DOI: 10.5114/areh.2024.136292
Original article
Advances in Rehabilitation, 2024, 38(1), 9–19

A – Research concept and design
B – Collection and/or assembly of data
C – Data analysis and interpretation
D – Writing the article
E – Critical revision of the article
F – Final approval of article

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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Received: 2024-01-29
Accepted: 2024-03-07
Published: 2024-03-12

Abstract

Introduction: Interest has recently frown in the use of exercise in managing hypothyroidism associated impairments. The objective of this research was to assess and contrast the effects of aerobic and resistance exercise regimens, and a combination of both, on depressive symptoms and sleep quality in women with managed hypothyroidism.
Material and methods: A total of sixty women, aged 35 to 45 years, 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 a week, during a span of 12 weeks, while also undergoing levothyroxine therapy. Outcome measures included depression assessed with the Beck Depression Inventory II (BDI-II) and sleep quality, evaluated using the 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 ($p < 0.05$). Most significantly, the AE/RE group demonstrated greater improvements in both outcomes then the AE and RE groups alone ($p < 0.05$).
Conclusions: In well-managed hypothyroid women, AE, RE, and combined AE/RE can improve depression and sleep quality. However, combined AE/RE appears to induce the greatest improvements in both measures.

Keywords: depression, hypothyroidism, sleep quality

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]. Patients with hypothyroidism usually present with increased levels of thyroid-stimulating hormone (TSH) associated with decreased free thyroxine (FT4) and triiodothyronine (FT3) [2]. Disruptions in thyroid hormone levels are associated with structural and physiological alterations in brain functions, leading to adverse impacts on neurocognitive abilities [3]. There is an undeniable link between hypothyroidism and depression; this was first reported in 2017 by Tayde et al., who observed a significant increase in "nerve strokes" while examining patients with thyroid problems [4]. Also, a reduction in thyroid hormone activity within the metabolic pathways of the brain is considered a potential contributor to the development of depression in hypothyroidism [5,6]. Additionally, hypothyroidism-related depression-like responses may be influenced by 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 likewise, any disruption in endocrine function can adversely affect sleep [10]. Hypothyroid patients exhibit dissociation between sleep quantity and quality, characterized by extended daytime napping but 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].

The conventional treatment of hypothyroidism prioritizes the normalization of serum TSH through levothyroxine adjustments, with the aim of establishing biochemical euthyroidism [13]. The restoration of a 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, the patients remain significantly more susceptible to depression [15] and sleep disturbances [9] compared to non-affected individuals.

Hypothyroidism and its associated impairments have generally received less attention from researchers and clinicians with regard to the effect of exercise training compared to other chronic health disorders. Nevertheless, some studies have investigated the potential therapeutic advantages of exercise training individuals suffering with clinical hypothyroidism [16-18]. Two of these studies found exercise to increase FT4 and FT3 level and reduce TSH in hypothyroid patients [16,17]; it was possible that the physical activity modulated circulating TSH levels by exerting a regulatory role on the hypothalamic-pituitary axis [19]. However, a recent review found that physical activity in hypothyroid patients does not affect thyroid function, despite enhancing mental and physical health [18].

Existing research indicates that engaging in regular physical activity enhances mood, promotes a positive outlook, and potentially offers a means of managing depression and sleep impairment symptoms [20,21]. However, studies exploring the benefits of exercise on hypothyroidism-associated depression and sleep impairments are limited. Nevertheless, various exercise training forms have been found to have therapeutic benefits in other populations: aerobic exercise (AE) alleviated anxiety, depression and improved sleep quality in perimenopausal women [22], while similarly, resistance exercises (RE) minimized depressive symptoms [23] and enhanced sleep quality [24] among young adults. Also, a combination of aerobic and resistance exercises (AE/RE) yielded improvement in sleep quality and depressive symptoms among obese women [25].

In hypothyroidism, AE resulted in considerable declines in depressive symptoms [26,27], while RE 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 compared to AE [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 AE, RE and AE/RE would all effectively improve depression and sleep quality in treated hypothyroid women, although significant differences would exist between the three training methods.

Currently, the most beneficial type of exercise for managing depression and sleep problems linked to hypothyroidism remains uncertain. Hence, the aim of this randomized controlled study was to compare the effect of aerobic, resistance, and mixed exercise forms on depression, as the main focus, and sleep quality, as a secondary aspect, 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 performed as a prospective, randomized-controlled, parallel-group, and single-center research project, which took place from January 2022 to December 2022. Recruitment occurred at the endocrine unit for outpatient care, with referrals facilitated by a physician. The exercise interventions were carried out at a privately-owned exercise center.

Ethical consideration

The study protocol was approved by the Ethics Committee of Human Scientific Research (acceptance code

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

The participants number required for each group, and minimum sample size, were determined using G Power 3.1 software, according to Rao et al. [32], which utilized the Beck Depression Inventory II (BDI-II) score. The calculations considered an α error probability of 5%, a 95% power and a 0.5 effect size. Consequently, the calculated minimum 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 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. The allocation sequence was held in opaque-sealed envelopes containing sequential numbers, thus 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 the participant group assignments.

Participants

The study recruited 60 female patients. The inclusion criteria comprised 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 a Pittsburgh Sleep Quality Index (PSQI) score greater than 5 [35]. The participants were aged 30-50 years, had a body mass index (BMI) of 20-30 kg/m², and were on stable levothyroxine therapy. The following were excluded: 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 women were equally distributed into four equal-sized distinct groups: AE, RE, AE/ RE and a control group. The progression of the patients through the study is depicted in Figure 1.

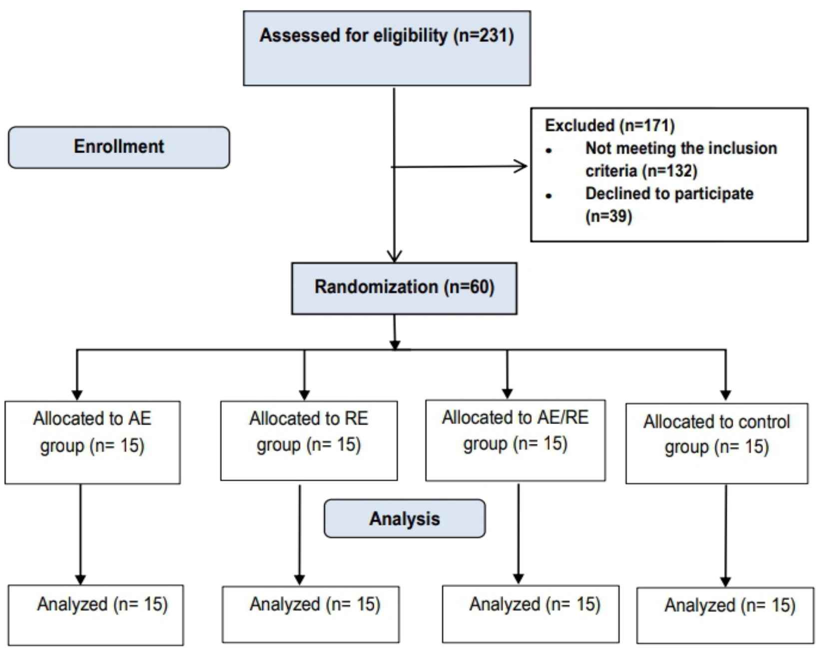

Fig. 1. The sequence steps of the study

Outcome measures

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. Baseline body weight and height were precisely measured using a UGM-200 digital weight/height scale (China Perlong); this data was used to calculate individual BMI by dividing the height of the participants in meters squared 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 to 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. provide 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 Arabic version of the PSQI, 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 suggesting worse sleep [41].

Interventions

Hormonal therapy

All participants, regardless of their assigned intervention group, received ongoing levothyroxine therapy according to the individual dosages 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 FITT concept, i.e. Frequency, Intensity, Time, and Type [42].

Aerobic exercises (AE)

The patients allocated to the AE group attended three training sessions per week for 12 weeks. Each session comprised 30 to 45 minutes of low-to-moderate intensity treadmill running aiming for an individualized exercise heart rate between 50 and 70% of maximal heart rate (HRmax), derived from baseline maximal treadmill testing, and corresponding to 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 proceeded each session, which concluded with a three-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 four weeks, the intensity ranged from 55 to 60% of HRmax, and the final four weeks, it was increased to 60-70% HRmax. During each of these three stages, the duration of the session began at 30 minutes and gradually increased to 45 minutes; gradual increases in session duration were prioritized 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); this value, i.e. the maximum weight manageable for a single complete repetition with proper form, was determined for each group of muscles prior to the program [44]. Each RE session was structured into three distinct phases: stretching and flexibility movements as part of a warm-up for ten minutes followed by an active phase that extends for twenty to fifty minutes, and concluding with a five-minute cool-down period involving further stretching. The active phase employed an individualized training protocol featuring one to three sets of 10-15 repetitions per exercise, separated by 5 to 10 seconds of passive rest within sets and one to two minutes of rest between sets, ensuring that 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 to 60% in the middle four weeks, and then to 65% in the last four weeks. During each of these three stages, the count of sets was increased before introducing greater training load.

Table 1. Baseline characteristic of the study groups

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/m2]	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.

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 warm-up, followed by an active phase comprising 20-25 minutes of dedicated AE and 20 to 30 minutes of individualized resistance training protocols, as outlined previously for the respective AE and RE groups. The sessions concluded with a five-minute cool-down period involving further stretching exercises. As with the single-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, the data was tested for normality and homogeneity of variance, fulfilling the 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. The paired t-test was used to compare pre- and post-intervention means within each group, and ANOVA to examine the differences between group means at baseline and post-intervention. In the case of significant ANOVA results, pairwise comparisons were conducted using Fisher's LSD test to identify specific group differences. The statistical analysis was performed using SPSS version 22.

Results

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

Initially, no notable disparities were identified between the groups in terms of demographic characteristics, anthropometric measurements, thyroid function tests or 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 ($p > 0.05$).

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 ($p < 0.05$) (Table 2). No change from baseline was seen in any outcome measure in the control group ($p > 0.05$) (Table 2).

Between groups post-intervention

After completing the trial, the analysis showed significant variations in the means of both outcomes (BDI-II and PSQI) between groups ($p < 0.05$). Post hoc testing revealed that all exercise groups had substantially better scores on all outcome measures compared to the control group (Table 3). No notable disparities were seen between the AE and RE groups in relation to BDI-II or PSQI score, 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).

Table 2. Outcome measurements at baseline and after the intervention

Outcome		AE	RE	AE/RE	Control group	p-value[b]
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[a]	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[a]	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

The outcome data are presented as means ± standard deviation (SD) or mean difference (MD) with a 95% confidence interval (CI). p-valuea: the p-values obtained from the Paired t-test. p-valueb: the p-value obtained from the one-way ANOVA test. A p-value less than 0.05 indicates statistical significance

Discussion

The World Health Organization has substantiated that consistent physical activity plays a pivotal role in averting and controlling noncommunicable diseases, and highlights its multifaceted advantages encompassing improved mental health and overall well-being [45]. However, limited research has examined the effectiveness of exercise therapy specifically targeting impairments associated with hypothyroidism. Our investigation is the first randomized controlled study to examine and compare three distinct forms of exercise training, namely aerobic, resistance, and a combination of the two, in women clinically diagnosed with hypothyroidism, focusing on the impact on depression and sleep quality. Our studies have yielded the following key findings: (i) All three exercise modalities, viz. AE, RE and combined AE/RE, resulted in notable improvements in depression levels and sleep quality among women with managed hypothyroidism relative to baseline measurements and the control group receiving no exercise intervention. (ii) In particular, the combined

Table 3. Pairwise *post hoc* comparisons 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 (*post hoc* Fisher's least significant difference test). A p-value < 0.05 was regarded as significant.

AE/RE exhibited significantly greater improvements in both measured outcomes compared to either AE or RE used independently. (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 brain-derived neurotrophic factor might be linked to the effects of engaging in physical exercise [48]. Evidence also suggests that engaging in physical activity can alter an individual's reaction to emotional events ,with physical activity potentially facilitating 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 has been found to promote the suppression of negative emotions and symptoms of mood distress [50].

Similar findings were obtained by a preliminary study conducted by Indian researchers on the impact of yoga on depression in a group of 38 women with hypothyroidism. Subsequent to engaging in yoga sessions, a notable decrease in BDI-II levels was observed [26].

Also, similar results were achieved by a previous study examining the effect of an eight-week resistance exercise regimen undertaken by 55 young adults; the findings indicate notably reduced depressive symptoms compared to both the baseline measures and the control group as evaluated by the quick inventory of depressive symptomatology [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 of four articles investigating the impacts of supervised resistance training programs on individuals diagnosed with depression or experiencing depressive symptoms, 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, as well as an increase in brain-derived neurotrophic factor concentration [53].

Conflicting outcomes have been reported in studies comparing the three training modalities. 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, a study on the benefits of the same three exercise protocols on the mental health-related quality of life in hypothyroid women found that the combined exercise achieved the greatest benefits, with the aerobic and resistance protocols both obtaining similar values [16].

In contrast to the present findings, a recent systematic review found RE to be the most effective regimen for treating depression in both depressed and non-depressed youths (94.9%), followed by AE (75.1%), and lastly AE/RE (43.8%) [29]. Similarly, another systematic review on the effect of various exercise interventions on depressive symptoms found that each of the three forms of physical activity achieved substantial reductions 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 is important to note that the latter review specifically focused on children and adolescents, which may have led 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]. Therefore, another important finding in this current study is that all exercise groups achieved notably superior enhancements in sleep quality contrasted with both the initial baseline values and the control group.

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. The results revealed an enhancement in sleep quality, measured through the insomnia severity index. This was attributed to heightened core body temperature during exercise sessions [57]. Another study exploring the impacts of aerobic training on the quality of sleep among elderly individuals over a span of six months found a number of significant outcomes to the exercise regimen: a notable augmentation in the overall duration of sleep, improved effectiveness of sleep, and a decrease in the time it takes to sleep [58]. However, 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 systematic review of thirteen studies affirmed that RE has the immediate and long-term advantages 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].

Our present findings also indicate that the combined AE/RE induced the best improvement in sleep quality, as assessed by the PSQI, with a non-significant difference between the groups receiving AE and RE alone. Similarly, a previous study found that 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 study examined the impact of aerobic and resistance training on the quality of sleep in individuals experiencing sleep disturbances. Comparative analysis indicated that both intervention groups achieved a notably lower mean sleep quality score, evaluated through the PSQI, compared to the control group. However, no significant difference was found between the two forms of exercise in terms of their impact on sleep quality [61].

In contrast, a review study compared the impacts of aerobic and resistance training on sleep quality among older adults experiencing sleep disturbances. While both forms resistance and aerobic training 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 training routine based on aerobic, resistance or a combination of aerobic and resistance training, affected sleep quality in sedentary individuals at high risk of cardiovascular disease. The PSQI showed that all intervention groups demonstrated 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 studies, it is important to consider certain limitations when evaluating its conclusions. One such limitation is that the assessment of depression and sleep quality utilized a generic questionnaire rather than those specific to hypothyroidism; unfortunately no such tool was available.

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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