Systematic Review

J Prev Med Public Health 2025;58:1-10 • https://doi.org/10.3961/jpmph.24.354

pISSN 1975-8375 eISSN 2233-4521

Journal of Preventive Medicine & Public Health

Effects of Physical and Mind-body Exercise on Sleep Quality in Individuals With Diabetes Mellitus: A Systematic Review and Meta-analysis

Yohanes Andy Rias[1,2], Renny Wulan Apriliyasari[3], Made Satya Nugraha Gautama[4], Faizul Hasan[1], Margareta Teli[5], Hsiao-Yean Chiu[6], Ratsiri Thato[1,7]

[1]Faculty of Nursing, Chulalongkorn University, Bangkok, Thailand; [2]Faculty of Health, College of Nursing, Institut Ilmu Kesehatan Bhakti Wiyata Kediri, Kediri, Indonesia; [3]Department of Nursing, Institut Teknologi Kesehatan Cendekia Utama Kudus, Kabupaten Kudus, Indonesia; [4]Department of Nursing, Faculty of Medicine, Universitas Pendidikan Ganesha, Singaraja, Indonesia; [5]Nursing School, Polytechnic of Health Ministry of Health Kupang, Kupang, Indonesia; [6]School of Nursing, College of Nursing, Taipei Medical University, Taipei, Taiwan; [7]Research Unit for Enhancing Well-being in Vulnerable and Chronic Illness Populations, Chulalongkorn University, Bangkok, Thailand

Objectives: Physical and mind-body exercises represent distinct intervention strategies that may improve sleep quality by influencing physiological and psychological factors. Nevertheless, their effectiveness in individuals with diabetes is not well-established. This systematic review and meta-analysis aimed to examine the impacts of physical and mind-body exercise interventions on sleep quality in patients with diabetes mellitus.

Methods: Six randomized controlled trials (RCTs) that met the inclusion criteria were identified from PubMed, CINAHL, Embase, Scopus, Web of Science, Cochrane, and Ovid-Medline Library. The effect size for sleep quality was calculated using the standardized mean difference (SMD) with a 95% confidence interval (CI), employing a random-effects model. Heterogeneity and publication bias were also examined, and subgroup, meta-regression, and sensitivity analyses were performed.

Results: Physical and mind-body exercise interventions significantly improved sleep quality, with an SMD of -1.040 (95% CI, -1.686 to -0.394). Subgroup analysis revealed significant differences with respect to the type of intervention ($p=0.047$), or its duration ($p=0.282$). Meta-regression analysis indicated that mean hemoglobin A1c level was the only factor to be significantly related to the effect size for sleep quality, demonstrating a negative association ($p=0.033$). The assessment of publication bias and the sensitivity analysis suggested that the findings were reliable and robust.

Conclusions: Physical and mind-body exercises may serve as effective interventions for patients with diabetes mellitus who experience poor sleep quality. However, to substantiate these findings, additional rigorous RCTs with larger sample sizes, longer follow-up periods, and standardized interventions are required.

Key words: Diabetes mellitus, Mind-body exercise, Physical exercise, Sleep quality

Received: Jul 6, 2024 Revised: Aug 27, 2024 Accepted: Sep 10, 2024

Corresponding author: Ratsiri Thato
Faculty of Nursing, Chulalongkorn University, 11 Rama I Road, Wang Mai, Bangkok 10030, Thailand
E-mail: ratsiri.T@chula.ac.th

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (https://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Sleep quality is a multidimensional construct that encompasses various aspects of sleep, including duration, efficiency, latency, continuity, depth, and satisfaction [1,2]. Globally, poor sleep quality is a common issue among individuals with diabetes mellitus, affecting up to half of this population [3]. Diabetes mellitus is a chronic metabolic disorder characterized by

Copyright © 2025 The Korean Society for Preventive Medicine

hyperglycemia and impaired insulin secretion or action [4]. It is associated with various complications, such as cardiovascular disease, neuropathy, nephropathy, retinopathy, and depression [5]. Poor sleep quality can exacerbate these complications by disrupting glucose metabolism, increasing inflammation, altering hormonal regulation, and reducing quality of life [6]. Consequently, improving sleep quality is a key objective for those living with diabetes mellitus.

Current treatments for sleep problems in individuals with diabetes mellitus include both pharmacological and non-pharmacological interventions [7-9]. Pharmacological approaches, such as the use of hypnotics, antidepressants, and melatonin, can improve sleep quality. However, they carry potential side effects like dependence, tolerance, rebound insomnia, daytime sedation, and possible interactions with anti-diabetic medications [8,10]. Non-pharmacological strategies, such as cognitive-behavioral therapy, relaxation techniques, stimulus control, sleep hygiene education, and bright light therapy [7,9,11], may offer a safer and more effective alternative to pharmacological methods. Nevertheless, they have certain drawbacks, such as high costs, limited availability, low patient adherence, and insufficient supporting evidence.

Physical and mind-body exercise are two non-pharmacological interventions that may improve sleep quality in individuals with diabetes mellitus [12]. Physical exercise is defined as any bodily movement that requires energy expenditure and enhances physical fitness [13]. Mind-body exercise encompasses activities that combine physical movement, breathing, and mental focus to achieve a heightened state of awareness and relaxation [14]. Physical exercise includes activities that involve exerting the body's muscles, such as aerobic exercise, resistance training, and high-intensity interval training [15]. Mind-body exercise comprises-practices that integrate the body and mind, including yoga, tai chi, qigong, and meditation [16]. Several studies have suggested that both physical and mind-body exercise may improve sleep quality by influencing various physiological and psychological factors related to sleep in people with diabetes [17,18]. These factors include stress, anxiety, depression, pain, inflammation, blood glucose levels, mood, self-efficacy, cognitive function, cardiovascular health, and circadian rhythms. The findings of these studies indicate that physical and mind-body exercise can be beneficial for patients with diabetes mellitus who experience poor sleep quality, potentially improving their overall well-being and quality of life. Surprisingly, no systematic review and meta-analysis has yet examined the impact of sleep problems on patients with diabetes mellitus.

A systematic review and meta-analysis can synthesize and compare results from multiple studies, aiding in the identification of effective interventions, highlighting areas that require further research, and informing clinical practice guidelines. Given the current gap in the literature, a comprehensive analysis is urgently needed to evaluate the effects of physical and mind-body exercises on sleep quality in individuals with diabetes mellitus. The primary objective of this systematic review and meta-analysis was to assess the impact of these exercises on sleep quality in patients with diabetes. Secondary objectives included exploring potential moderators (such as exercise type, intensity, frequency, and duration) of the effects, investigating possible mediators (such as psychological factors) that influence the relationship between exercise and sleep quality, comparing the efficacy of physical exercises with mind-body practices, and assessing the risk of bias and the quality of evidence in the included studies.

METHODS

Search Strategy

To identify relevant studies, we thoroughly searched multiple databases, including PubMed, CINAHL, Embase, Scopus, Web of Science, Cochrane, and Ovid-Medline Library. This search included all records from the inception of these databases up to July 13, 2023. We employed specific keywords related to exercise and sleep problems. No limitations were imposed on the language of publication or the duration of the studies included. The specifics of our search strategy are detailed in Supplemental Material 1.

Study Selection

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [19].

We selected trials based on the following criteria: (1) the participants were adults diagnosed with diabetes, with a mean age of 18 years or older; (2) the intervention included any form of physical activity, such as exercise, training, aerobic exercises, fitness routines, treadmill workouts, dance, and walking, while mind-body interventions such as tai chi, qigong, yoga, Pilates, progressive muscle relaxation, and mindfulness-based cognitive therapy were also considered as treatment options; (3) the research included a comparison group, which could be a no-treatment control (e.g., waitlist), standard care for chronic physical illness, or engagement in non-therapeutic activities (e.g., health education, recreational activities); and (4) the study was a randomized controlled trial (RCT). The effectiveness of the intervention was assessed using subjective measures of sleep quality.

The titles and abstracts of eligible articles were independently reviewed by 2 researchers (YAR and RWA). Subsequently, the full texts of the selected studies were reassessed. Any disagreements that arose were resolved through discussions with additional researchers, namely MSNG, FH, MT, HYC, and RT.

Data Extraction

Data were independently extracted from each included study by 3 researchers (YAR, RWA, and MSNG), encompassing details on study characteristics, participant characteristics, intervention specifics, and intended outcomes. We attempted to contact the original authors by email to acquire any supplementary or missing information. In instances of disagreement, discrepancies were resolved by reaching a consensus.

Descriptions of Outcome Measures

The primary outcomes in this study were subjective measures of sleep quality, including the General Health Questionnaire, Pittsburgh Sleep Quality Index (PSQI), and the Swedish Health-Related Quality of Life questionnaire.

Risk of Bias Assessment

The risk of bias in each included study was independently assessed by 3 researchers (RT, FH, and YAR) using version 1 of the Cochrane risk-of-bias tool [20]. Six domains of bias were assessed: random sequence generation, allocation concealment, performance bias, detection bias, attrition bias, and reporting bias. Each domain received a judgment of low, unclear, or high risk of bias. Discrepancies were resolved through consensus.

Data Synthesis and Analysis

All analyses were conducted using Comprehensive Meta-analysis 2.0 (Biostat, Englewood, NJ, USA). We chose a random-effects model over a fixed-effects model due to its more conservative approach [21]. We determined the effect size using the standardized mean difference (SMD) with a 95% confidence interval (CI); thus, we measured the differences in outcomes and sample sizes between the experimental and control groups, both before and after testing. To evaluate the magnitude of the effect size, we employed Cohen categories with 95% CIs as follows: $g=0.2$ to 0.5 indicated a small effect; $0.5<g\leq0.8$ represented a moderate effect; and $g>0.8$ denoted a large effect [22]. The Q test and I^2 statistic were used to assess heterogeneity between studies, with $Q<0.05$ and $I^2>50\%$ indicating significant heterogeneity.

Ethics Statement

The study protocol was preregistered with the International Prospective Register of Systematic Reviews (registration No. CRD4202222239789).

RESULTS

Included Studies and Characteristics

Our initial database searches yielded 1469 articles. After assessing the eligibility of 13 full-text articles, we ultimately included 6 studies in the systematic review. Of these, 6 were meta-analyses, as illustrated in Figure 1. Table 1 presents the characteristics of the 6 articles, which were published between 2005 and 2021. Two of the studies were conducted in Iran [17,23], with the remaining studies taking place in Spain [24], Sweden [25], India [18], and China [26]. The studies predominantly featured male participants, with mean ages ranging from 38.00 years to 62.25 years and sample sizes varying from 19 to 300 participants. Table 1 also details the physical and mind-body exercise interventions used. Regarding the types of interventions, the majority (4 studies) implemented aerobic exercise. One study each utilized yoga exercise and a combination of yoga and aerobic exercise. The duration of the interventions spanned from 1 week to 16 weeks. For sleep assessment, 4 of the 6 studies employed the PSQI.

Effect of Physical and Mind-body Exercise Interventions on Sleep Quality

As presented in Table 2, the effects of physical and mind-body exercise interventions on sleep quality in patients with diabetes mellitus were assessed across 5 studies. The pooled effect was found to be statistically significant. Specifically, the pooled effect on sleep quality exhibited an SMD of -1.040 (95% CI, -1.686 to -0.394).

Moreover, as shown in Figure 2, the studies exhibited a high degree of heterogeneity ($I^2=87.01\%$). Subgroup analysis re-

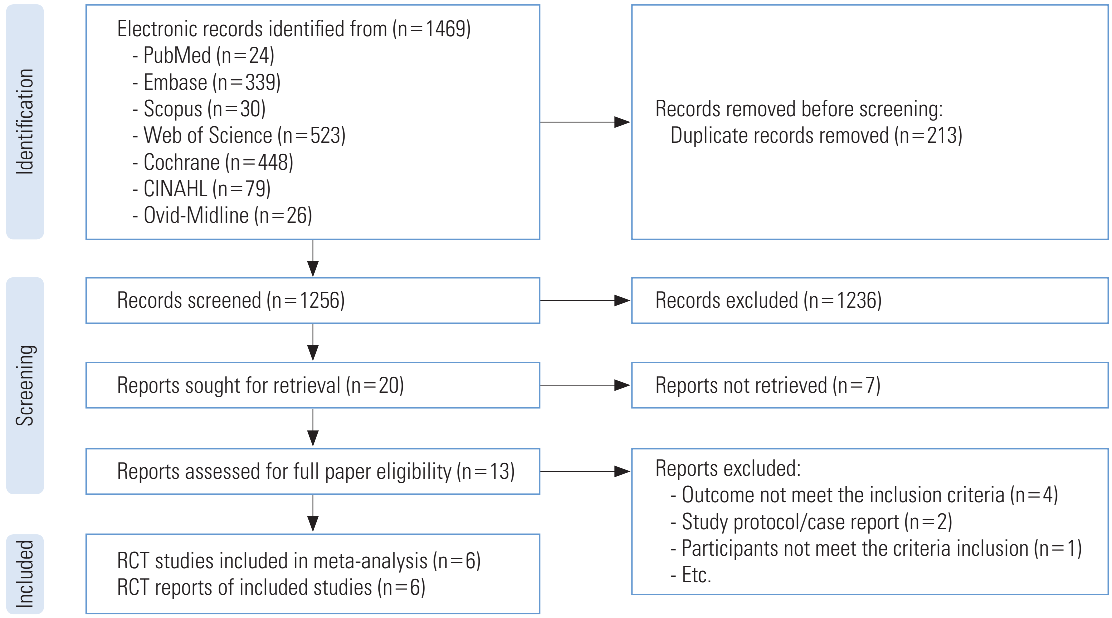

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram. RCT, randomized controlled trials.

Table 1. Characteristics of included studies

Study	Country	Sample size	Female (%)	Type of diabetes	Age, mean±SD (y)	Mean HbA1c, mmol/mol	Description of intervention		Outcome/ measurement
							Intervention group	Control group	
Alarcón-Gómez et al. (2021) [24]	Spain	Total: 19 IG: 11 CG: 8	47.4	Type 1	38.0±5.5	37.1	Supervised, high-intensity interval training (cycling) Frequency: 3x/wk Duration: 6 wk	No exercise (instructed to maintain their current lifestyle and dietary intake)	Sleep quality: PSQI
Ebrahimi et al. (2017) [23]	Iran	Total: 39 IG: 28 CG: 11	100	Type 2	46.31±2.95	NI	Aerobic and yoga exercise program Frequency: 110 min, 3x/wk Duration: 12 wk	No detailed information	Sleep quality: PSQI
Fritz et al. (2011) [25]	Sweden	Total: 50 IG: 30 CG: 20	35.0	Type 2	62.25±1.25	53.25	Unsupervised, Nordic walking Frequency: 5 h/wk Duration: 16 wk	No exercise (instructed to continue habitual daily activities)	Sleep quality: SWED-QUAL sleep domain
Sardar et al. (2014) [17]	Iran	Total: 53 IG: 27 CG: 26	0	Type 2	45.56±5.41	53.25	Aerobic training with an ergometer bike Frequency: 45 to 60 min, 3x/wk Duration: 8 wk	No exercise (usual care, did not participate in any exercise)	Sleep quality: GHQ domain
Viswanathan et al. (2021) [18]	India	Total: 300 IG: 150 CG: 150	38.0	Type 2	50.8±8.3	55.00	Supervised, yoga intervention Frequency: 50 min, 5x/wk Duration: 12 wk	No exercise (advised to engage in simple exercises)	Sleep quality: PSQI
Wang et al. (2005) [26]	China	Total: 40 IG: 20 CG: 20	50.0	Type 2	49.4±5.5	NI	Aerobic exercise Frequency: 40 min, 3-4x/wk Duration: 1 wk	No exercise (advised to engage in exercise voluntarily)	Sleep quality: Sleep Quality Survey Scale

SD, standard deviation; HbA1c, hemoglobin A1c; IG, intervention group; CG, control group; GHQ, general health questionnaire; NI, no information; PSQI, Pittsburgh Sleep Quality Index; SWED-QUAL, Swedish Health-Related Quality of Life Questionnaire.

vealed significant differences in the effect size for sleep quality among patients with type 2 diabetes regarding the type of intervention (p=0.047), or its duration (p=0.282). Meta-regression using a random-effects model was conducted to assess the impacts of the intervention's duration in weeks, mean age, and mean body mass index (BMI) on the effect size for sleep quality. This analysis identified a significant, negative association solely between mean hemoglobin A1c level and the effect size for sleep quality ($p=0.033$). The covariates of intervention duration and mean age did not significantly influence sleep quality ($p>0.05$). Egger test results suggested an absence of publication bias ($p=0.42$).

Table 2. Moderator analysis: subgroup analysis and meta-regression

Characteristics	n	Moderator analysis	*p*-value
Subgroup analysis, SMD (95% CI)			
Type of intervention			
Aerobic exercise	4	-1.36 (-2.02, -0.69)	<0.001
Others[1]	2	-0.40 (-1.07, 0.28)	0.247
p-value		0.047	
Intervention duration (wk)			
<12	3	-1.41 (-2.42, -0.41)	0.006
≥12	3	-0.71 (-1.49, 0.08)	0.077
p-value		0.282	
Meta-regression, β coefficient (95% CI)			
Mean age	6	0.05 (-0.09, 0.10)	0.928
Duration	6	0.08 (-0.05, 0.21)	0.215
BMI	4	0.06 (-0.38, 0.51)	0.781
Hemoglobin A1c	4	0.07 (0.01, 0.14)	0.033

SMD, standardized mean difference; CI, confidence interval; BMI, body mass index.
[1]Others refers to mind-body exercise involving yoga alone (1 study) and a combination of aerobic exercise and yoga (1 study).

Sensitivity Analysis

To evaluate the robustness of the meta-analysis results regarding changes in sleep quality, sensitivity analyses were performed. These analyses involved the sequential exclusion of individual studies. No findings changed significantly, supporting the robustness of the results.

Methodological Quality

Figure 3 presents an evaluation of the methodological quality based on the Risk of Bias 2.0 criteria. Among the included studies, 1 raised some concerns, while the remainder demonstrated a low risk of bias resulting from the randomization process. Regarding bias due to deviation from the intended intervention, 3 studies presented some concerns, primarily due to limitations in participant blinding, whereas the others were assessed as low risk. Concerning bias from missing outcome data, 5 studies were deemed low risk, and 1 raised some concerns due to patient attrition during the intervention. All studies showed a low risk of bias both in the measurement of outcomes and in the selection of reported results. Overall, 3 studies were categorized as low risk, while 3 presented some concerns.

Study name	SMD	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study						
Alarcón-Gómez et al., 2021	-1.629	0.535	0.286	-2.676	-0.581	-3.047	0.002
Ebrahimi et al., 2017	-0.840	0.368	0.136	-1.562	-0.118	-2.281	0.023
Fritz et al., 2011	-1.289	0.316	0.100	-1.909	-0.669	-4.077	0.000
Sardar et al., 2014	-0.618	0.281	0.079	-1.169	-0.067	-2.196	0.028
Viswanathan et al., 2021	-0.130	0.116	0.013	-0.356	0.097	-1.124	0.261
Wang et al., 2005	-2.104	0.394	0.155	-2.876	-1.331	-5.338	0.000
	-1.040	0.330	0.109	-1.686	-0.394	-3.157	0.002

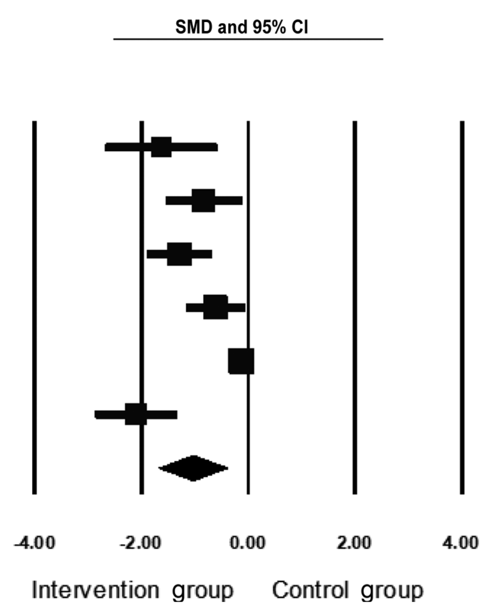

Figure 2. Forest plot for the effect of physical and mind-body exercise on sleep quality in patients with diabetes mellitus. SMD, standardized mean difference; CI, confidence interval.

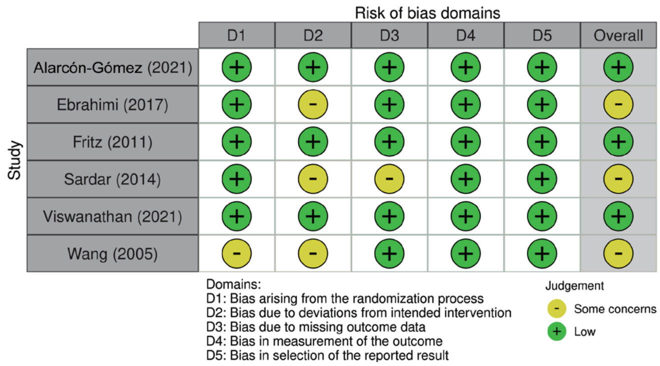

Figure 3. Forest plot for the effect of physical and mind-body exercise on sleep quality in patients with diabetes mellitus.

DISCUSSION

Poor sleep quality is a common issue among individuals with diabetes mellitus, with the potential to adversely impact overall health and well-being. Accordingly, we conducted a systematic review and meta-analysis to evaluate the effects of physical and mind-body exercise interventions on sleep quality in this population. Our findings indicate that physical and mind-body exercise interventions significantly improved sleep quality in individuals with diabetes mellitus. Subgroup analysis revealed significant differences in effect size for the sleep quality of patients with type 2 diabetes regarding the type or duration of intervention. Meta-regression indicated a significant negative association between hemoglobin A1c level and the effect size for sleep quality. However, the duration of diabetes, BMI, and mean age did not significantly influence the quality of sleep. The sensitivity analysis supported the robustness of the results.

The observation that physical and mind-body exercise interventions significantly increase sleep quality in individuals with diabetes mellitus aligns with the available literature. Prior research indicates that exercise can improve various sleep parameters, including duration, efficiency, latency, continuity, depth, and satisfaction [24,27]. Physical exercise may improve sleep quality by reducing stress, anxiety, depression, pain, inflammation, and blood glucose levels. It can also boost mood, self-efficacy, cognitive function, and cardiovascular health, in addition to regulating circadian rhythms [27,28]. Similarly, mind-body exercise may improve sleep quality by fostering increased awareness and relaxation, modulating autonomic nervous system activity, improving emotional regulation and coping skills; and reducing negative thoughts and rumination [29,30]. The mechanisms by which physical and mind-body exercise influence sleep quality in individuals with diabetes mellitus may be mediated by psychological factors, such as perceived stress, mood, self-esteem, and quality of life [31]. Consequently, physical and mind-body exercise interventions could be beneficial for individuals with diabetes mellitus who experience poor sleep quality, which can adversely impact their glycemic control and general health [12,31,32].

The findings indicated a significant impact of aerobic exercise, but not of either yoga alone or a combined mind-body exercise regimen that included yoga and aerobic yoga, on the sleep quality of patients with type 2 diabetes. This suggests that physical exercise alone may be more beneficial than combined exercise for improving sleep quality in this population. In contrast, a study by Ebrahimi et al. [23] reported that both yoga and aerobic exercise enhanced sleep quality after 6 weeks. However, the positive effects of aerobic exercise diminished after 12 weeks. The study concluded that yoga was more effective in improving sleep quality in women with type 2 diabetes than the same number of weeks of aerobic exercise. Notably, however, the study had certain limitations, such as relying on a single questionnaire and employing different durations for the yoga and aerobic exercise sessions, potentially influencing the results. In a similar vein, research by S Delevatti et al. [33] demonstrated that aerobic training improved both physical and psychological domains of quality of life, reduced depressive symptoms, and improved sleep quality in patients with type 2 diabetes. Moreover, several relevant meta-analyses comparing aerobic and resistance exercise concluded that aerobic exercise was superior in lowering glycosylated hemoglobin levels [11,34]. Another study also reported significant differences in changes from baseline in BMI, peak oxygen consumption, and maximum heart rate [35].

Subgroup analysis revealed no significant differences in the effect size for sleep quality when comparing types and durations of interventions. This suggests that both physical and mind-body exercise interventions can improve sleep quality in patients with diabetes, regardless of the length of the intervention. Meta-regression analysis indicated that the mean BMI of participants was the only factor that had a significant, and negative, association with the effect size for sleep quality. This implies that physical and mind-body exercise interventions may be more effective for patients with diabetes mellitus who have a lower BMI. This observation aligns with findings from other studies that have linked obesity with poor sleep quality and an increased risk of sleep disorders, such as obstructive sleep apnea, insomnia, and restless legs syndrome [36,37]. Obesity can compromise sleep quality through mechanical obstruction of the upper airway, disruption of hormonal regulation of appetite and metabolism, heightened inflammation and oxidative stress, and impacts on psychological health [36,38]. Consequently, physical and mind-body exercise interventions may improve sleep quality by promoting weight loss and mitigating obesity-related complications in patients with diabetes mellitus.

Furthermore, these findings have substantial implications for healthcare policy and clinical practice, especially for professionals who work with patients with type 2 diabetes. It is crucial to recognize the importance of assessing sleep quality and activity levels in the management of diabetes and to integrate these assessments into standard care protocols. Healthcare policies should be established to support routine screening for sleep disturbances and physical activity levels in patients with diabetes, as these factors can significantly impact health outcomes. From a clinical standpoint, healthcare providers should consider including various forms of exercise in their treatment plans, tailoring interventions to individual patient needs and preferences. Such a personalized approach is likely to increase patient adherence and improve outcomes. Policymakers and healthcare systems should prioritize the expansion of exercise interventions, which could be achieved through community programs, telemedicine initiatives, or subsidized gym memberships for patients with diabetes. These patients should be empowered to select the type of aerobic training that best suits their personal preferences and accessibility, potentially increasing their long-term commitment to physical activity. The primary policy objective should be to promote and facilitate regular physical activity rather than to prescribe specific types of exercise.

To inform evidence-based policies, further research is necessary to identify the optimal type, duration, and intensity of exercise interventions to improve sleep quality in patients with diabetes. Future longitudinal studies should focus on outcomes that are relevant to patients. Additionally, conducting cost-effectiveness analyses of various exercise interventions, in the context of their impact on diabetes management and overall healthcare costs, would be valuable for policymakers. Our findings indicate promising avenues for improving diabetes care through exercise and sleep quality management. However, they also underscore the need for more robust research to inform policy development. Healthcare systems and policymakers should consider these findings when developing comprehensive diabetes management strategies and should also invest in additional research to refine and validate these approaches.

The recommendations provided should be interpreted with caution due to the limited number of studies within each subgroup and the heterogeneity observed among the studies. Factors including the type and intensity of exercise, baseline characteristics of the participants, and the methods used to measure sleep quality could have influenced the results. The studies under review exclusively utilized self-reported questionnaires to assess sleep quality. Future research and policy development should include objective measures such as actigraphy or polysomnography to enable a more thorough assessment of sleep quality.

This study had several strengths. First, it exclusively included RCTs in the systematic review and meta-analysis, improving the statistical power and precision of the findings. Second, a subgroup analysis was incorporated to explore potential sources of heterogeneity among the studies, such as the type of intervention. Third, a meta-regression was performed to examine the impact of covariates such as the duration of intervention, mean age, and mean BMI on the effect size for sleep quality. Additionally, publication bias was evaluated using the Egger test, with no evidence of such bias detected. Finally, the robustness of the results was confirmed through a sensitivity analysis, which involved sequentially excluding individual studies and revealed no significant changes in the findings.

This study also had certain limitations. First, the number of qualified studies incorporated into this meta-analysis was relatively small, potentially limiting the generalizability and validity of the findings. Additionally, the studies included in the meta-analysis exhibited a high degree of heterogeneity. This suggests that there could be other factors influencing the impact of physical and mind-body exercise interventions on sleep quality that were not considered in this analysis. Furthermore, the effect size for sleep quality was measured using SMD, which may not fully convey the clinical significance or relevance of the intervention for patients with diabetes mellitus.

CONCLUSION

In conclusion, our findings suggest that physical and mind-body exercises can effectively improve sleep quality in patients with diabetes mellitus. However, our results underscore the necessity for rigorous future trials to determine which specific interventions are most beneficial based on the characteristics of individual patients and their treatments. These studies should also explore the mechanisms at play and establish optimal protocols for physical and mind-body exercises aimed at improving sleep quality in this patient population. Furthermore, future investigations should incorporate objective measurement tools such as actigraphy or polysomnography in conjunction with self-reported questionnaires to achieve a more thorough evaluation of sleep quality. Such progress in research methodology will help refine our understanding and guide the development of more effective interventions to improve sleep quality in individuals with diabetes mellitus.

NOTES

Supplemental Materials

Supplemental material is available at https://doi.org/10.3961/jpmph.24.354.

Conflict of Interest

The authors have no conflicts of interest associated with the material presented in this paper.

Funding

None.

Acknowledgements

The authors thank all patients who participated in the study. The authors would like to thank Postdoctoral Fellowship, Second Century Fund (C2F), Chulalongkorn University, Faculty of Nursing, Chulalongkorn University, and School of Nursing, College of Nursing, Taipei Medical University, Institut Ilmu Kesehatan Bhakti Wiyata Kediri, Universitas Pendidikan Ganesha, Polytechnic of Health Ministry of Health Kupang, and Institut Teknologi Kesehatan Cendekia Utama Kudus for the academic support.

Author Contributions

Conceptualization: Andy Rias Y, Apriliyasari RW, Thato R. Data curation: Andy Rias Y, Apriliyasari RW, Gautama MSN, Hasan F, Teli M, Chiu HY, Thato R. Formal analysis: Andy Rias Y, Apriliyasari RW. Funding acquisition: None. Methodology: Andy Rias Y, Chiu HY, Thato R. Visualization: Apriliyasari RW. Writing – original draft: Andy Rias Y, Apriliyasari RW, Gautama MSN, Hasan F, Teli M. Writing – review & editing: Andy Rias Y, Hasan F, Teli M, Chiu HY, Thato R.

ORCID

Yohanes Andy Rias *https://orcid.org/0000-0001-5403-2161*
Renny Wulan Apriliyasari *https://orcid.org/0000-0001-9423-7508*
Made Satya Nugraha Gautama *https://orcid.org/0000-0001-8194-9784*
Faizul Hasan *https://orcid.org/0000-0001-7802-1328*
Margareta Teli *https://orcid.org/0000-0002-9816-2045*
Hsiao-Yean Chiu *https://orcid.org/0000-0002-6419-9309*
Ratsiri Thato *https://orcid.org/0000-0003-0871-0798*

REFERENCES

1. Ohayon M, Wickwire EM, Hirshkowitz M, Albert SM, Avidan A, Daly FJ, et al. National Sleep Foundation's sleep quality recommendations: first report. Sleep Health 2017;3(1):6-19. https://doi.org/10.1016/j.sleh.2016.11.006
2. McCarter SJ, Hagen PT, St Louis EK, Rieck TM, Haider CR, Holmes DR, et al. Physiological markers of sleep quality: a scoping review. Sleep Med Rev 2022;64:101657. https://doi.org/10.1016/j.smrv.2022.101657
3. Lecube A, Sánchez E, Gómez-Peralta F, Abreu C, Valls J, Mestre O, et al. Global assessment of the impact of type 2 diabetes on sleep through specific questionnaires. A case-control study. PLoS One 2016;11(6):e0157579. https://doi.org/10.1371/journal.pone.0157579
4. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care 2009;32(Suppl 1):S62-S67. https://doi.org/10.2337/dc09-S062
5. Giri B, Dey S, Das T, Sarkar M, Banerjee J, Dash SK. Chronic hyperglycemia mediated physiological alteration and metabolic distortion leads to organ dysfunction, infection, cancer progression and other pathophysiological consequences: an update on glucose toxicity. Biomed Pharmacother 2018;107:306-328. https://doi.org/10.1016/j.biopha.2018.07.157
6. Briançon-Marjollet A, Weiszenstein M, Henri M, Thomas A, Godin-Ribuot D, Polak J. The impact of sleep disorders on glucose metabolism: endocrine and molecular mechanisms. Diabetol Metab Syndr 2015;7:25. https://doi.org/10.1186/s13098-015-0018-3
7. Siebern AT, Suh S, Nowakowski S. Non-pharmacological treatment of insomnia. Neurotherapeutics 2012;9(4):717-727.

https://doi.org/10.1007/s13311-012-0142-9
8. Barakat S, Abujbara M, Banimustafa R, Batieha A, Ajlouni K. Sleep quality in patients with type 2 diabetes mellitus. J Clin Med Res 2019;11(4):261-266. https://doi.org/10.14740/jocmr2947w
9. Raveendran AV, Chacko EC, Pappachan JM. Non-pharmacological treatment options in the management of diabetes mellitus. Eur Endocrinol 2018;14(2):31-39. https://doi.org/10.17925/EE.2018.14.2.31
10. Plantinga L, Rao MN, Schillinger D. Prevalence of self-reported sleep problems among people with diabetes in the United States, 2005-2008. Prev Chronic Dis 2012;9:110244. https://doi.org/10.5888/pcd9.110244
11. Zhang HZ, Zhang P, Chang GQ, Xiang QY, Cao H, Zhou JY, et al. Effectiveness of cognitive behavior therapy for sleep disturbance and glycemic control in persons with type 2 diabetes mellitus: a community-based randomized controlled trial in China. World J Diabetes 2021;12(3):292-305. https://doi.org/10.4239/wjd.v12.i3.292
12. Fan B, Song W, Zhang J, Er Y, Xie B, Zhang H, et al. The efficacy of mind-body (Baduanjin) exercise on self-reported sleep quality and quality of life in elderly subjects with sleep disturbances: a randomized controlled trial. Sleep Breath 2020;24(2):695-701. https://doi.org/10.1007/s11325-019-01999-w
13. Dasso NA. How is exercise different from physical activity? A concept analysis. Nurs Forum 2019;54(1):45-52. https://doi.org/10.1111/nuf.12296
14. Salmon P, Lush E, Jablonski M, Sephton SE. Yoga and mindfulness: clinical aspects of an ancient mind/body practice. Cogn Behav Pract 2009;16(1):59-72. https://doi.org/10.1016/j.cbpra.2008.07.002
15. Yang YJ. An overview of current physical activity recommendations in primary care. Korean J Fam Med 2019;40(3):135-142. https://doi.org/10.4082/kjfm.19.0038
16. Wang YT, Huang G, Duke G, Yang Y. Tai chi, yoga, and qigong as mind-body exercises. Evid Based Complement Alternat Med 2017;2017:8763915. https://doi.org/10.1155/2017/8763915
17. Sardar MA, Boghrabadi V, Sohrabi M, Aminzadeh R, Jalalian M. The effects of aerobic exercise training on psychosocial aspects of men with type 2 diabetes mellitus. Glob J Health Sci 2014;6(2):196-202. https://doi.org/10.5539/gjhs.v6n2p196
18. Viswanathan V, Sivakumar S, Sai Prathiba A, Devarajan A, George L, Kumpatla S. Effect of yoga intervention on biochemical, oxidative stress markers, inflammatory markers and sleep quality among subjects with type 2 diabetes in South India: results from the SATYAM project. Diabetes Res Clin Pract 2021;172:108644. https://doi.org/10.1016/j.diabres.2020.108644
19. Hutton B, Salanti G, Caldwell DM, Chaimani A, Schmid CH, Cameron C, et al. The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: checklist and explanations. Ann Intern Med 2015;162(11):777-784. https://doi.org/10.7326/M14-2385
20. Higgins JP, Green S. Cochrane handbook for systematic reviews of interventions. Chichester: Wiley-Blackwell; 2008, p. 187-241.
21. DerSimonian R, Laird N. Meta-analysis in clinical trials revisited. Contemp Clin Trials 2015;45(Pt A):139-145. https://doi.org/10.1016/j.cct.2015.09.002
22. Cohen J. Statistical power analysis for the behavioral sciences. Burlington: Elsevier Science; 2013, p. 77-83.
23. Ebrahimi M, Guilan-Nejad TN, Pordanjani AF. Effect of yoga and aerobics exercise on sleep quality in women with type 2 diabetes: a randomized controlled trial. Sleep Sci 2017;10(2):68-72. https://doi.org/10.5935/1984-0063.20170012
24. Alarcón-Gómez J, Chulvi-Medrano I, Martin-Rivera F, Calatayud J. Effect of high-intensity interval training on quality of life, sleep quality, exercise motivation and enjoyment in sedentary people with type 1 diabetes mellitus. Int J Environ Res Public Health 2021;18(23):12612. https://doi.org/10.3390/ijerph182312612
25. Fritz T, Caidahl K, Osler M, Ostenson CG, Zierath JR, Wändell P. Effects of Nordic walking on health-related quality of life in overweight individuals with type 2 diabetes mellitus, impaired or normal glucose tolerance. Diabet Med 2011;28(11):1362-1372. https://doi.org/10.1111/j.1464-5491.2011.03348.x
26. Wang JY, Hou SF, Zhang L. Influence of exercise therapy on emotion and quality of sleep in type 2 diabetic patients. Chin J Clin Rehabil 2005;9(23):4-5 (Chinese).
27. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. Diabetes Care 2016;39(11):2065-2079. https://doi.org/10.2337/dc16-1728
28. American Diabetes Association. Physical activity/exercise and diabetes mellitus. Diabetes Care 2003;26(suppl_1):s73-s77. https://doi.org/10.2337/diacare.26.2007.S73
29. Neuendorf R, Wahbeh H, Chamine I, Yu J, Hutchison K, Oken BS. The effects of mind-body interventions on sleep quality: a systematic review. Evid Based Complement Alternat Med 2015;2015:902708. https://doi.org/10.1155/2015/902708

30. Doorley J, Greenberg J, Stauder M, Vranceanu AM. The role of mindfulness and relaxation in improved sleep quality following a mind-body and activity program for chronic pain. Mindfulness (N Y) 2021;12(11):2672-2680. https://doi.org/10.1007/s12671-021-01729-y
31. Priya G, Kalra S. Mind-body interactions and mindfulness meditation in diabetes. Eur Endocrinol 2018;14(1):35-41. https://doi.org/10.17925/EE.2018.14.1.35
32. Yang HJ, Koh E, Sung MK, Kang H. Changes induced by mind-body intervention including epigenetic marks and its effects on diabetes. Int J Mol Sci 2021;22(3):1317. https://doi.org/10.3390/ijms22031317
33. S Delevatti R, Schuch FB, Kanitz AC, Alberton CL, Marson EC, Lisboa SC, et al. Quality of life and sleep quality are similarly improved after aquatic or dry-land aerobic training in patients with type 2 diabetes: a randomized clinical trial. J Sci Med Sport 2018;21(5):483-488. https://doi.org/10.1016/j.jsams.2017.08.024
34. Zhang J, Tam WW, Hounsri K, Kusuyama J, Wu VX. Effectiveness of combined aerobic and resistance exercise on cognition, metabolic health, physical function, and health-related quality of life in middle-aged and older adults with type 2 diabetes mellitus: a systematic review and meta-analysis. Arch Phys Med Rehabil 2024;105(8):1585-1599. https://doi.org/10.1016/j.apmr.2023.10.005
35. Yang Z, Scott CA, Mao C, Tang J, Farmer AJ. Resistance exercise versus aerobic exercise for type 2 diabetes: a systematic review and meta-analysis. Sports Med 2014;44(4):487-499. https://doi.org/10.1007/s40279-013-0128-8
36. McNeil J, Doucet É, Chaput JP. Inadequate sleep as a contributor to obesity and type 2 diabetes. Can J Diabetes 2013;37(2):103-108. https://doi.org/10.1016/j.jcjd.2013.02.060
37. Hung HC, Yang YC, Ou HY, Wu JS, Lu FH, Chang CJ. The association between self-reported sleep quality and overweight in a Chinese population. Obesity (Silver Spring) 2013;21(3):486-492. https://doi.org/10.1002/oby.20259
38. Lee SW, Ng KY, Chin WK. The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: a systematic review and meta-analysis. Sleep Med Rev 2017;31:91-101. https://doi.org/10.1016/j.smrv.2016.02.001