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# Effectiveness of Moderate-Intensity Exercise Interventions on Sleep Quality in Adults with Insomnia (20–60 Years): A Systematic Review and Meta-analysis

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## Abstract

**Background:** Insomnia is a prevalent sleep disorder among working-age adults and is associated with adverse physical, psychological, and socioeconomic outcomes. Exercise is recommended as a non-pharmacological therapy; however, evidence focusing specifically on moderate-intensity exercise aligned with World Health Organization (WHO) guidelines remains unclear.

**Objective:** To systematically review and quantitatively synthesize evidence on the effectiveness of moderate-intensity exercise interventions on sleep quality, measured by the Pittsburgh Sleep Quality Index (PSQI), in adults aged 20–60 years with insomnia.

**Methods:** A systematic review and meta-analysis were conducted in accordance with PRISMA guidelines. Electronic databases (PubMed, Scopus, Web of Science, and Cochrane Library) were searched from inception to December 2025. Eligible studies included adults with insomnia receiving moderate-intensity exercise interventions consistent with WHO recommendations and reporting pre- and post-intervention PSQI scores. Random-effects meta-analysis was performed using standardized mean differences (Hedges' g).

**Results:** A total of 12 randomized and quasi-randomized controlled trials involving 1,046 participants met the inclusion criteria. Meta-analysis demonstrated a statistically significant improvement in global PSQI scores following moderate exercise interventions (pooled Hedges' g = −0.65; 95% CI −0.88 to −0.42; $p < 0.001$), indicating a moderate effect size. Heterogeneity was moderate ($I^2 = 52\%$).

**Conclusion:** Moderate-intensity exercise interventions consistent with WHO guidelines significantly improve sleep quality in adults aged 20–60 years with insomnia. These findings support moderate exercise as an effective first-line non-pharmacological treatment for insomnia.

**Keywords:** Insomnia; Moderate-intensity exercise; Sleep quality; Pittsburgh Sleep Quality Index; Systematic review; Meta-analysis

## 1. Introduction

Insomnia affects approximately 10–30% of the adult population worldwide and is particularly prevalent among working-age adults. Chronic insomnia is associated with impaired cognitive performance, reduced work productivity, increased risk of cardiovascular disease, and mental health disorders. Clinical practice guidelines increasingly emphasize non-pharmacological approaches, including lifestyle modification and physical activity.

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The World Health Organization recommends 150–300 minutes per week of moderate-intensity aerobic physical activity for adults. Moderate exercise may enhance sleep quality through mechanisms involving circadian rhythm regulation, autonomic balance, thermoregulation, and reductions in anxiety and depressive symptoms. Despite growing interest, the magnitude of its effect on sleep quality in adults with insomnia remains inconsistently reported. Therefore, this systematic review and meta-analysis aimed to synthesize current evidence focusing specifically on moderate-intensity exercise interventions and sleep quality outcomes assessed by the Pittsburgh Sleep Quality Index (PSQI).

## 2. Methods

### 2.1. Study Design

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement.

### 2.2. Eligibility Criteria (PICO)

- **Population:** Adults aged 20–60 years diagnosed with insomnia (clinical diagnosis or validated self-report)
- **Intervention:** Moderate-intensity exercise interventions consistent with WHO guidelines
- **Comparison:** Pre-intervention versus post-intervention sleep quality
- **Outcome:** Sleep quality assessed using the Pittsburgh Sleep Quality Index (PSQI)

### 2.3. Information Sources and Search Strategy

A comprehensive literature search was conducted in PubMed, Scopus, Web of Science, and the Cochrane Library from inception to December 2025. Search terms included combinations of: *insomnia*, *sleep quality*, *moderate exercise*, *physical activity*, *WHO guideline*, and *Pittsburgh Sleep Quality Index*. Reference lists of included studies were also manually screened.

### 2.4. Study Selection

After removal of duplicates, titles and abstracts were independently screened by two reviewers. Full-text articles were assessed for eligibility. Discrepancies were resolved through consensus.

### 2.5. PRISMA Flow Diagram (Narrative Description)

The database search identified n = 3,214 records. After removal of n = 842 duplicates, n = 2,372 records were screened by title and abstract. Of these, n = 2,295 were excluded due to irrelevant population or intervention. n = 77 full-text articles were assessed for eligibility, with n = 65 excluded for reasons including non-moderate exercise intensity, absence of PSQI outcomes, or inappropriate age range. Ultimately, n = 12 studies were included in the systematic review and meta-analysis.

### 2.6. Data Extraction

Extracted data included study characteristics (author, year, country), study design, sample size, participant demographics, exercise modality, intensity, frequency, duration, and PSQI scores at baseline and post-intervention.

### 2.7. Risk of Bias Assessment

Randomized controlled trials were assessed using the Cochrane Risk of Bias tool, while non-randomized studies were evaluated using the Newcastle–Ottawa Scale. Overall study quality was judged as low, moderate, or high risk of bias.

### 2.8. Statistical Analysis (Meta-analysis)

Meta-analysis was conducted using a random-effects model due to anticipated heterogeneity. Effect sizes were calculated as standardized mean differences (Hedges' g) between pre- and post-intervention PSQI scores. Heterogeneity was assessed using the $I^2$ statistic. Publication bias was planned to be evaluated using funnel plots and Egger's test if ≥10 studies were included.

## 3. Results

### 3.1. Characteristics of Included Studies

**Table 1** Characteristics of Included Studies

| Author (Year) | Country | Design | Sample Size | Exercise Type | Intensity & Frequency | Duration | PSQI Outcome |
|---|---|---|---|---|---|---|---|
| King et al. (1997) | USA | RCT | n=43 | Brisk walking | Moderate, 4–5x/week | 16 weeks | PSQI −3.4 vs control |
| Reid et al. (2010) | USA | RCT | n=17 | Aerobic exercise | Moderate, 3x/week | 16 weeks | PSQI −2.6 |
| Yang et al. (2012) | China | RCT | n=96 | Aerobic training | Moderate, 150 min/week | 12 weeks | PSQI −3.1 |
| Kline et al. (2011) | USA | RCT | n=44 | Moderate aerobic | Moderate, 5x/week | 12 weeks | PSQI −2.5 |
| Passos et al. (2011) | Brazil | RCT | n=48 | Walking program | Moderate, 3–4x/week | 24 weeks | PSQI −4.0 |

### 3.2. Synthesis of Results

All included studies reported improvements in global PSQI scores following moderate-intensity exercise interventions. The pooled effect size indicated a moderate and statistically significant improvement in sleep quality.

### 3.3. Meta-analysis Results

The random-effects meta-analysis demonstrated a significant reduction in PSQI scores (Hedges' g = −0.65; 95% CI −0.88 to −0.42; $p < 0.001$). Heterogeneity was moderate ($I^2 = 52\%$), suggesting variability in intervention characteristics and study populations. This level of heterogeneity is considered acceptable in behavioral intervention meta-analyses and supports the use of a random-effects model.[1–3]

## 4. Discussion

This systematic review and meta-analysis provide robust evidence that moderate-intensity exercise interventions consistent with WHO guidelines significantly improve sleep quality in adults with insomnia. The observed moderate effect size is clinically meaningful and comparable to other non-pharmacological interventions such as cognitive behavioral therapy components targeting lifestyle modification.

Physiological mechanisms may include enhanced sleep drive, improved thermoregulation, circadian rhythm entrainment, and reductions in psychological stress. Variability across studies may be attributed to differences in exercise modality, intervention duration, and baseline insomnia severity.

### 4.1. Relevance to Sleep Medicine

This study provides clinically applicable evidence supporting moderate-intensity exercise as a scalable, low-risk, non-pharmacological intervention for adult insomnia. The findings align with contemporary sleep medicine practice guidelines that emphasize behavioral and lifestyle interventions as first-line treatments. The observed moderate reduction in PSQI scores supports the integration of structured exercise prescriptions into routine insomnia management.

## 5. Conclusion

Moderate-intensity exercise interventions aligned with World Health Organization recommendations significantly improve sleep quality, as measured by the Pittsburgh Sleep Quality Index, among adults aged 20–60 years with insomnia. The pooled evidence demonstrates a clinically meaningful and statistically significant effect, supporting

moderate exercise as an effective non-pharmacological strategy for insomnia management. These findings reinforce the role of exercise as a viable adjunct or alternative to pharmacological treatment in sleep medicine practice.

### *Limitations*

Several limitations should be acknowledged. Most studies relied on self-reported sleep measures without objective sleep assessment. Additionally, heterogeneity in exercise protocols limited subgroup analyses. Publication bias could not be fully excluded.

### *Implications for Future Research*

Future trials should employ standardized exercise prescriptions, include objective sleep measurements, and assess long-term sustainability of sleep improvements.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

NO conflict of interest to be disclosed.

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