Article published online: 2024-02-20

Home-Based Aerobic Interval Training Combined with Resistance Training Improved Daytime Dysfunction in Adults with Obesity and Sleep-Disordered Breathing

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Sleep Sci 2024;17(2):e117–e124.

Abstract

Introduction There have been many barriers to exercising at a gym due to the coronavirus disease 2019 (COVID-19) pandemic worldwide. Home-based aerobic interval training (AIT) combined with resistance training (RT) may be helpful for obese adults with sleep-disordered breathing (SDB) to overcome those barriers and improve their subjective sleep disorders. Thus, the present study aimed to examine the effects of home-based AIT combined with RT on subjective sleep disorders in obese adults with SDB.

Material and Methods This study has a one-group pretest-posttest design. Twenty-one adults with obesity and SDB were assigned to perform 8 weeks of AIT combined with RT. Subjective sleep disorder variables including the Pittsburgh Sleep Quality Index (PSQI), Berlin Questionnaire, and Epworth Sleepiness Scale were defined as primary outcomes. Anthropometric variables, physical fitness components, and blood biomarkers were assigned as secondary outcomes. All outcome measurements were examined at baseline and after 8 weeks of training.

Results Daytime dysfunction of PSQI was significantly improved after 8 weeks of the exercise program ($p < 0.05$). Upper and lower chest expansion and estimated maximum oxygen consumption were significantly increased after 8 weeks of the exercise program (all $p < 0.05$). None of the blood biomarkers changed after 8 weeks of training.

Conclusion This study suggests that home-based AIT combined with RT effectively alleviates daytime dysfunction and seems to be more helpful in improving global PSQI in adults with obesity. Future studies with a larger sample size, under a controlled trial are recommended to prove the benefits of the exercise program.

Keywords
- physical fitness
- exercise
- sleep quality
- resistance training

received February 9, 2023
accepted August 2, 2023

DOI https://doi.org/10.1055/s-0043-1777708.
ISSN 1984-0659.

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Introduction

Sleep-disordered breathing (SDB) is a sleep disorder which is commonly found in adults with obesity.[1] The SDB continuum comprises of primary snoring, partial airway collapse, upper airway resistance syndrome, and obstructive sleep apnea (OSA). The latter is the most severe form of SDB, with a prevalence of 3.7 to 97.3% in Asian adults.[2] A common coexisting pathway between obesity and SDB is the inflammatory pathway.[1,3] Numerous studies have found that some of the inflammatory markers and metabolic markers, such as C-reactive protein (CRP), and glycated hemoglobin (HbA1c) are associated with SDB.[4,5] A link between SDB and obesity can also be activated of oxidative stress and endothelial dysfunction, which may lead to atherosclerosis and cardiovascular diseases.[6] Therefore, early diagnosis and treatment of SDB are needed to inhibit the adverse consequences of cardiovascular diseases.

A weight management program is suggested as the preliminary treatment for SDB.[7] A recent meta-analysis found that physical exercise improves subjective sleep parameters such as daytime sleepiness, increases the quality of life, and reduces OSA severity.[8] Most physical exercise studies have an emphasis on individual aerobic exercise[9,10] or exercise combined with a diet program.[11–13] Aerobic interval training (AIT) or high-intensity interval training (HIIT) is intermittent aerobic training at high intensity alternated with lower intensity.[14] It has been extensively used in a wide range of populations, such as obese adults and other vulnerable subjects.[15,16] There is evidence to support that AIT, or HITT, is safe, time-efficient, and superior to traditional aerobic training for improving aerobic capacity, vascular function, and blood biomarkers.[17,18] Supervised training at centers is commonly used to examine the effects of AIT or HIIT programs in SDB patients found to improve sleep indices and subjective sleep disorders.[19,20] However, there have been many restrictions to performing such center-based training programs with individual supervision due to the coronavirus disease 2019 (COVID-19) pandemic.[21] Therefore, home-based AIT combined with resistance training (RT) was chosen in this study to gain the maximum effect[16] in adults with obesity and SDB.

The present study aimed to investigate the effects of AIT combined with RT on subjective sleep disorders, physical fitness components, anthropometric variables, and blood biomarkers in adults with obesity. We hypothesized that obese adults with SDB would show improvement in subjective sleep disorders, anthropometric variables, physical fitness components, and blood biomarkers compared to the period prior to receiving exercise intervention.

Material and Methods

Study Population

This study was conducted at the Snoring Clinic at Maharaj Nakhon Si Thammarat Hospital, and from Walailak University, between September and December of 2020. A total of 21 obese adults in the age range of 18 to 65 years old were recruited and asked to complete 3 subjective sleep questionnaires including the Pittsburgh Sleep Quality Index (PSQI) (total PSQI score > 5), the Berlin Questionnaire (score for category 1 or 2 ≥ 2), and the Epworth Sleepiness Scale (ESS) (total score ≥ 10). The participants who had positive responses to one of these three questionnaires were enrolled in the study. All participants were classified as obese based on their body mass index (BMI) using the International Obesity Task Force (IOTF) criteria.[22] The study excluded participants who underwent treatments such as continuous positive airway pressure therapy, oral appliance, or other treatments that could affect the study results. Additionally, those who followed different exercise programs, diet programs, or had medical conditions that limited their exercise ability (such as symptomatic cardiac disease or neurological deficits) were also excluded from the study. This study was approved by the Human Research Ethics Committee of the Walailak Univerity (#WUEC-20–005–01). Written informed consent was mandatory to be included in the study (Thai Clinical Trials Registry: TCTR20201113003).

Study Design

A one-group pre–posttest design was conducted. Participants were assigned to perform 8 weeks of AIT combined with RT as the intervention group ($n = 21$). Primary outcomes included the Pittsburgh Sleep Quality Index (PSQI), Berlin Questionnaire, and Epworth Sleepiness Scale. Secondary outcomes included anthropometric variables (i.e., body weight [BW]), body mass index (BMI), percent of body fat (%BF), physical fitness components (respiratory muscle strength, chest muscle strength, estimated maximum oxygen consumption, chest expansion), and blood biomarkers. All of the outcome measurements were examined at baseline and after 8 weeks of the exercise program. Importantly, the intra-rater reliability of the anthropometric variables and physical fitness components were evaluated prior to the start of the study. All measurements found an acceptable intraclass correlation coefficient (ICC > 0.9, all $p < 0.001$).

Intervention (Home-based Exercise Program)

The exercise program was designed as a home-based training program including a combination of 20 to 24 minutes of aerobic interval training (AIT) plus 20 minutes of RT. All participants were encouraged to perform these exercises 3 days per week for 8 weeks. The AIT + RT program was modified according to previous studies.[15,16] We reduced the exercise's intensity and duration for it to be simpler to conduct and safer for the participants. Thus, the AIT program was composed of 4 3-minute bouts with an intensity higher than 75% maximum heart rate (MHR) (rate of perceived of exertion [RPE] [modified Borg scale] > 4 of 10, or talk test = not able to speak comfortably), interspersed with 3 minutes of recovery period with an intensity lower than 75% MHR. The AIT exercise types included brisk walking/jogging/ running on a treadmill or outdoors, and leg ergometer cycling or outdoor cycling. Before beginning the first exercise session, we determined the target heart rate (THR) for each individual. The first session was instructed by a physiotherapist at our gym. The subsequent sessions were conducted independently by the participants at home. The monitoring of THR during the AIT sessions was performed using a Polar H10 watch (Polar Electro Oy, Kempele, Finland). If the THR reached 75% MHR, the participants were asked to rate a dyspnea scale using a modified Borg scale. The participants must memorize their dyspnea RPE score if the THR reached 75% MHR. The modified Borg scale was used for monitoring the exercise intensity of the participants if they did not have a running watch. The gym was also provided for participants who were not able to exercise at home according to the restriction on exercise tools. Heart rate monitoring tools were offered to participants if they preferred to utilize our gym. However, the participants needed to exercise and monitor their heart rate by themselves. After the AIT, the 20-minute RT program was conducted using a dumbbell and body weight (BW). The RT comprised of a minimum of 50% of 1-repetition maximum (RM), and 10 to 15 repetitions for 2 to 3 sets with a 1-minute rest interval. Exercises included bicep curls, triceps extensions, curl-ups, back extensions, push-ups, bodyweight squats (with or without additional weight), and dumbbell chest press. The participants were taught to apply different sizes of water bottles containing water or sand instead of using dumbbells for exercise at home. Five minutes of stretching exercises were conducted as warm-up and cool-down periods before and after the training sessions. A logbook was given to the participants for recording their exercise sessions at home. In addition, the procedures to perform the exercise intervention, HR monitoring during exercise, and the RT poses were also provided in the logbook. All participants were asked to return the logbook to confirm that they followed our exercise prescriptions. We also created an online private group to monitor their exercise and interchange knowledge during participation in the study.

Outcome Measurements

Subjective Sleep Disorders

Subjective sleep disorders were measured through the PSQI, the Berlin Questionnaire, and ESS. These are all self-administered questionnaires. The PSQI is used to examine the sleep quality for the previous month, which was translated in Thai by Sitasuwan et al.[23] It contains 19 self-rated questions and takes 10 minutes to complete. It is divided into seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The score of all 7 components range from 0 to 21, with a total score higher than 5 indicating poor sleep quality. The ESS is used to examine excessive daytime sleepiness (EDS). It was translated into Thai version by Banhiran et al.[24] It composes of 8 situations for the potential of dozing off or falling asleep with a rating scale of 0 to 3. A score >10 in the ESS is classified as a person with EDS and at risk of SDB. The Berlin Questionnaire is used to identify the risk of a person who may have OSA. It is categorized into three subgroups including snoring, daytime sleepiness, and risk for obesity and hypertension. It was translated into Thai by Suksakorn et al.[25] It has good validity and reliability for assessing patients with OSA or SDB. It is composed of 10 question items and takes 5 minutes to administer. A total score ≥ 2 for each category displays a positive risk for having OSA or SDB. Interestingly, these sleep questionnaires are valid, reliable, and commonly used in various SDB dimensions.[26]

Anthropometric Variables

Body weight, BMI, %BF, and visceral fat were measured using a bioelectrical impedance analyzer (Tanita BC-418, Tokyo, Japan). Participants were requested to stand on the scale, barefoot, and keeping both hands on the machine's handles for 10 seconds.

Physical Fitness Components

Chest Expansion

Three levels of chest expansion including the upper (2nd intercostal space), middle (4th intercostal space), and lower chest (5th intercostal space) were determined using tape measurement. Participants were asked to take a deep breath in and out while the tape measure was placed on their chest wall. The chest expansion score is the chest expansion after full inspiration minus the chest expansion after full expiration. The average of two times of chest expansion measurements was recorded.

Muscle Strength

Participants were asked to stretch their chest muscle and extremities muscles before examining muscle strength. A seated chest press machine was used to determine the pectoralis muscle strength. Meanwhile, the other exercises included bicep curls, triceps extensions, curl-ups, back extensions, push-ups, and squats using body weight and dumbbells to determine muscle strength. One-repetition maximum was used to calculate muscle strength. The formula for estimating 1-RM (kg) is as follows: 1-RM (kg) = lifting weight (kg) / (1 - 0.02 $\times$ repetitions).[27] All muscle strengths were determined one time (at baseline) except for chest muscle strength, which was examined at baseline and after 8 weeks of training.

Respiratory Muscle Strength

Respiratory muscle strength including maximum inspiratory pressure (MIP), and maximum expiratory pressure (MEP) were examined using the MicroRPM respiratory muscle testing (Germany). The maximum value obtained from at least three trials which met the ATS criteria was chosen for analysis.[28]

Estimated Maximum Oxygen Consumption (VO_2max)

The Åstrand-Ryhming cycle ergometer test was used to determine an estimated VO_2max. Participants were asked to perform cycling for 6 minutes by following the guidelines.[29] The average heart rate of the last 2 minutes was used to determine an estimated VO_2max using a nomogram. The absolute estimated VO_2max (l/min) and relative estimated VO_2max (ml/kg/min) were used for analysis.

Blood Biomarkers

Approximately, 9 milliliters of venous blood samples were drawn from each participant at the antebrachial area after a 12-hour restraint of food and beverage. Total cholesterol (TC), triglyceride, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), glycosylated hemoglobin (HbA1c), and C-reactive protein (CRP) were analyzed by the standard laboratory method. All tests were performed using an Auto Analyser A15 (BioSystems S.A, Barcelona, Spain). Low-density lipoprotein cholesterol (LDL-C) was measured by the Freidewald equation. Glycosylated hemoglobin was measured using high performance liquid chromatography (HPLC). C-reactive protein was examined by immunoturbidimetric assay.

Sample Size Calculation

The sample size was calculated based on a previous study[20] using G-Power software (Version 3.1). Sleep variables including EDS (effect size = 1.10) and the Berlin Questionnaire (category 2) (effect size = 0.85) were used to calculate the sample size. We input these values into the G-power software and arrived at a range of 11 to 17 participants. To account for potential dropouts, we added 20% of participants (at least 4 individuals) to our sample. Ultimately, our study included 21 participants.

Statistical Analysis

All data were recorded, entered, and analyzed using theIBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA). Data distribution was examined using the Shapiro-Wilk test. The Paired Sample *t*-test and the Wilcoxon Signed-Rank test were used to compare baseline and after 8 weeks of the training program for normal distribution, and non-normal distribution data, respectively. Descriptive data was expressed as mean ± standard deviation (SD) for continuous normal data distribution, median (interquartile range [IQR]) for continuous skewed data, and counts (percentages) if indicating categorical data. The significance level was set at $p < 0.05$.

Results

Participant Characteristics

There were 28 participants initially enrolled in the study; however, 7 of them were excluded because they were unavailable (lack of time), received other treatments, and had a history of asthma as shown in ►**Fig. 1**. Later, another four participants were identified as dropout samples because they lacked the time to perform the exercise programs or had traveling obstacles. Nineteen, 17, and 20 participants were positive on the PSQI, ESS, and Berlin questionnaire (category 1) at baseline, respectively. Eleven participants (52%) were positive for all 3 questionnaires at the first screening. The average AIT and RT sessions for all participants were 15 times (62.5%) and 12 times (50%), respectively. The types of exercise included in the AIT included walking/running on treadmill (53%), walking/running outside (27%), and cycling (20%). The reasons for participants not completing the exercise program (24 times) are explained in ►**Fig. 1**. The other baseline characteristics of the participants are shown in ►**Table 1**.

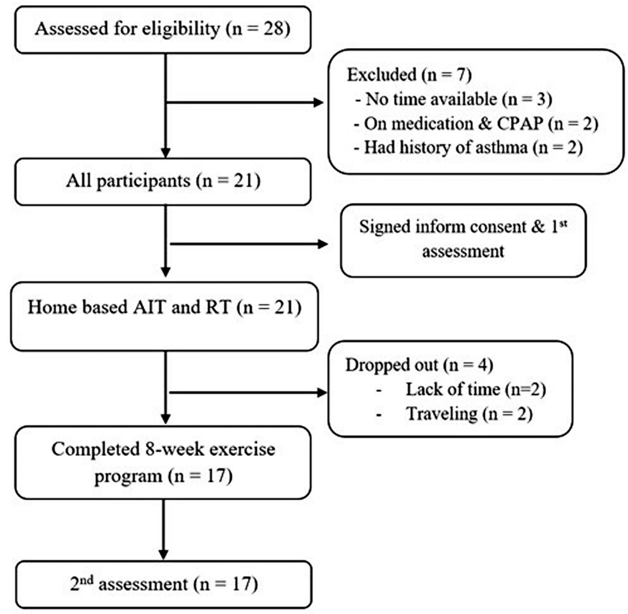

Fig. 1 Flow diagram for participants throughout this study.

Primary and Secondary Outcomes Measurements

Component 7 of the PSQI (daytime dysfunction) improved after 8 weeks of training ($p = 0.017$). Meanwhile, the other subjective sleep disorders tended to improve at the end of training (►**Fig. 2**). In addition, there were significant increases in upper and lower chest expansion, and in the absolute and relative estimated VO_2 after 8 weeks of training (all $p < 0.05$). However, all of the blood biomarkers found no changes after 8 weeks of intervention (all $p > 0.05$) (►**Table 2**).

Discussion

The main finding of this study was the improvement of daytime dysfunction of the PSQI after 8 weeks of AIT combined with RT. In addition, the other subjective sleep disorders tended to improve in all questionnaire forms, especially the global PSQI. Among all of the physical fitness components, the estimated VO_2max and chest expansion at upper and lower part of thoracic wall found an increment after 8 weeks of AIT and RT, but none of the anthropometric variables and blood biomarkers changed after 8 weeks of training.

The present study is the first of its kind to determine the effect of home-based AIT combined with RT in adults with obesity and SDB. Previously, there were studies on home-based traditional aerobic exercise programs in patients with SDB.[30,31] Brandão et al.[30] examined the effects of 12 weeks of a home-based exercise program including aerobic exercises, strengthening exercises, balance training, coordination, and flexibility in the elderly with poor sleep quality. This study

Table 1 Baseline characteristics of the participants

	Completed exercise program ($n = 17$)
Age (years), (mean ± SD)	41.00 ± 10.59
Gender, n (%)	
Male	11 (64.71)
Female	6 (35.29)
Subjective sleep disorders	
PSQI	
- Com1 (Subjective sleep quality), median (IQR)	1.00 (1.00–2.00)
- Com2 (Sleep latency), median (IQR)	1.00 (0.00–1.00)
- Com3 (Sleep duration), median (IQR)	1.00 (1.00–2.00)
- Com4 (Habitual sleep efficiency), median (IQR)	0.00 (0.00–1.00)
- Com5 (Sleep disturbances), median (IQR)	1.00 (1.00–2.00)
- Com6 (Medication use)	No one used medication
- Com7 (Daytime dysfunction), median (IQR)	1.50 (1.00–3.00)
- Global PSQI, (mean ± SD)	7.29 ± 2.69
Epworth Sleepiness Scale (0 – 24), (mean ± SD)	10.59 ± 5.75
Berlin Questionnaire (Items 1 – 5), (mean ± SD)	3.47 ± 1.55
Berlin questionnaire (items 6 – 8), median (IQR)	0.00 (0.00–2.50)
Comorbidities	
Hypertension, n (%)	5 (23.81%)
Diabetes mellitus, n (%)	1 (4.76%)

Abbreviation: PSQI, Pittsburgh Sleep Quality Index.

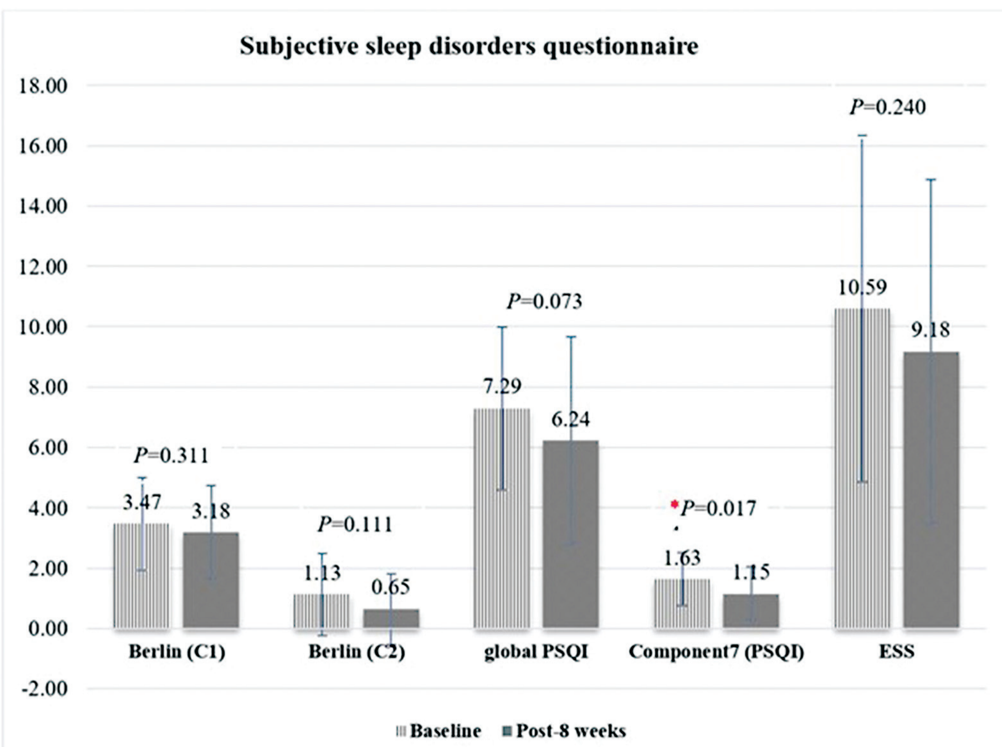

Fig. 2 Comparison of subjective sleep disorders questionnaire between baseline and post-8 weeks of exercise (* = significant difference between baseline and post 8 weeks of training).

Table 2 Comparison of anthropometric variables and physical fitness at baseline and post eight weeks of training

	Baseline	Post 8 weeks	Mean difference (95%CI)	*p*
Anthropometric variables				
BW (kg)	85.54 ± 13.28	85.09 ± 13.92	−0.44 (−1.74–0.85)	0.474
BMI (kg/m^2)	29.92 ± 3.64	29.68 ± 3.41	−0.24 (−0.69–0.20)	0.265
%BF	32.86 ± 5.12	32.65 ± 4.73	−0.21 (−0.86–0.44)	0.500
Visceral fat	15.59 ± 5.59	15.35 ± 5.87	−0.24 (−1.02–0.55)	0.536
Chest expansion				
Upper chest	3.05 ± 0.49	3.75 ± 0.99	0.70 (0.15–1.25)	0.016
Middle chest	3.30 ± 0.66	3.63 ± 1.19	0.33 (−0.28–0.93)	0.267
Lower chest	3.12 ± 0.56	3.82 ± 1.30	0.70 (0.03–1.36)	0.041
Respiratory muscle strength				
MIP (cmH_2O)	105.88 ± 35.72	109.53 ± 28.35	3.65 (−4.74–12.03)	0.370
MEP (cmH_2O)	83.94 ± 30.46	88.59 ± 29.45	4.65 (−7.70–16.99)	0.437
Estimated VO_2max				
Relative VO_2max (ml/kg/min)	29.89 ± 6.70	35.45 ± 6.62	5.56 (3.09–8.02)	0.000
Absolute VO_2max (L/min)	2.52 ± 0.55	2.95 ± 0.40	0.43 (0.22–0.64)	0.001
Chest muscle strength (1-RM, kg)	31.01 ± 14.28	31.21 ± 12.47	0.20 (−3.24–3.65)	0.903
Blood biomarkers				
TC (mg/dL)	209.94 ± 40.86	207.94 ± 36.44	−2.00 (−13.05–9.05)	0.706
Triglyceride (mg/dL)	166.94 ± 41.12	172.35 ± 38.55	5.41 (−20.80–31.62)	0.667
LDL-C (mg/dL)	148.94 ± 42.74	150.88 ± 37.49	1.94 (−9.86–13.74)	0.732
HDL-C (mg/dL)	47.88 ± 11.57	49.88 ± 9.21	2.00 (−0.52–4.52)	0.112
HbA1c (%)	6.08 ± 0.57	6.05 ± 0.51	−0.03 (−0.13–0.07)	0.532
CRP (mg/L)*	2.21 ± 1.47	2.78 ± 2.02	0.56 (−0.15–1.28)	0.114

Abbreviations: %BF, percent of body fat; 1-RM, 1-repetition maximum; BMI, body mass index; BW, body weight; CRP, C-reactive protein; HbA1C, glycated hemoglobin type A1C; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; MEP, maximum expiration pressure; MIP, maximum inspiration pressure; TC, total cholesterol; VO_2max, maximum oxygen consumption.
The data was presented using mean ± standard deviation, except for mean differences which were presented using mean (upper and lower bound of 95% confidence interval of mean).

showed an improvement in all seven PSQI components and ESS,[30] whereas the present study found an improvement of daytime dysfunction and tended to alleviate in global PSQI. Meanwhile, the study by Servantes et al.[31] found that 3 months of home-based aerobic exercise with/without RT improved functional capacity, strength, endurance, and sleep indices in patients with chronic heart failure and sleep apnea.[31] Interestingly, both studies[30,31] showed a high adherence rate (98–100%) to the exercise programs compared with the present study (62.5%). Meanwhile, those previous studies[30,31] were intensively monitored, when compared with the present study, using phone calls and visiting the participants' homes. Moreover, the lack of motivation to exercise at home is another factor that can lead to lower exercise adherence.[32] Consequently, our results showed less effectiveness and improvement than previous studies.[30,31] In addition, the present study did not control the diet habits of the participant; therefore, all of anthropometric variables found no changes. To our knowledge, obesity is the most common risk of SDB.[1] Thus, the improvement in daytime dysfunction in our study may be irrelevant to obesity, which is similar to previous studies.[9,10] Meanwhile, the previous review studies also supported our finding that physical exercise can improve daytime sleepiness and sleep quality independently from body composition, that is, BMI in sleep apnea patients.[33,34] However, there are many mechanisms behind the improvement of the sleep parameter.[34] One theory claims that the severity of sleep apnea is related to the exercise capacity,[35] oxidative stress, endothelial dysfunction,[36] and nocturnal hypoxemia.[37] Interestingly, many previous studies confirmed that AIT or HIIT improved aerobic capacity and endothelial function.[38,39] Thus, an obvious increment in exercise capacity (estimated VO_2max) in our study may consequently improve daytime dysfunction and even other subjective sleep parameters, such as sleep quality. Furthermore, the improvement of ventilatory and peripheral muscles play a crucial role in increasing oxygen capacity.[40] Therefore, even though the effect of AIT combined with RT in our study did not show significant improvement in MIP & MEP, the mean difference of data showed an increase in respiratory muscle strength. It has been known that the accumulation of fat on the chest wall or the mediastinum causes a reduction of lung compliance, chest wall mobility, and functional residual capacity, which may induce more suffer on breathing during sleep.[41] Interestingly, even though our study found no changes in body composition, the effect of the combination exercise intervention remained to ead to an increase in chest expansion. The latter mechanism may finally reinforce an improvement of some sleep parameters in this study. However, none of the blood biomarkers was altered after 8 weeks of training. Thus, these blood biomarkers may counterbalance the positive effects of the exercise program. This might be induced by an increase in inflammatory markers, oxidative stress, impaired vascular endothelium, and by an intermittent hypoxia and sleep fragmentation in OSA or SDB.[42] These mechanisms might be the hindering cornerstone that results most of the subjective sleep disorders have limited improvement of subjective sleep disorders.

Recently, the studies have investigated the effects of a HIIT program in obese adults with SDB.[19,20] These studies showed an improvement in sleep indices[19] and subjective sleep disorders.[20] However, these studies prescribed a center-based exercise program tailored by the researchers, which was different from the present study.[19,20] The center-based training may have fewer confounding factors and be easier for the participants to follow the study protocol. However, the home-based AIT combined with RT in our study was safe, practical to follow in general, and especially feasible to prescribe to obese adults with SDB because none of the participants reported any serious events during exercise.

There were some limitations found in this study. First, some of participants used the RPE scale or talk test to monitor their exercise intensity. Thus, error in measuring the THR might have occurred even though the RPE scale or talk test was used instead of the heart rate tracker watch. Second, the exercise adherence rate in our study was lower than that in previous studies.[30,31] To solve this problem, an online-based exercise program using various mobile applications might be appropriate for monitoring and increasing exercise adherence. In addition, phone calls and internet-based communication via mobile applications could be applied for increasing the exercise adherence rate. These implementations might result in better improvements in subjective sleep disorders than those encountered in the present study. Thirdly, it should be noted that our study did not provide information on the physical activity levels of individual participants, which could potentially impact the study's outcomes. Therefore, future studies should include information on the physical activity of all participants to enhance the accuracy of the findings. However, there were some strengths found in our study. First, three subjective sleep disorders questionnaires were used in our study to monitor a diversity of subjective sleep disorders, including sleep quality, nighttime sleepiness, and daytime sleepiness. Therefore, the primary outcome measurement was comprehensively assessed by our teams. However, the polysomnography should confirm the presence of the SDB. Secondly, our study was the first to investigate the effectiveness of AIT through a home-based program, and no participants reported any significant adverse events during exercise. Thus, AIT combined with RT in a home-based setting is suitable for the current situation with the pandemic of COVID-19 worldwide. It was effective for an improvement in daytime dysfunction and other subjective sleep disorders. Future studies with a larger sample size under a controlled trial design matched for age, sex, and disease are highly recommended to confirm the present findings.

Funding Statement
The authors are thankful to the Research Institute for Health Science of Walailak University for partially granting the research fund (Research Grant WU-IRG-63-004).

Conflict of Interests
The authors have no conflict of interests to declare.

Acknowledgments
The authors are deeply grateful to all participants who dedicated their time to participate in this study.

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