The effectiveness of aerobic exercise in improving sleep quality in adults with various health conditions: a systematic review and meta-analysis

La eficacia del ejercicio aeróbico para mejorar la calidad del sueño en adultos con diversas afecciones de salud: una revisión sistemática y un metanálisis

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Abstract

Introduction. Aerobic exercise has been recognized as a potential non-pharmacological intervention to improve sleep quality, particularly in populations with diverse health conditions such as depression, obesity, polycystic ovary syndrome (PCOS), insomnia, substance dependence, breast cancer, functional dyspepsia, menopause, and mental disorders. Objective. This study evaluates the impact of aerobic exercise on sleep quality in adults with various health conditions through a systematic review and meta-analysis. Methodology. A systematic approach was used to collect and evaluate relevant literature from the Scopus and WoS databases, focusing on studies published between 2019 and 2024. Meta-analysis was conducted using a random-effects model to account for variability between studies, with heterogeneity measured using the Q test and I^2. Results. The results showed that aerobic exercise significantly improved sleep quality, as measured by the Pittsburgh Sleep Quality Index (PSQI), with a Standard Mean Difference (SMD) of -0.69 (95% CI -1.11, -0.27). However, the high level of heterogeneity (I^2 = 91%) indicates significant variation between studies, likely due to differences in methodology, sample population, type of aerobic exercise, and intervention duration. Aerobic exercise not only improves sleep quality but also has positive effects on quality of life and psychological well-being. Reductions in depression and anxiety symptoms, as well as improvements in quality of life, have been reported in several studies.

Discussion. These findings support the use of aerobic exercise as part of a comprehensive health management strategy to improve sleep quality and mental health in adults with various health conditions. Further research with more homogeneous designs, longer intervention durations, and the use of objective measurement tools is needed to strengthen the existing scientific evidence. This study makes a significant contribution to the existing literature and offers new insights for healthcare professionals in designing holistic and evidence-based exercise programs.

Keywords

Aerobic exercise, sleep quality, health conditions, mental health, quality of life.

Resumen

Introducción. El ejercicio aeróbico se ha reconocido como una posible intervención no farmacológica para mejorar la calidad del sueño, especialmente en poblaciones con diversas afecciones, como depresión, obesidad, síndrome de ovario poliquístico (SOP), insomnio, dependencia de sustancias, cáncer de mama, dispepsia funcional, menstruación y trastornos mentales.
Objetivo. Este estudio evalúa el impacto del ejercicio aeróbico en la calidad del sueño en adultos con diversas afecciones mediante una revisión sistemática y un metanálisis.
Metodología. Se utilizó un enfoque sistemático para recopilar y evaluar la literatura de las bases de datos Scopus y WoS, centrándose en los estudios publicados entre 2019 y 2024. El metanálisis se realizó mediante un modelo de efectos aleatorios para considerar la variabilidad entre estudios, y la heterogeneidad se midió mediante la prueba Q e I^2. Resultados. Los resultados mostraron que el ejercicio aeróbico mejoró significativamente la calidad del sueño, según lo medido por el Índice de Calidad del Sueño de Pittsburgh (PSQI), con una Diferencia de Medias Estándar (DME) de -0,69 (IC del 95 %: -1,11, -0,27). Sin embargo, el alto nivel de heterogeneidad (I^2 = 91 %) indica una variación significativa entre los estudios, probablemente debido a diferencias en la metodología, la población de la muestra, el tipo de ejercicio aeróbico y la duración de la intervención. El ejercicio aeróbico no solo mejora la calidad del sueño, sino que también tiene efectos positivos en la calidad de vida y el bienestar psicológico. Diversos estudios han reportado reducciones en los síntomas de depresión y ansiedad, así como mejoras en la calidad de vida. Discusión. Estos hallazgos respaldan el uso del ejercicio aeróbico como parte de una estrategia integral de gestión de la salud para mejorar la calidad del sueño y la salud mental en adultos con diversas afecciones. Se necesitan más investigaciones con diseños más homogéneos, intervenciones de mayor duración y el uso de herramientas de medición objetivas para fortalecer la evidencia científica existente. Este estudio hace una contribución significativa a la literatura existente y ofrece nuevos conocimientos para los profesionales de la salud en el diseño de programas de ejercicio holísticos y basados en evidencia.

Palabras clave

Ejercicio aeróbico, calidad del sueño, condiciones de salud, salud mental, calidad de vida.

Introduction

Insomnia is a prevalent disorder worldwide, with an estimated prevalence of around 30% of the population (C. Y. Huang et al., 2016), and the prevalence increases with age, reaching up to 60% in the elderly (C. Y. Huang et al., 2016; Zheng et al., 2017). Sleep quality among young adults has declined over the past few years, as revealed by several studies and reports (AlDabal, 2011; Edwards & Loprinzi, 2017; Vélez et al., 2013).

The prevalence of short sleep duration is relatively high in the United States, with 72.7% of individuals experiencing less than 9 hours of sleep among children aged 6-12 years, less than 8 hours among adolescents aged 13-18 years, and less than 7 hours among adults aged 18-60 years (Centers for Disease Control and Prevention, 2017). A recent survey involving college students from 26 countries with varying levels of economic income found that sleep durations of 6 hours, 7-8 hours, and 9 hours occurred in 39.2%, 46.9%, and 13.9% of the college student population, respectively (Peltzer & Pengpid, 2016). In the elderly population, sleep disorders are common and associated with both physical and psychological factors (Ha & Kim, 2019; Kim et al., 2019). Insomnia can lead to depression, anxiety, and metabolic syndrome (Mourady et al., 2017; Zheng et al., 2017). Reducing stress, when correlated with sleep, has a positive effect on sleep quality, both endocrinologically and biopsychologically, by reducing hyper-arousal and symptoms associated with insomnia (Hu et al., 2020).

Exercise can improve sleep quality control (Yang et al., 2012). As supported by existing research, participating in regular physical activity has been proven to enhance mood, promote a positive outlook, and potentially offer a way to manage sleep disorders among others (Alnawwar et al., 2023; Parra et al., 2020). The effectiveness of exercise on sleep quality applies to people of various age ranges and different chronic conditions (Aoike et al., 2018; Roveda et al., 2017). A 12-week functional and resistance training program showed a significant decrease in sleep disturbances and overall sleep quality scores (Silva et al., 2024). The Pittsburgh Sleep Quality Index (PSQI) is used to measure sleep quality. Responses on the PSQI are rated on a scale of 0 to 3 (total score of 21). Higher scores indicate poorer sleep quality (Buysse et al., 1989).

Aerobics is an evolving exercise program that integrates gymnastics, dance, music, based on aerobic exercise, and is characterized by aspects of health, strength, and beauty (Ma, 2022). Movements composed in aerobic gymnastics aim to shape a balanced personality, and this exercise also has a positive impact on the growth and development of body organs (López-Nuevo et al., 2021). The World Health Organization recommends that adults over 65 years old engage in moderate to vigorous-intensity aerobic and resistance exercises weekly (Who, 2010). Similarly, the American Academy of Sleep Medicine (AASM) recommends regular physical activity to maintain good sleep hygiene. AASM suggests that exercise can be a non-pharmacological intervention to improve sleep quality (Sateia et al., 2017).

Although increasing research shows that combined exercise regimens are more beneficial for reducing several components of multiple sclerosis (MS) compared to aerobic or resistance exercise alone (Dieli-Conwright et al., 2018; Earnest et al., 2014; Ostman et al., 2017), aerobic exercise (AE) also improves sleep quality among perimenopausal women (Zhao et al., 2022). In a study in Iran, the reliability of the Persian version of the PSQI had a Cronbach's alpha coefficient of 0.77 (Farrahi Moghaddam et al., 2012).

To our knowledge, no systematic literature review and meta-analysis have specifically examined the impact of AE on sleep quality alone. If any exist, they are less than five years old from the date of this study. Given this background, conducting a comprehensive systematic review and meta-analysis is crucial to identify, assess, and synthesize findings from previous research regarding the impact of AE on sleep quality for adults across various health conditions. This review aims to provide a deeper understanding of the relationship between AE and sleep quality in adults with diverse health conditions, and hopefully contribute to references for future research.

Method

This study employs the Systematic Literature Review (SLR) method, an approach designed to discover, assess, and interpret all available and relevant information in the literature or references to comprehensively answer research questions (Snyder, 2019; Xiao & Watson, 2019). SLR helps in providing a summary of the current knowledge or topics related to the research question (Kurniati et al., 2022), serving as a valuable source of information where authors need to summarize and evaluate trustworthy scientific literature using an organized method based on established objectives, making it useful for other researchers (Gopalakrishnan & Ganeshkumar, 2013).

The data sources for this study were obtained from searches in the Scopus and WoS databases. The chosen method for this literature review utilizes the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021), introduced in 2009 (Moher et al., 2009). PRISMA is one of the best methods that can help authors conduct systematic reviews and meta-analyses correctly and assists in reviewing the structure like a roadmap. The PRISMA method is also the most frequently used method in articles such as literature reviews (Hutton et al., 2016; Moher et al., 2016; Shamseer et al., 2015; Stewart et al., 2015).

The search strategy uses the query ("aerobic exercise" OR "aerobic training") AND "sleep quality" AND control AND (impact* OR effect*) AND physical literacy ” as the search strategy. Article selection is limited to new article publications within the last 5 years (Paul et al., 2021) namely from 2019 to 2024 currently with the literature search period starting from May 12, 2024. Eligibility criteria were necessary for selecting the appropriate articles (Ahmadi et al., 2018). Articles were screened based on inclusion and exclusion criteria as detailed in Table 1.

Table 1. The inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Adult participants	Child participants
2019-2024	Before 2019
Document type: Scopus and WoS indexed articles	Document type: books, book chapters, theses, short reports, conference papers, literature reviews, and those not indexed in Scopus and WoS
Types of aerobic exercises related to sleep quality interventions	Non-aerobic exercises and those not related to sleep quality

The data extraction process was conducted meticulously to ensure the accuracy and consistency of information obtained from each included study. Study characteristics data included the study duration, sample condition, exercise intervention, measurements, and primary outcomes. Demographic characteristics covered the country where the study was conducted, participant age, and sample size.

Data analysis was conducted using RevMan 5.4 and JASP 0.18.3. Given the substantial variability in some experimental endpoints, we used a random-effects model for all outcomes. Mean differences (MD) and standard deviations from baseline to final outcomes were extracted and entered into the database for analysis, with 95% confidence intervals (CIs) used to compare results. Heterogeneity among the studies included was measured using the Q and I^2 inconsistency tests. I^2 values of 25%, 50%, and 75% indicated low, moderate, and high heterogeneity, respectively (Higgins et al., 2003).

Statistical significance was determined at $p < 0.05$, and effect sizes along with 95% confidence intervals were graphically displayed using forest plots. Additionally, funnel plots, the Rank Correlation Test, and Egger's Test were used to evaluate the potential for publication bias. Funnel plots assist in visualizing the distribution of effect sizes among studies, where asymmetry in the plot can indicate publication bias. The Rank Correlation Test detects asymmetry in the funnel plot by calculating the correlation between effect sizes and standard errors. Egger's Test provides an additional statistical test for asymmetry in the funnel plot, which may suggest publication bias.

Results

The literature search which started on May 12, 2024 was completed on July 22, 2024 with initial identification results of 4,249 records in two databases (Scopus and Wos). As illustrated in Figure 1, during the initial screening stage, we selected research articles, resulting in 2,684 records that met the inclusion criteria. This means 1,565 records were excluded based on criteria that included types of books, book chapters, theses, short reports, conference papers, and literature reviews. Additionally, 1,370 records were excluded because the specified query was not fully present in the abstract list. Thus, the initial screening yielded 221 articles that met the inclusion criteria.

In the advanced screening stage, 8 records were removed because they were not in English, and 53 records were deemed ineligible by the automation tool for the years 2019-2024. The remaining articles were monitored by investigating the titles and abstracts based on their relevance to the current SLR and meta-analysis topic. These articles were analyzed, and relevant information was organized, considering several classifications and criteria aligned with the information needs (Table 1).

Data extraction was organized to categorize, evaluate, and summarize the articles that met the predetermined criteria. Through the analysis of the collected data, we were able to reach recommendations and results relevant to the topic. The analysis of the articles that met the inclusion criteria revealed key findings, showing that at least 17 articles were suitable based on the analysis (see Table 2).

Figure 1. PRISMA flow diagram showing the study identification and selection process.

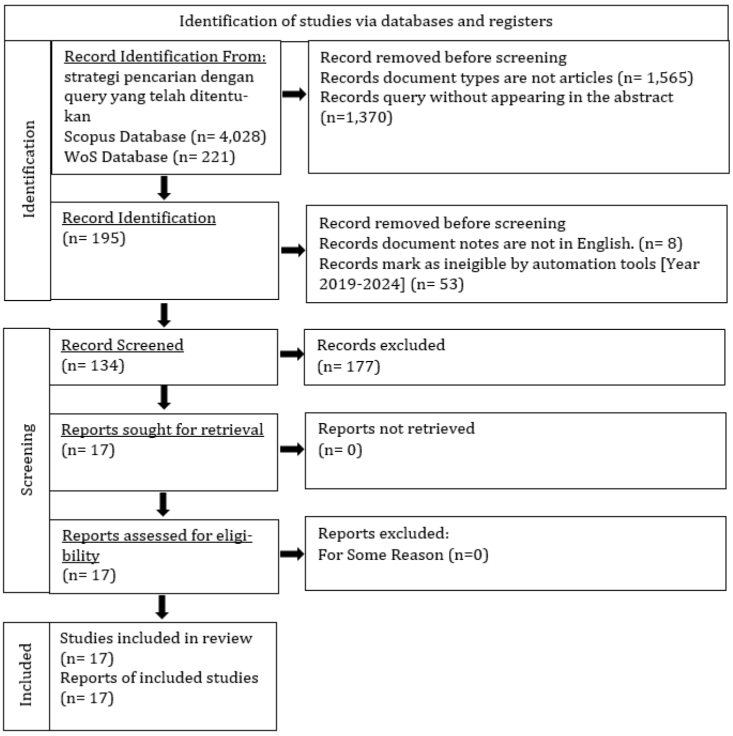


Table 2. Characteristics of included studies

Study	M/F or T	Age (Year)	Duration	Sample Condition	Intervention	Measurement	Result
(Gaudreau-Majeau et al., 2024)	14/26	53 ± 11	3 sessions/week for 8 weeks	PCR positive for COVID-19 and symptoms persisting for three months post-infection	Aerobic exercise, resistance training, and breathing exercises	Neuropsychological/cognitive (MoCA, HVLT, Digit Span, Trail Making Test, verbal fluency test), Psychological Condition (PSS), DS (GDS), Anxiety (STAI), SQ (PSQI)	There is no significant difference in sleep quality. Significant reduction in perceived stress and depression symptoms in the rehabilitation group compared to the control group
(Elgayar et al., 2024)	0/60	35-45	3 times/week for 12 weeks	Mild to moderate depression (BDI-II 14-28) and sleep disorder	AE with treadmill at 50-70% HRmax RE using 55-65% of 1RM	DS (BDI-II), SQ (PSQI)	Significant improvement in BDI-II and PSQI scores in the exercise group compared to baseline and control group. The AE/RE group showed greater improvement in BDI-II and PSQI scores compared to the AE and RE groups

(de Moraes Sirydakis et al., 2024)	20/19	52.50 ± 12.97	11 weeks, including balance, strength, and aerobic exercises (2 times/week)	Infected with moderate to severe COVID-19	Multicomponent physical exercise, balance, strength, and aerobic exercises	QoL (EQ-5D-5L, SQ (PSQI-BR), DS (PHQ-9), HP (visual analog scale on the EQ-5D-5L questionnaire)	ITT Analysis: Significant improvement in QoL and SQ (IG group), reduction in DS (IG and CG), non-significant HP. PP Analysis: Significant improvement in SQ and DS in both groups, non-significant QoL and HP
(Chang et al., 2024)	100	44.73 ± 11.697	10 days after radical mastectomy (baseline), after the first, third, and sixth chemotherapy cycles	Breast cancer undergoing chemotherapy post-radical mastectomy	Music therapy combined with aerobic exercise from the first to sixth chemotherapy session, along with routine nursing care	SQ (PSQI)	Significant reduction in IG global PSQI scores compared to CG at all measurement times. Significant improvement in all PSQI components except sleep medication use in IG
(Ezpeleta et al., 2023)	80	18-65	Baseline and 3 months post-intervention, 5 sessions/week, 60 minutes/session	Obesity and NAFLD	Alternate-day fasting (600 kcal on fasting days, ad libitum eating on feast days) combined with aerobic exercise	SQ (PSQI), Insomnia Severity (ISI), Obstructive Sleep Apnea Risk (OSA), Berlin Questionnaire	Significant BM reduction in combination and ADF groups, with no significant changes in SQ, sleep duration, or insomnia severity in all groups. OSA risk remained unchanged significantly in all groups
(Benham et al., 2023)	34	18–40	Baseline and 6 months post-intervention	PCOS	10 cycles of HIIT 30 seconds followed by LIIT 90 seconds	SQ (PSQI) measured at the beginning and end of the intervention	PSQI scores positively correlated with BMI, WC, BM, A1C, and insulin resistance. In the HIIT group, changes in PSQI scores were associated with BM and WC. PSQI scores with exercise were non-significant
(Sarıtoy & Usgu, 2023)	60	18-45	8 weeks, 3 times/week	Former smokers who quit within the last month	Submaximal aerobic exercise for MIA at 40% HRmax and MoIA at 60% HRmax	Anxiety (BAS), SQ (PSQI), SF-36, Nicotine Addiction Test (Fagerström), and Substance Craving Scale (SCS)	The MoIA group showed a significant reduction in SCS scores compared to MIA and control. In MIA, significant reduction in PSQI scores compared to control. No significant difference in SF-36 or BAS scores
(Huang et al., 2023)	89/0	36.85 ± 8.72	12 weeks	Treated at a drug rehabilitation institution	HQ: 4 times/week, 1 hour/session. AE: 4 times/week, 1 hour/session	SQ (PSQI), QoL (SF-36), and actigraphy for objective SQ measurement	HQ: Significant improvement in all PSQI aspects except sleep medication use, physical aspects, general health, body pain, and mental health of SF-36. AE: PSQI and objective SQ improved but not as well as HQ
(Alipouri et al., 2023)	48/0	20-50	8 weeks	Migraine without aura, vitamin D deficiency (20-29 ng/ml)	AE + VD: 3 times/week and vitamin D supplementation 50,000 IU/week. AE + Pla: 3 times/week. VD: Vitamin D supplementation 5	Depression severity (BDI), SQ (PSQI), physical self-concept (PSCQ)	AE + VD showed a significant reduction in BDI scores compared to AE + Pla, VD, and Placebo. AE + VD showed a significant improvement in PSQI scores compared to AE + Pla, VD, and Placebo. AE + VD showed a significant improvement in PSCQ scores compared to VD and Placebo. AE + Pla and VD groups also showed improvement, but not as well as AE + VD
(Dadgostar et al., 2023)	12/20	±43.7	12 weeks	Psychiatrist-diagnosed insomnia, systolic blood pressure <180 mmHg and diastolic <100 mmHg	Combined aerobic and resistance training, 3 days aerobic and 3 days resistance per week	SQ (PSQI) subjective and objective	IG showed significant improvement in subjective SQ, sleep duration, sleep efficiency, and total PSQI score. Non-significant in sleep latency, sleep disturbance, and sleep medication use. Significant changes in total PSQI score compared to CG

(Ali Ismail et al., 2022)	0/60	41-52	8 weeks	Perimenopause with functional dyspepsia	IG: Aerobic exercise + BRT. CG: BRT only	Cortisol, estradiol, SQ (PSQI), dyspepsia severity (GDSS), abdominal symptoms (VAS), DS, anxiety, and stress (DASS-42)	IG showed significant reduction in GDSS, VAS, cortisol, PSQI, and DASS-42 scores, and significant increase in estradiol levels. All variables except estradiol in CG showed significant improvement post-intervention
(Nourizadeh et al., 2022)	0/99	18-45	8 weeks	Breast cancer survivors	AG: at HE7, HE GU, and SP6 points for 10 minutes, 3 times/day. AEG: gym for 60 minutes, 3 times/week. CG: Routine care at oncology clinic	SQ (PSQI) measured before intervention	Total PSQI score significantly reduced in AG and AEG compared to CG. No significant difference between AG and AEG in reducing sleep disturbance scores
(Xu et al., 2022)	60	18–55	12 weeks	Methamphetamine dependence	IG: Moderate-intensity aerobic exercise for 1 hour, 5 times/week. CG: Conventional rehabilitation care without additional physical exercise	QoL (QOL-DA), anxiety (SAS), DS (SDS), SQ (PSQI), physical health test (heart rate, blood pressure, vital capacity, grip strength, vertical jump, flexibility, speed, reaction time)	Significant improvement in social health in IG compared to CG. Significant improvement in mental health: QOL-DA Psychology, SAS, PSQI. Significant improvement in physical health: QOL-DA Symptom, QOL-DA Physiology, vertical jump, sit-and-reach, 50-meter running
(Amalia et al., 2021)	0/24	±53.12	12 weeks	Menopause without severe disease	AEG: Aerobics 2x90 minutes/week. CG: Daily activities without additional exercise or memory enhancement supplements	Plasma estradiol (ELISA), SQ (PSQI), cognitive function (MoCA-Ina)	Significant improvement in SQ and cognitive function in AEG compared to CG. Non-significant increase in plasma estradiol in AEG and decrease in CG. PSQI and MoCA-Ina showed significant improvement in SQ and cognitive function in AEG compared to CG
(Zeibig et al., 2021)	20/52	35-44	12 weeks	Outpatient with psychiatric disorders (depression, anxiety, insomnia, ADHD)	IG: Moderate to vigorous aerobic exercise combined with behavioral change techniques for exercise sustainability	Severity of global and specific disorder symptoms (SCL-90-R), SQ (PSQI), Physical Activity, Exercise, and Sport Questionnaire (BSA)	Significant improvement in global symptom severity, depression, anxiety, and SQ in IG compared to CG. Significant increase in exercise amount in IG compared to CG. Significant post-intervention differences between groups for depression, SQ, and exercise amount
(Cheung et al., 2021)	30	±60	12 weeks	Diagnosed with stage IIIB or IV non-small cell lung cancer	AEG: 60 minutes at the gym 2x/week. Tai chi group: 2x/week based on 24-form Yang style. CG: Given written PA guidelines by WHO	SQ (PSQI), Depression (HADS), Fatigue (BFI), QoL (EORTC QLQ-C30 and LC13), PA (actigraphy), physical performance (6MWT, up-and-go, sit-to-stand, 1-leg standing), circadian rhythm (saliva cortisol)	No significant changes in SQ, anxiety, depression, or fatigue among groups. Significant improvement in agility and leg strength in AEG. Improvement in anxiety, exercise capacity, and balance in the tai chi group
(Song & Yu, 2019)	120	>60	16 weeks	Diagnosed with mild cognitive impairment	IG: MoIA program 3 group training sessions of 60 min/week involving up and down steps on a 10 cm high bench, accompanied by upper limb movements. CG: General health education program with eight classes every two weeks	Cognitive function (MoCA-C), HRQoL (QOL-AD-C), SQ (PSQI), depression (GDS)	Significant improvement in cognitive function and HRQoL in IG compared to CG. The relationship between exercise and improved cognitive function mediated by reduced depression symptoms and improved SQ

AE, Aerobic Exercise; RE, Resistance Exercise; HIIT, High-Intensity Interval Training; LIIT, Low-Intensity Interval Training; BRT, Behavioral Relaxation Training; AG, Acupressure Group; AEG, Aerobic Exercise Group; MoIA, Moderate-Intensity Aerobic; MIA, mild-intensity aerobic activity; MoCA, Montreal Cognitive Assessment; HVLT, Hopkins Verbal Learning Test; PSS, Perceived Stress Scale; GDS, Geriatric Depression Scale; STAI, State-Trait Anxiety Inventory; PSQI, Pittsburgh Sleep Quality Index; BDI-II, Beck Depression Inventory II; PHQ-9, Patient Health Questionnaire-9; EQ-5D-5L, EuroQol-5 Dimension-5 Levels; ISI, Insomnia Severity Index; SCL-90-R, Symptom Checklist-90-Revised; HADS, Hospital Anxiety and Depression Scale; BFI, Brief Fatigue Inventory; QoL-DA, Quality of Life in Drug Addiction; 6MWT, 6-Minute Walk Test; HRQoL, Health-Related Quality of Life; QoL-AD, Quality of Life in Alzheimer's Disease; VAS, Visual Analog Scale; GDSS, Gastrointestinal Symptom Severity; DASS-42, Depression, Anxiety, and Stress Scale-42; SDS, Self-Rating Depression Scale; SAS, Self-Rating Anxiety Scale; SCS, Substance Craving Scale; SF-36, Short Form-36 Health Survey; PSCQ, Physical Self-Concept Questionnaire; BAS, Brief Anxiety Scale; GDSS, Gastrointestinal Symptom Severity Scale; OAS, Obstructive Sleep Apnea Syndrome; NAFLD, Non-Alcoholic Fatty Liver Disease

Table 2 includes various studies utilizing different types of physical interventions such as resistance training, balance training, high-intensity interval training (HIIT), and primarily aerobic exercise. Additionally, it includes combinations of physical exercise with supplementary therapies like music therapy and behavioral therapy. The sample populations in these studies consist of individuals with diverse health conditions, including COVID-19, depression, obesity, non-alcoholic fatty liver disease (NAFLD), polycystic ovary syndrome (PCOS), insomnia, substance dependence, breast cancer, functional dyspepsia, menopause, and psychiatric disorders.

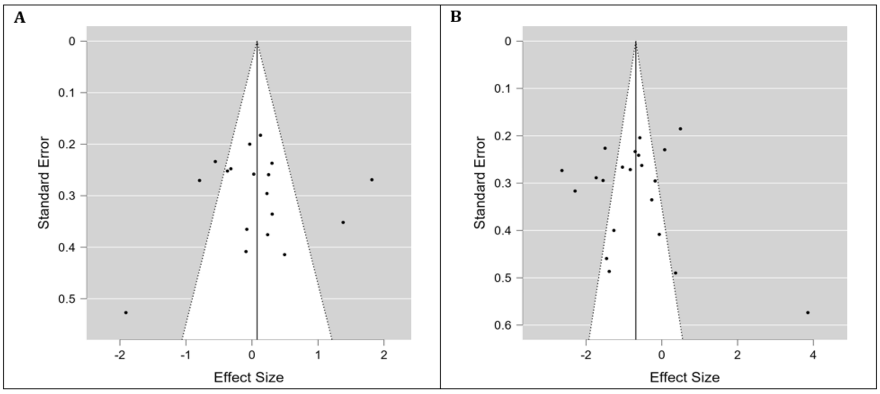
The duration of interventions in these studies varied from 8 to 16 weeks, with exercise frequencies ranging from 2 to 5 sessions per week. Outcome measurements were conducted using various validated tools, such as the Pittsburgh Sleep Quality Index (PSQI) to assess sleep quality, the Beck Depression Inventory-II (BDI-II) to measure depression levels, the Perceived Stress Scale (PSS) to evaluate stress levels, and various questionnaires to assess quality of life and other psychological conditions.

These studies demonstrate that physical interventions have a significant positive impact on sleep quality, reduction in depressive symptoms, reduction in anxiety levels, and improvement in quality of life. However, the specific effects of these interventions may vary depending on the intervention type and the participants' health condition. Overall, these findings support that physical interventions have substantial benefits in improving aspects of sleep quality, mental health, and physical health across various populations with diverse health conditions.

Table 3. Meta-Analysis for Fixed and Random Effects

Category	Sample size		Fixed and Random Effects			Test for overall effect						Residual Heterogeneity Estimates	
			Residual			SMD	Std. Error	z	p-value	95% CI		I^2 (%)	τ
	Experimental	Control	Chi^2	df	p-value					Lower	Upper		
Baseline	522	497	92.86	17	< 0.00001	0.08	0.17	0.51	0.61	-0.23	0.38	82	0.34
Intervantion	626	628	235.02	20	< 0.00001	-0.69	0.27	3.20	0.001	-1.11	-0.27	91	0.87

Figure 2. Funnel plot for each category, A) Baseline, B) Intervention



The analysis of the funnel plot offers several vital points to consider, particularly the symmetry of the funnel plot itself. A funnel plot is used to detect the presence of publication bias. Figure 2A displays the relationship between effect size and standard error. The analysis in Table 3 for the baseline shows that Kendall's τ has a value of 0.072 with p = 0.709, while Egger's test yields z = -0.752 with p = 0.452. Both tests indicate that there is no significant evidence of asymmetry in the funnel plot (p > 0.05). Therefore, it can be concluded that there is no significant publication bias in the analyzed data.

Table 4. Rank correlation test for funnel plot asymmetry and regression test for funnel plot asymmetry

Category	Kendall's		Egger's test	
	τ	p	z	p
Baseline	0.072	0.709	-0.752	0.452
Intervantion	-0.010	0.976	1.709	0.087

The funnel plot produced in Figure 2B shows good symmetry around the mean effect size, indicating that there is no significant publication bias. The distribution of points (representing individual studies) evenly spread on both sides of the mean effect line supports this conclusion. Furthermore, the regression asymmetry test, commonly known as Egger's test, in Table 3 for the intervention group, with a z-value of 1.709 and a p-value of 0.087, provides additional evidence that there is no significant publication bias (p > 0.05). These results suggest that the variation in observed effect sizes is not influenced by external factors unrelated to the research methodology. Additionally, the rank correlation test results (Kendall's τ) further support these findings. With Kendall's τ value of -0.010 and a p-value of 0.976, it can be concluded that there is no significant correlation between effect size and standard error, again indicating that there is no significant publication bias in the analyzed studies.

The forest plot displays the comparison between experimental and control groups from various studies. Each study provides standard deviation (SD), mean, and sample size (Total) for both groups. The Standard Mean Difference (SMD) and 95% confidence interval (CI) are also included for each study.

Results in Figure 4A, the forest plot of the baseline group, show that the total sample size for the experimental group is 522, while for the control group, it is 497. The heterogeneity analysis indicates a Tau^2 value of 0.34, a Chi^2 value of 92.86 with df = 17 and p < 0.00001, and an I^2 value of 82%. The high heterogeneity (I^2 = 82%) indicates significant variability among these studies, and the significant Chi^2 value also suggests that the differences among these studies are not due to chance alone. The overall effect analysis shows a Z-value of 0.51 with p = 0.61, indicating that there is no significant overall effect between the experimental and control groups (p > 0.05).

Figure 4. Forest plot for each category, A) Baseline

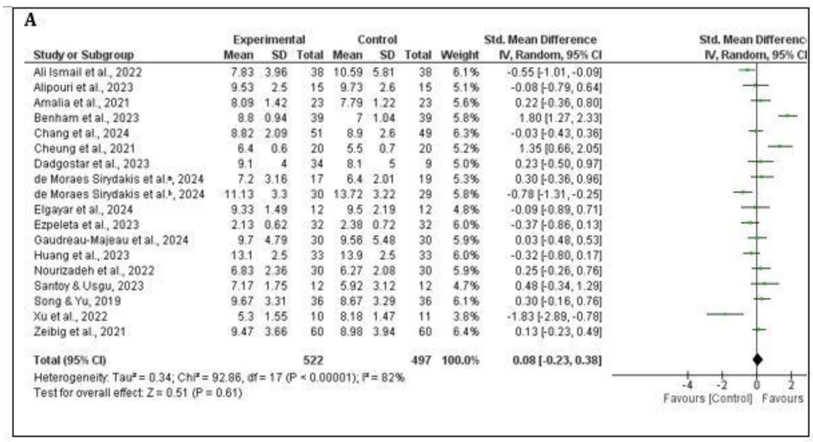
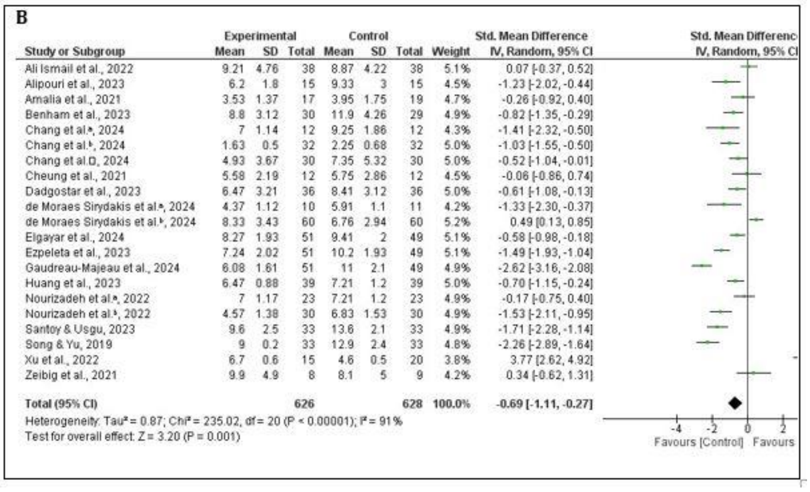


Figure 5. Forest plot for each category, B) Intervention



This high heterogeneity may be due to differences in methodology, sample populations, or interventions used, highlighting the need for further research to understand the factors contributing to this variability. Although the lack of a significant overall effect suggests that the interventions tested do not have a significant impact compared to the control overall, the differences in individual studies should be noted.

Studies with significant results have 95% CIs that do not cross the zero line, indicating a significant difference between the experimental and control groups (Ali Ismail et al., 2022; Elgayrat et al., 2024; Xu et al., 2022). Conversely, other studies with non-significant results have 95% CIs that cross the zero line, indicating no significant difference between the experimental and control groups.

The forest plot presented in Figure 4B for the intervention group, with a total sample size of 626 for the experimental group and 628 for the control group, shows that the overall standardized mean effect size from all studies is -0.69 with a 95% confidence interval (-1.11, -0.27). This indicates that, overall, the experimental group tends to have lower outcomes compared to the control group. The Z-value of 3.20 and p-value of 0.001 indicate statistically significant results, suggesting that the difference between the experimental and control groups is not due to chance.

Additionally, the heterogeneity analysis shows a Tau^2 value of 0.87, a Chi^2 value of 235.02 with df = 20, P < 0.00001, and an I^2 value of 91%. This indicates very high heterogeneity among the studies, suggesting considerable variation in effect sizes. This variation may be due to differences in study design, populations, or types of interventions used.

The contribution of individual studies indicates that some studies with large negative effect sizes, such as those conducted by Chang et al. (2024), Dadgostar et al. (2023), and Huang et al. (2023), show that the experimental groups in these studies had much lower outcomes compared to the control groups. Conversely, some studies, like the one conducted by Zeibig et al. (2021), show a positive effect, although not significant, indicating that the experimental group's results were better compared to the control group. Studies that show significant results include Benham et al. (2022), Chang et al.a (2024), Chang et al.b (2024), Cheung et al. (2023), de Moraes Sirydakis et al. (2024), Nourizadeh et al.a (2022), and Song & Yu (2019). In contrast, studies that show non-significant results include Ali Ismail et al. (2022), Alipouri et al. (2023), Amalia et al. (2021), Chang et al.c (2024), Dadgostar et al. (2023), Elgayyar et al. (2024), Ezpeleta et al. (2023), Gaudreau-Majeau et al. (2024), Huang et al. (2023), Nourizadeh et al. (2022b), Sarritoy & Usgui (2023), Xu et al. (2022), and Zeibig et al. (2021).

Discussion

This review reveals that aerobic exercise has a significant positive impact on the sleep quality of adults with various health disorders. The analysis includes 17 studies examining the effects of aerobic exercise on sleep quality, involving populations with diverse health conditions such as depression, obesity, non-alcoholic fatty liver disease (NAFLD), polycystic ovary syndrome (PCOS), insomnia, substance dependence, breast cancer, functional dyspepsia, menopause, and psychiatric disorders.

Aerobic exercise consistently shows improvements in sleep quality, as measured using the Pittsburgh Sleep Quality Index (PSQI). For example, a study by Elgayar et al. (2024) demonstrated that aerobic and resistance training interventions significantly improved PSQI and Beck Depression Inventory-II (BDI-II) scores after 12 weeks. Additionally, a study by Xu et al. (2022) found that moderate-intensity aerobic exercise over 12 weeks enhanced physical and mental health, as well as sleep quality. The high level of heterogeneity (I^2 = 91% in the intervention group) indicates significant variations among the analyzed studies. These variations may be due to differences in study design, sample populations, types of aerobic exercise, and intervention durations. For instance, studies by Chang et al. (2024) and Huang et al. (2023) showed lower results in the experimental group compared to the control group, which may be due to methodological differences or sample characteristics.

In addition to improving sleep quality, aerobic exercise also positively affects quality of life and psychological conditions. A study by de Moraes Sirydakis et al. (2024) showed significant improvements in quality of life (QoL) and reductions in depressive symptoms after a multicomponent physical exercise intervention. Another study by Ali Ismail et al. (2022) found that aerobic exercise combined with breathing techniques (BRT) reduced cortisol levels and improved sleep quality and estradiol levels in peri-menopausal women with functional dyspepsia.

The meta-analysis indicates that aerobic exercise has a significant effect on improving sleep quality, with a Standard Mean Difference (SMD) of -0.69 (95% CI -1.11, -0.27) in the intervention group, suggesting that the experimental group tends to have better sleep quality compared to the control group. However, the high heterogeneity highlights the need for further research to understand the factors contributing to the variation in results. Several factors influencing the study outcomes include the type of aerobic exercise used, the duration and frequency of the intervention, and sample characteristics. For instance, a study by Chang et al. (2024) utilized a combination of music therapy and aerobic exercise, resulting in significant improvements in all components of the PSQI except for the use of sleep medication. Another study by Benham et al. (2023) demonstrated that high-intensity interval training (HIIT) correlated with improvements in PSQI, although not significantly, in women with polycystic ovary syndrome (PCOS).

Several limitations identified in this analysis include methodological variations among studies, different intervention durations, and the use of various tools to assess sleep quality. Additionally, most studies employed subjective approaches to evaluate sleep quality, which psychological factors can influence. Using actigraphy or polysomnography as objective measures of sleep quality remains limited.

These findings have significant clinical implications for health practitioners in designing appropriate exercise programs for individuals with specific health conditions. Aerobic exercise interventions can be integrated as part of a comprehensive health management strategy to improve sleep quality and mental health. Furthermore, additional research with more homogeneous designs and the use of objective measurement tools is needed to confirm these findings and strengthen the existing scientific evidence. Overall, aerobic exercise has a significant positive impact on sleep quality in adults with various health disorders. This intervention not only improves sleep quality but also contributes to a better quality of life and psychological conditions. Despite variations in results among studies, these findings support using aerobic exercise as an effective non-pharmacological intervention for enhancing sleep quality and mental health.

This study has several limitations that need to be considered in interpreting the results. First, the search was limited to literature available in English, which may limit the inclusion of relevant articles in other languages. Second, the articles included in this analysis were only from indexed databases such as Scopus and WoS, which may not cover the full spectrum of existing research. Searching other databases or including grey literature such as theses, conference proceedings, and books may have added a wider variety of findings. Furthermore, differences in methodology between studies included in the meta-analysis, such as variability in intervention duration, type of aerobic exercise used, and sleep quality measurement instruments, contributed to the high heterogeneity in the results of the analysis. This high heterogeneity suggests that other factors such as study design, participant characteristics, and methods used may have influenced the results found.

Therefore, although the main findings of this study demonstrate the effectiveness of aerobic exercise in improving sleep quality, further studies with more homogeneous designs, longer intervention durations, and more consistent use of objective measurement tools are needed to strengthen the existing evidence and address these limitations. Future research should consider using more uniform study designs, longer intervention durations, and objective tools for assessing sleep quality. Additionally, further studies are needed to explore the underlying biological mechanisms linking aerobic exercise and sleep quality. Research involving larger samples and more diverse populations is also required to reinforce the generalizability of these findings. Thus, aerobic exercise can be viewed as a potentially effective and efficient approach for improving sleep quality and mental health in adults with various health conditions. These findings make a significant contribution to the existing literature and provide new insights for health practitioners in designing holistic and evidence-based exercise programs.

Conclusions

Analysis of 17 studies involving populations with diverse health conditions such as depression, obesity, polycystic ovary syndrome (PCOS), insomnia, and breast cancer found that aerobic exercise consistently improves sleep quality as measured by the Pittsburgh Sleep Quality Index (PSQI). Aerobic exercise, whether performed alone or combined with other interventions such as music therapy, showed significant improvements in PSQI scores and reductions in symptoms of depression and anxiety after 8 to 16 weeks of intervention. The meta-analysis revealed a significant effect of aerobic exercise with a Standard Mean Difference (SMD) of -0.69 (95% CI -1.11, -0.27) in the intervention group, indicating better sleep quality compared to the control group. However, the high level of heterogeneity (I^2 = 91%) highlights significant variation among the studies. These findings have clinical implications for health practitioners in designing exercise programs for individuals with health conditions. Further research with more homogeneous designs, longer intervention durations, and the use of objective measurement tools is needed to strengthen the existing scientific evidence.

References

Ahmadi, H., Gholamzadeh, M., Shahmoradi, L., Nilashi, M., & Rashvand, P. (2018). Diseases diagnosis using fuzzy logic methods: A systematic and meta-analysis review. In *Computer Methods and Programs in Biomedicine*, 161, 145–172. https://doi.org/10.1016/j.cmpb.2018.04.013

AlDabal, L. (2011). Metabolic, Endocrine, and Immune Consequences of Sleep Deprivation. *The Open Respiratory Medicine Journal*, *5*(1), 31–43. https://doi.org/10.2174/1874306401105010031

Ali Ismail, A. M., Saad, A. E., Fouad Abd-Elrahman, N. A., & Abdelhalim Elfahl, A. M. (2022). Effect of Benson's relaxation therapy alone or combined with aerobic exercise on cortisol, sleeping quality, estrogen, and severity of dyspeptic symptoms in perimenopausal women with functional dyspepsia. *European Review for Medical and Pharmacological Sciences*, *26*(22), 8342-8350. https://doi.org/10.26355/eurrev_202211_30367

Alipouri, M., Amiri, E., Hoseini, R., & Hezarkhani, L. A. (2023). Effects of eight weeks of aerobic exercise and vitamin D supplementation on psychiatric comorbidities in men with migraine and vitamin D insufficiency: A randomized controlled clinical trial. *Journal of Affective Disorders*, 334, 12–20. https://doi.org/10.1016/j.jad.2023.04.108

Alnawwar, M. A., Alraddadi, M. I., Algethmi, R. A., Salem, G. A., Salem, M. A., & Alharbi, A. A. (2023). The Effect of Physical Activity on Sleep Quality and Sleep Disorder: A Systematic Review. *Cureus*. https://doi.org/10.7759/cureus.43595

Amalia, L., Fitriana, L. A., Darmawati, I., Nasution, L. A., Anggadiredja, K., Setiawan, I., Suherman, A., Novan, N. A., Komariyah, L., & Adnyana, I. K. (2021). The Effect of Aerobic Exercises on Estradiol Plasma, Quality of Sleep, and Cognitive Function in Menopausal Women. *Malaysian Journal of Medicine and Health Sciences*, *17*, 28–32.

Aoike, D. T., Baria, F., Kamimura, M. A., Ammirati, A., & Cuppari, L. (2018). Home-based versus center-based aerobic exercise on cardiopulmonary performance, physical function, quality of life and quality of sleep of overweight patients with chronic kidney disease. *Clinical and Experimental Nephrology*, *22*(1), 87–98. https://doi.org/10.1007/s10157-017-1429-2

Benham, J. L., Booth, J. E., Goldfield, G., Friedenreich, C. M., Rabi, D. M., & Sigal, R. J. (2023). Self-reported sleep quality and exercise in polycystic ovary syndrome: A secondary analysis of a pilot randomized controlled trial. *Clinical Endocrinology*, *98*(5), 700–708. https://doi.org/10.1111/cen.14900

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2). https://doi.org/10.1016/0165-1781(89)90047-4

Centers for Disease Control and Prevention. (2017). How Much Sleep Do I Need? *Cdc.Gov*, *12*(6).

Chang, L., Wang, Y., Zhang, J., Zhao, W., Li, X., & Yang, L. (2024). Effect of music therapy combined with aerobic exercise on sleep quality among breast cancer patients undergoing chemotherapy after a radical mastectomy: a randomized controlled trial. *BMC Women's Health*, *24*(1), 408. https://doi.org/10.1186/s12905-024-03241-6

Cheung, D. S. T., Takemura, N., Lam, T. C., Ho, J. C. M., Deng, W., Smith, R., Yan, Y., Lee, A. W. M., & Lin, C. C. (2021). Feasibility of Aerobic Exercise and Tai-Chi Interventions in Advanced Lung Cancer Patients: A Randomized Controlled Trial. *Integrative Cancer Therapies*, *20*. https://doi.org/10.1177/15347354211033352

Dadgostar, H., Basharkhah, A., Ghalehbandi, M., & Kashaninasab, F. (2023). An investigation on the effect of exercise on insomnia symptoms. *International Journal of Preventive Medicine*, *14*(1). https://doi.org/10.4103/ijpvm.ijpvm_204_21

de Moraes Sirydakis, M. E., Danielevicz, A., de Melo, P. U. G., Bregalda, J., Constantini, M. I., Pelliciari, G., Sampaio, S. K., Rech, C. R., Maurici, R., Gerage, A. M., & Delevatti, R. S. (2024). Improving quality of life, sleep and mental health through multicomponent training versus Brazilian recommendations of physical activity in post-COVID-19 patients: CORE-study–A randomized controlled trial. *Mental Health and Physical Activity*, *27*. https://doi.org/10.1016/j.mhpa.2024.100615

Dieli-Conwright, C. M., Courneya, K. S., Demark-Wahnefried, W., Sami, N., Lee, K., Buchanan, T. A., Spicer, D. V., Tripathy, D., Bernstein, L., & Mortimer, J. E. (2018). Effects of aerobic and resistance exercise on metabolic syndrome, sarcopenic obesity, and circulating biomarkers in overweight or obese survivors of breast cancer: A randomized controlled trial. *Journal of Clinical Oncology*, *36*(9). https://doi.org/10.1200/JCO.2017.75.7526

Earnest, C. P., Johannsen, N. M., Swift, D. L., Gillison, F. B., Mikus, C. R., Lucia, A., Kramer, K., Lavie, C. J., & Church, T. S. (2014). Aerobic and strength training in concomitant metabolic syndrome and type 2 diabetes. *Medicine and Science in Sports and Exercise*, *46*(7). https://doi.org/10.1249/MSS.0000000000000242

Edwards, M. K., & Loprinzi, P. D. (2017). Experimentally increasing sedentary behavior results in decreased sleep quality among young adults. *Mental Health and Physical Activity*, *12*. https://doi.org/10.1016/j.mhpa.2017.04.002

Elgayar, S. L., Elgendy, S., & Youssef, T. M. (2024). Comparative Effects of Aerobic, Resistance, and Combined exercises on Depression and Sleep Quality in Women with Controlled Hypothyroidism. A Randomized Controlled Trial. *Advances in Rehabilitation*, *37*(4). https://doi.org/10.5114/areh.2024.136292

Ezpeleta, M., Gabel, K., Cienfuegos, S., Kalam, F., Lin, S., Pavlou, V., & Varady, K. A. (2023). Alternate-Day Fasting Combined with Exercise: Effect on Sleep in Adults with Obesity and NAFLD. *Nutrients*, *15*(6). https://doi.org/10.3390/nu15061398

Farrahi Moghaddam, J., Nakhaee, N., Sheibani, V., Garrusi, B., & Amirkafi, A. (2012). Reliability and validity of the Persian version of the Pittsburgh Sleep Quality Index (PSQI-P). *Sleep and Breathing*, *16*(1). https://doi.org/10.1007/s11325-010-0478-5

Gaudreau-Majeau, F., Gagnon, C., Djedaa, S. C., Bérubé, B., Malo, J., Iglesies-Grau, J., Gayda, M., Bherer, L., & Besnier, F. (2024). Cardiopulmonary rehabilitation's influence on cognitive functions, psychological state, and sleep quality in long COVID-19 patients: A randomized controlled trial. *Neuropsychological Rehabilitation*. https://doi.org/10.1080/09602011.2024.2338613

Gopalakrishnan, S., & Ganeshkumar, P. (2013). Systematic reviews and meta-analysis: Understanding the best evidence in primary healthcare. *Journal of Family Medicine and Primary Care*, *2*(1). https://doi.org/10.4103/2249-4863.109934

Ha, J., & Kim, J. (2019). Factors influencing perceived health status among elderly workers: Occupational stress, frailty, sleep quality, and motives for food choices. *Clinical Interventions in Aging*, *14, 1493–1501*. https://doi.org/10.2147/CIA.S210205

Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. In *British Medical Journal*, 327(7414), 557–560. https://doi.org/10.1136/bmj.327.7414.557

Hu, Y., Visser, M., & Kaiser, S. (2020). Perceived Stress and Sleep Quality in Midlife and Later: Controlling for Genetic and Environmental Influences. *Behavioral Sleep Medicine*, *18*(4), 537–549. https://doi.org/10.1080/15402002.2019.1629443

Huang, C. Y., Chang, E. T., & Lai, H. L. (2016). Comparing the effects of music and exercise with music for older adults with insomnia. *Applied Nursing Research*, *32*. https://doi.org/10.1016/j.apnr.2016.06.009

Huang, X., Wang, X., Shao, Y., Lin, A., Zhang, Z., Qi, H., Sun, C., & Yang, H. (2023). Effects of health qigong exercise on sleep and life quality in patients with drug abuse. *Hong Kong Journal of Occupational Therapy*, *36*(1), 13–19. https://doi.org/10.1177/15691861231156002

Hutton, B., Catalá-López, F., & Moher, D. (2016). The PRISMA statement extension for systematic reviews incorporating network meta-analysis: PRISMA-NMA. *Medicina Clínica (English Edition)*, *147*(6). https://doi.org/10.1016/j.medcle.2016.10.003

Kim, H. J., Oh, S. Y., Joo, J. H., Dong-Woo, C., & Eun-Cheol, P. (2019). The relationship between sleep duration and perceived stress: Findings from the 2017 community health survey in Korea. *International Journal of Environmental Research and Public Health*, *16*(17). https://doi.org/10.3390/ijerph16173208

Kurniati, E., Suwono, H., Ibrohim, I., Suryadi, A., & Saefi, M. (2022). International Scientific Collaboration and Research Topics on STEM Education: A Systematic Review. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(4). https://doi.org/10.29333/ejmste/11903

López-Nuevo, C. E., Sanchez-Molina, J., & Ureña, G. D. (2021). Adherence to healthy habits and academic performance in Vocational Education Students. *Retos*, *42,* 118–125. https://doi.org/10.47197/RETOS.V42I0.87138

Ma, C. (2022). Design and Practice of Aerobics Teaching Design Based on Data Fusion Algorithm. *Wireless Communications and Mobile Computing*, *2022*. https://doi.org/10.1155/2022/1275508

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Journal of Clinical Epidemiology*, *62*(10). https://doi.org/10.1016/j.jclinepi.2009.06.005

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., Estarli, M., Barrera, E. S. A., Martínez-Rodríguez, R., Baladia, E., Agüero, S. D., Camacho, S., Buhring, K., Herrero-López, A., Gil-González, D. M., Altman, D. G., Booth, A., … Whitlock, E. (2016). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Revista Espanola de Nutricion Humana y Dietetica*, *20*(2). https://doi.org/10.1186/2046-4053-4-1

Mourady, D., Richa, S., Karam, R., Papazian, T., Moussa, F. H., El-Osta, N., Kesrouani, A., Azouri, J., Jabbour, H., Hajj, A., & Khabbaz, L. R. (2017). Associations between quality of life, physical activity, worry, depression and insomnia: A cross-sectional designed study in healthy pregnant women. *PLoS ONE*, *12*(5). https://doi.org/10.1371/journal.pone.0178181

Nourizadeh, R., Khanipour, S., Zamiri, R. E., Namin, M. S., Khalili, A., & Hakimi, S. (2022). A Comparison of the Effects of Self-Acupressure and Aerobic Exercises on Sleep Disorders of Breast Cancer Survivors: A Controlled Randomized Clinical Trial. *Medical Acupuncture*, *34*(2), 131–136. https://doi.org/10.1089/acu.2020.1515

Ostman, C., Smart, N. A., Morcos, D., Duller, A., Ridley, W., & Jewiss, D. (2017). The effect of exercise training on clinical outcomes in patients with the metabolic syndrome: A systematic review and meta-analysis. *Cardiovascular Diabetology*, *16*(1). https://doi.org/10.1186/s12933-017-0590-y

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., & Moher, D. (2021). Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. *Journal of Clinical Epidemiology*, *134*. https://doi.org/10.1016/j.jclinepi.2021.02.003

Parra, E., Arone, A., Amadori, S., Mucci, F., Palermo, S., & Marazziti, D. (2020). Impact of Physical Exercise on Psychological Well-being and Psychiatric Disorders. *Journal for ReAttach Therapy and Developmental Diversities*, *3*(2). https://doi.org/10.26407/2020jrtdd.1.39

Paul, J., Lim, W. M., O'Cass, A., Hao, A. W., & Bresciani, S. (2021). Scientific procedures and rationales for systematic literature reviews (SPAR-4-SLR). *International Journal of Consumer Studies*. https://doi.org/10.1111/ijcs.12695

Peltzer, K., & Pengpid, S. (2016). Sleep duration and health correlates among university students in 26 countries. *Psychology, Health and Medicine*, *21*(2). https://doi.org/10.1080/13548506.2014.998687

Quadros da Silva, E., Bernardi, N. G., Marques, M. G. de S., Morais, S. R. L. de, Nascimento Júnior, J. R. A. do, Branco, B. H. M., & Oliveira, D. V. de. (2024). Effects of 12 weeks of functional and resistance training on stress perception and sleep quality in Brazilianolder people. *Retos*, 56, 690-698. https://doi.org/10.47197/retos.v56.104513

Roveda, E., Vitale, J. A., Bruno, E., Montaruli, A., Pasanisi, P., Villarini, A., Gargano, G., Galasso, L., Berrino, F., Caumo, A., & Carandente, F. (2017). Protective Effect of Aerobic Physical Activity on Sleep Behavior in Breast Cancer Survivors. *Integrative Cancer Therapies*, *16*(1). https://doi.org/10.1177/1534735416651719

Sarıtoy, A., & Usgu, S. (2023). The effect of aerobic exercises of different intensities on anxiety, cigarette addiction, sleep quality, and quality of life in former smokers. *Irish Journal of Medical Science*, *192*(3). https://doi.org/10.1007/s11845-022-03065-z

Sateia, M. J., Buysse, D. J., Krystal, A. D., Neubauer, D. N., & Heald, J. L. (2017). Clinical Practice Guideline for the Pharmacologic Treatment of Chronic Insomnia in Adults: An American academy of sleep medicine clinical practice guideline. *Journal of Clinical Sleep Medicine*, *13*(2). https://doi.org/10.5664/jcsm.6470

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., Altman, D. G., Booth, A., Chan, A. W., Chang, S., Clifford, T., Dickersin, K., Egger, M., Gøtzsche, P. C., Grimshaw, J. M., Groves, T., Helfand, M., … Whitlock, E. (2015). Preferred reporting items for systematic review and meta-analysis protocols (prisma-p) 2015: Elaboration and explanation. In *BMJ (Online)* (Vol. 349). https://doi.org/10.1136/bmj.g7647

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*. https://doi.org/10.1016/j.jbusres.2019.07.039

Song, D., & Yu, D. S. F. (2019). Effects of a moderate-intensity aerobic exercise programme on the cognitive function and quality of life of community-dwelling elderly people with mild cognitive impairment: A randomised controlled trial. *International Journal of Nursing Studies*, *93*. https://doi.org/10.1016/j.ijnurstu.2019.02.019

Stewart, L. A., Clarke, M., Rovers, M., Riley, R. D., Simmonds, M., Stewart, G., & Tierney, J. F. (2015). Preferred reporting items for a systematic review and meta-analysis of individual participant data: The PRISMA-IPD statement. In *JAMA - Journal of the American Medical Association*, 313(16), 1657–1665. https://doi.org/10.1001/jama.2015.3656

Vélez, J. C., Souza, A., Traslaviña, S., Barbosa, C., Wosu, A., Andrade, A., Frye, M., Fitzpatrick, A. L., Gelaye, B., & Williams, M. A. (2013). The Epidemiology of Sleep Quality and Consumption of Stimulant Beverages among Patagonian Chilean College Students. *Sleep Disorders*, *2013, 1–10*. https://doi.org/10.1155/2013/910104

Who, W. H. O. (2010). Global recommendations on physical activity for health. *Geneva: World Health Organization*. https://doi.org/10.1080/11026480410034349

Xiao, Y., & Watson, M. (2019). Guidance on Conducting a Systematic Literature Review. In *Journal of Planning Education and Research*, 39(1), 93–112. https://doi.org/10.1177/0739456X17723971

Xu, J., Zhu, Z., Liang, X., Huang, Q., Zheng, T. Z., & Li, X. (2022). Effects of moderate-intensity exercise on social health and physical and mental health of methamphetamine-dependent individuals: A randomized controlled trial. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.997960

Yang, P. Y., Ho, K. H., Chen, H. C., & Chien, M. Y. (2012). Exercise training improves sleep quality in middle-aged and older adults with sleep problems: A systematic review. *Journal of Physiotherapy*, *58*(3), 157–163. https://doi.org/10.1016/S1836-9553(12)70106-6

Zeibig, J. M., Seiffer, B., Sudeck, G., Rösel, I., Hautzinger, M., & Wolf, S. (2021). Transdiagnostic efficacy of a group exercise intervention for outpatients with heterogenous psychiatric disorders: a randomized controlled trial. *BMC Psychiatry*, *21*(1). https://doi.org/10.1186/s12888-021-03307-x

Zhao, Y., Niu, H., & Liu, S. (2022). Effects of aerobics training on anxiety, depression and sleep quality in perimenopausal women. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.1025682

Zheng, B., Yu, C., Lin, L., Du, H., Lv, J., Guo, Y., Bian, Z., Chen, Y., Yu, M., Li, J., Chen, J., Chen, Z., & Li, L. (2017). Associations of domain-specific physical activities with insomnia symptoms among 0.5 million Chinese adults. *Journal of Sleep Research*, *26*(3), 330–337. https://doi.org/10.1111/jsr.12507

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