05 was determined using the post-hoc Fisher's least significant difference test.

## Discussion

The World Health Organization has substantiated the pivotal role of consistent physical activity in averting and controlling noncommunicable diseases, highlighting its multifaceted

advantages encompassing mental health and overall well-being [45]. Limited research exists within the domain of exercise therapy specifically targeting impairments associated with hypothyroidism. Our investigation represents the inaugural randomized controlled study that examines and compares three distinct forms of exercise training namely aerobic, resistance, and a combination of aerobic/resistance training in women clinically diagnosed with hypothyroidism, focusing on the impact on depression and sleep quality. The major outcomes of our current investigation revealed the following key findings: (i) Relative to baseline measurements and the control group receiving no exercise intervention, all three exercise modalities AE, RE, or combined AE/RE resulted in notable improvements in depression levels and sleep quality among women with managed hypothyroidism. (ii) Particularly, the combined AE/RE exhibited significantly greater improvements in both measured outcomes compared to either AE and RE used independently among these patient cohorts. (iii) Interestingly, the improvements achieved by the AE and RE groups were not significantly different from one another.

Regular physical activity has been shown to alleviate the extent of symptoms related to hypothyroidism, including depression and sleep disturbances [46]. The effectiveness of exercise training as an antidepressant might be attributed to its ability to increase brain serotonin levels [27]. Additionally, it is noteworthy that serotonin enhances synaptic plasticity in the hippocampus, potentially aiding in alleviating symptoms linked to depression [47]. Moreover, the secretion of the neurotrophic brain-derived factor might be linked to the effects of engaging in physical exercise [48]. Besides, there is evidence that engaging in physical activity can alter an individual's reaction to emotional events. Physical activity may facilitate a quicker return to pre-stress levels [49]. As a result, individuals can effectively manage depressive symptoms through physical activity. Moreover, in individuals experiencing depression, increased physical activity promoted the suppression of negative emotions and symptoms of mood distress [50].

A preliminary study conducted by Indian researchers examined the impact of yoga on depression in a group of 38 women with hypothyroidism, yielding results in alignment with our own research. Subsequent to engaging in yoga sessions, a notable decrease in BDI-II levels was observed [26].

Consistent with our own results, an 8-week resistance exercise regimen undertaken by 55 young adults notably reduced depressive symptoms as evaluated by the quick inventory of depressive symptomatology, compared to both the baseline measures and the control group [23]. Likewise, comparable outcomes demonstrating a decrease in BDI-II scores were observed after an eight-week period of online home-based low-load resistance training among middle-aged individuals [51]. Furthermore, a systematic review that investigated the impacts of supervised

resistance training programs on individuals diagnosed with depression or experiencing depressive symptoms, encompassing a final sample of four articles, highlighted significant benefits of resistance training in ameliorating depressive symptoms [52]. A 12-week program combining aerobic and resistance training, conducted on a group of thirty-four women diagnosed with type 2 diabetes, resulted in a significant improvement in depression. This improvement was indicated by a decrease in BDI scores alongside an increase in brain-derived neurotrophic factor concentration [53].

Conflicting outcomes regarding the comparative effects of the three training modalities have been noted. Subsequently, a systematic review and meta-analysis involving eighteen randomized controlled trials investigated the impact of aerobic, resistance, and combined training on depressive symptoms among healthy older adults. The findings revealed that each of these exercise interventions showed potential for improving depressive symptoms [54]. Also, Ahmad et al. explored the benefits of the same three exercise protocols on the mental health-related quality of life in hypothyroid women and found significance difference in favor of the combined exercise with similar improvements in both aerobic and resistance solely protocols [16].

Diverging from our own research conclusions, a recent systematic review observed differences in the ranking of exercises for treating depression in both depressed and non-depressed youths. According to this review, the ranking favored RE as the most effective (94.9%), followed by AE (75.1%), and lastly AE/RE (43.8%) [29]. Similarly, another systematic review delved into the impact of various exercise interventions on depressive symptoms and concluded that each of the three forms of physical activity shown a substantial reduction in depression symptoms among children and adolescents. However, it highlighted that AE demonstrated the most notable effect in comparison to RE and AE/RE [55]. The discrepancy in findings could potentially be attributed to the wide array of intervention durations present in the studies selected for review. Moreover, the cause of depression in those particular studies might have differed significantly from thyroid disorders, impacting the observed outcomes. Furthermore, it's essential to note that the latter review specifically focused on patients within the children and adolescents' category, possibly leading to variations in the observed effects compared to studies involving different age groups or specific health conditions like thyroid disorders.

Hypothyroidism adversely affects the overall quality of sleep and continues to be a significant concern for numerous patients, even when they are undergoing treatment with levothyroxine [56]. Another important finding in this current study is the notably superior enhancements observed in sleep quality across all exercise groups when contrasted with both the initial baseline and the control.

Baron et al. conducted a study examining the effect of a 12-week moderate to vigorous aerobic training program on sleep among women experiencing insomnia and revealed an enhancement in sleep quality measured through the insomnia severity index, which was attributed to heightened core body temperature during exercise sessions [57]. Others explored the impacts of aerobic training on the quality of sleep among elderly individuals over a span of 6 months. They observed a notable augmentation in the overall duration of sleep, improved effectiveness of sleep, and a decrease in the time it takes to sleep significant outcomes of the exercise regimen [58]. While a restricted four-week aerobic training regimen characterized by mild intensity did not yield any statistically significant impact on the duration of sleep [59].

A comprehensive analysis of thirteen studies, conducted as a systematic review, affirmed the immediate and long-term advantages of RE in improving both the quantity and quality of sleep. Furthermore, the review noted that while isolated RE demonstrated benefits, these advantages were enhanced when RE was combined with AE [24].

The present study also showed that the combined AE/RE induced the best improvement in sleep quality, as assessed by the PSQI with non-significant difference between the solely AE and RE. Consistent with this finding, a regimen combining incremental walking and home-based strength training over a period of 16 weeks showed notably greater enhancement in patient-reported sleep quality, measured using the PSQI, among breast cancer survivors. This improvement surpassed the impact observed in a program focusing solely on mood-related exercises [60].

Additionally, a further clinical research was done to compare the impact of aerobic and resistance training on the quality of sleep in individuals experiencing sleep disturbances. Comparative analysis between groups indicated that the average scores of sleep quality, evaluated through the PSQI, were notably lower in both intervention groups compared to the control group. However, the disparity between the two forms of exercise did not show statistical significance in terms of their impact on sleep quality [61].

In contrast, a review study undertook a comparison between the impacts of aerobic and resistance training on sleep quality among older adults experiencing sleep disturbances. While both forms of training—resistance and aerobic—resulted in improvements in both the quality of sleep and overall quality of life, resistance training demonstrated a more pronounced effect on sleep efficiency, sleep onset latency, and sleep duration [62].

Another randomized controlled study examined how a one-year aerobic, resistance, and combination of aerobic and resistance training routine affected sleep quality in sedentary individuals at high risk of cardiovascular disease. The PSQI showed that all intervention groups

had significantly less sleep disruption than the control group. Notably, the group engaged in resistance exercise exhibited superior benefits in improving sleep compared to the aerobic training group [63].

The current study holds clinical significance as it offers valuable insights to endocrinologists, psychiatrists, and other healthcare practitioners dealing with hypothyroidism-related complications. It underscores the supplementary advantages of incorporating physical exercise into the treatment regimen for managing depression and sleep disturbances among women receiving treatment for hypothyroidism. Furthermore, the study highlights the positive outcomes associated with different exercise routines in women with hypothyroidism, potentially assisting physiotherapists in choosing the most appropriate exercise modality to address certain objectives in these specific patients.

The current study boasts several strengths. This trial is a pioneering effort in the field of exercise therapy for addressing depression and sleep quality difficulties connected to hypothyroidism. It is a unique and original contribution. Notably, it stands as the first study to directly compare the efficacy of three distinct types of exercise in addressing depression and sleep quality problems among women already receiving treatment for hypothyroidism. Nevertheless, like several other research, it is important to evaluate the conclusions of this study while taking into account certain limitations. One such limitation, the assessment of depression and sleep quality utilized a generic questionnaire rather than hypothyroidism -specific questionnaires, primarily because of their unavailability.

## **Conclusions**

In women with controlled hypothyroidism, the inclusion of low- to moderate-intensity AE, RE, or AE/RE alongside pharmacological treatment showed significantly enhanced improvements in depression and sleep quality compared to relying solely on medications. All forms of training contributed positively to alleviating depression and enhancing sleep quality, with superior outcomes observed in the combined AE/RE approach compared to either AE or RE alone in women with hypothyroidism.

## **Funding**

This research received no external funding.

## **Conflicts of interest**

The authors declare no conflict of interest.

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