Effects of Exercise on Improving Sleep Quality Among Elderly Patients: A Systematic Review and Meta-Analysis

Ra Hyun P Park, Angelica O. Panday, Shawn Wilgie M. Panugayan, Kristine Dhiana T. Paras, Margo Lydia C. Pascual, Darlene S. Payte, Patrick Franco V. Payuyo, Mikaela Marie L. Pereira, Betina Faye R. Perona, Kathleen Diane A. Pineda, Natasha Noelle U. Pineda, Ma. Cristine Madeleine J. Pizarro, Jose Ronilo G. Juangco, MD, MPH

Abstract

Introduction Several studies on the effectiveness of exercise in improving sleep quality in the elderly have been done but have conflicting results. This meta-analysis aimed to determine the effect of low- to moderate-intensity aerobic exercise in improving sleep quality among the elderly.

Methods EBSCO, ClinicalKey, PubMed, Wiley Online Library, and Cochrane Library were searched for articles using the terms “exercise AND sleep quality AND elderly”. The risk of bias assessment was done using the Cochrane Collaboration tool and encoded using RevMan 5.4. Data on outcome measures were subjected to meta-analysis using inverse variance methods.

Results Seven articles with a total of 225 participants were included. There was a statistically significant improvement in sleep quality with low to moderate intensity aerobic exercise (MD = -3.87 points; 95% CI -5.56, -2.19 points; p < 0.001). There was a statistically significant decrease in total sleep time after intervention (MD = -8.86; 95% CI -16.31, -1.41 points; p = 0.02). There was no improvement in sleep efficiency.

Conclusion Low and moderate intensity exercise improves sleep quality in the elderly and may be used as a non-pharmacologic intervention to enhance sleep quality.

Key words: elderly, exercise, sleep quality

Sleep is necessary for proper cognitive function, memory processing, sensorimotor integration, and concentration. It also plays a critical role in the physiological functions of the body and the psychological well-being of an individual. Normal healthy sleep is characterized based on the sleep duration, quality, timing and regularity, and absence of sleep disturbances and/or disorders.[1] In adults, particularly the elderly aged 65 years and above, an uninterrupted 7 to 8 hours of sleep is sufficient.[2] Prolonged sleep duration is associated with negative effects on health and may be an indication of poor sleep efficiency.[2] There have been several studies establishing the inverse relationship between age and sleep quality and duration.[1,3] As an individual ages, sleep becomes more fragmented with a reduction in slow wave sleep and rapid eye movement (REM)

Correspondence:
Ra Hyun P. Park, Department of Preventive and Community Medicine, College of Medicine, University of the East Ramon Magsaysay Memorial Medical Center, Inc., 64 Aurora Boulevard, Barangay Doña Imelda, Quezon City, PH 1113. E-mail: parkr0761@uerm.edu.ph

Department of Preventive and Community Medicine, College of Medicine, University of the East Ramon Magsaysay Memorial Medical Center, Inc., Quezon City, PH

sleep. One useful side-effect-free method to improve sleep quality and increase sleep quantity is physical activity or exercise.[4] Numerous studies have proven the beneficial effects of exercises such as tai chi, qigong, and yoga in improving sleep quality among elderly patients with specific sleep complaints. There have also been several studies combining the effects of different types of exercises such as aerobic and resistance training on elderly patients. However, most of these studies have conflicting results and focus on patients with comorbidities such as cardiovascular disease, cancer, and neurodegenerative diseases.

The research question used for the study was, "Does low to moderate intensity physical exercise affect the sleep quality outcomes of the elderly?" This meta-analysis aimed to determine the effect of low to moderate intensity aerobic exercise in improving the sleep quality among elderly individuals.

Methods

Eligibility Criteria

The following inclusion criteria were used to select the studies: original, clinical (randomized and non-randomized clinical trials, prospective studies, retrospective studies), published in English with no limits on date of publication and setting of the study, involving patients aged 60 years and older, low to moderate intensity physical exercise, and studies reporting pre- and post-intervention changes on sleep-related quality based on polysomnography and Pittsburgh Sleep Quality Index (PSQI).

Search Strategy

A literature search on MEDLINE and Academic Search was conducted using the EBSCO search engine, ClinicalKey, PubMed, Wiley Online Library and the Cochrane Library. The search strategy for each of these databases was developed using Medical Subject Headings (MeSH). To identify additional reports of relevant studies, reference lists of selected studies identified through the search were scanned and reviewed. The terms used for the search were "exercise AND sleep quality AND elderly". The search was limited to academic journals only; 'title field' and 'full text' were used as filters. Articles included in the search were from 2000 to 2020 with the last date of search set on August 15, 2020.

Study Selection

Four review authors screened the title and abstract of each article obtained from the search engine using the selection criteria. Full versions of the titles and abstracts which satisfied the selection criteria were downloaded and reviewed by the authors in pairs. If the information presented in the eligible studies were unclear, discussions were done among all of the review authors. In cases of disagreements among the review authors, the decision of the majority was followed. Review authors were not blinded to the journal titles or to the study authors or institutions.

Data Collection

The data extracted from each included article were trial design, number of participants in the treatment and control arms, and attrition rate; age range; frequency, duration, intensity, and type of the exercise; and total sleep time and sleep efficiency measured through polysomnography and the PSQI, including the statistical analysis and effect size. Total sleep time and sleep efficiency data were extracted from studies using polysomnography while global sleep quality data were extracted from studies using PSQI. Data extraction was done independently using standardized data collection forms and by following a REVMAN manual. Two study authors inputted the data of the results of the polysomnography and PSQI. For polysomnography, data regarding the baseline and posttreatment results of total sleep time and sleep efficiency were gathered while in PSQI, baseline and posttreatment results of global sleep quality index were entered in REVMAN.

Risk of Bias Assessment

The assessment of the risk of bias for each study was done using the CEBM Critical Appraisal Tool. This covered random sequence generation, allocation concealment, incomplete outcome data (e.g., dropouts and withdrawals) and selective outcome reporting. A judgment of "high risk" or "low risk" was made for the possible risk of bias in each of the six domains from the information extracted. A judgement of "unclear" was made for studies with insufficient detail reported. The study investigators were contacted for more information. Disagreements were resolved by discussion. The information generated from the assessment was encoded in REVMAN 5.4, and a graph for the risk of bias of all studies and their summary was generated.

Data Analysis

Continuous and generic inverse variance outcomes were analyzed using weighted mean difference with 95% confidence interval. The data set was encoded in REVMAN 5.4 for analysis. The confidence interval of 95% was used for studies with and without control. The study authors used a p-value of < 0.05 as an indication of statistically significant summary effect. Statistical heterogeneity was evaluated using chi-square and I^2 test. An I^2 value of $0 < 40\%$ was considered as no significant heterogeneity; 30-60%, as moderate heterogeneity; 50-90%, as substantial heterogeneity; and 75-100%, significant heterogeneity. The study authors used an I^2 result of $> 75\%$ and an x^2 result of < 0.01 as an indication of statistical heterogeneity. A random effects model was used for studies which showed statistical heterogeneity while a fixed effects model was used for studies with no significant heterogeneity.

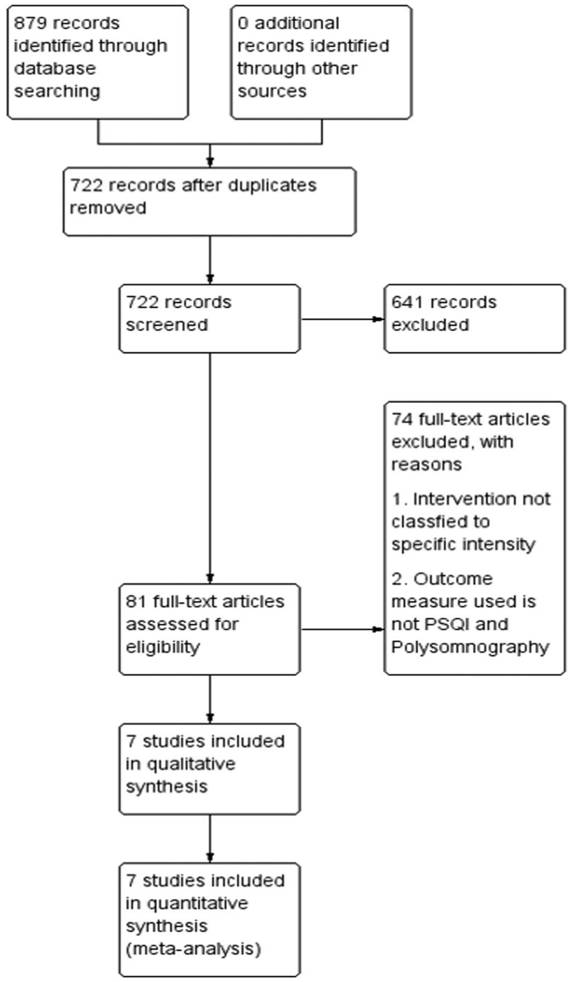

Figure 1. Flow Ddagram: Effects of exercise on sleep quality in the elderly.

Results

Study Selection

A total of 879 titles were identified, of which 722 titles remained after duplicates were removed. Of these, 641 were excluded due to irrelevance. The full text of the remaining 81 articles were retrieved and assessed for relevance; 74 titles were excluded for reasons stated in Figure 1. Seven full text articles were included for systematic review and all of them were included in the meta-analysis.

Study Characteristics

Table 1 shows the characteristics of the seven included studies which outlined the number of participants; age range and inclusion criteria; exercise type, frequency, duration; and outcomes measured. There were one randomized controlled trial (Taheri, 2018) and six quasi-experimental studies (Eshaghi, Kamrani, Seol, Lira, Benlouci, Santos) with pre- and post-test comparisons, involving 225 participants.[4,9-12] The main inclusion criterion was elderly aged 60 years old and above. The exercise type ranged from low to moderate intensity exercises. One study had a duration of two weeks, and another had nine weeks, both of which were daily. The duration of exercise in another was two months done three times a week. The duration was eight weeks in two studies, with one study having a frequency of three times a week and the other, twice a week. Two studies had a duration of 24 weeks with both having a frequency of three times a week. Four studies used PSQI and three studies used polysomnography to measure outcomes.

Table 1. Characteristics of included studies.

Author, year and country	Total participants T/C	Population	Exercise	Outcome measured
Taheri 20189 (Iran)	34 17/17	≥ 60 y/o Not Mentioned	Moderate intensity aerobics 3x/week 2 months	PSQI: sleep quality, sleep duration, sleep efficiency, sleep disturbance, sleep medications, global score
Eshaghi 201910 (Iran)	36 27/9	60-70 y/o PSQI > 11, no sleep apnea, not smoking, not taking hypnotic drugs	Low & moderate intensity exercise 3x/week 8 weeks	PSQI: information processing, selective attention, reaction time, quality of sleep
Kamrani, 20144 (Iran)	45 30/15	60-70 y/o no sleep apnea, not smoking, no moderate and vigorous physical activity, not taking hypnotic drugs, no musculoskeletal problems	Low & moderate intensity aerobic exercise 2x/week 8 weeks	PSQI: perceived sleep quality, sleep latency, sleep duration, sleep efficacy, sleep disturbance, use of sleep medication, daytime dysfunction, total sleep quality
Seol, 202011 (Japan)	60 60/0	65-79 y/o not taking sleeping pills, no insomnia diagnosis, no physician restrictions on exercise, no involvement in any experimental research during the past year	Low intensity exercise Daily 9 weeks	PSQI: sleep onset latency, sleep efficiency, total sleep time, wake after sleep onset, sleep satisfaction, fatigue, global score
Lira, 201112 (Brazil)	14 14/0	Mean age 70.3 yr Not mentioned	Moderate intensity exercise 3x/week 24 weeks	Polysomnography: total sleep time, sleep efficiency, awake time, Sleep Stage 1, Sleep Stage 2, Sleep Stage 3 and 4, REM, REM sleep latency
Benlouci, 200413 (USA)	14 14/0	67-86 y/o Not mentioned	Low & moderate intensity exercise Daily 2 weeks	Polysomnography: sleep-onset latency, sleep efficiency, wake after sleep onset.
Santos, 201214 (Brazil)	22 22/0	Mean age 71.3 yr Not mentioned	Moderate intensity exercise 3x/week 24 weeks	Polysomnography: total sleep time, sleep efficiency, sleep latency, REM sleep latency, time awake, Stage 1, Stage 2, Stage 3, Stage 4, % REM

Risk of Bias

As seen in Figures 2 and 3, randomization was done in only one study. Three studies had allocation concealment; four studies had no allocation concealment because there were no control groups. Three studies reported participants who did not finish the treatment or dropped out before the start; however, their attrition rates were within the acceptable range of < 20%. Thus, all studies are considered low risk for outcome bias. All studies were also considered low risk for reporting bias.

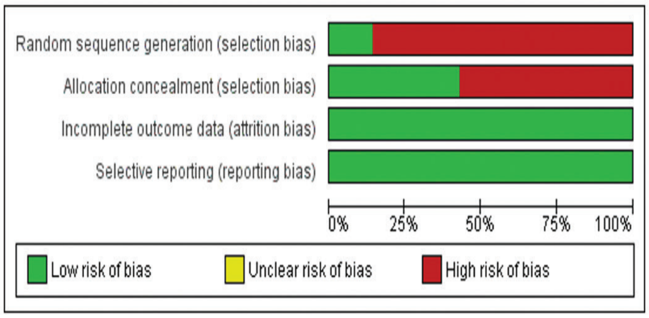

Figure 2. Risk of bias graph for all studies.

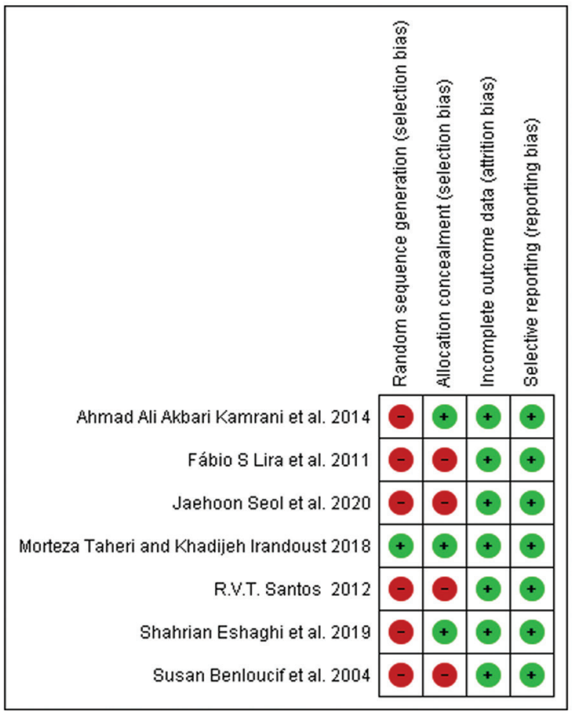

Figure 3. Risk of bias summary.

Results of Individual Studies and Synthesis of Results

Total Sleep Time

Four studies had total sleep time determined through polysomnography of which two showed an increase in total sleep time ranging from 14.88 to 24.91 minutes after low to moderate intensity exercise. Overall, there was a statistically significant (p = 0.02) decrease (8.86 minutes) in total sleep time posttreatment as shown in Figure 4.

Sleep Efficiency

Two of the four studies showed an increase in sleep efficiency with a mean increase range of 4.63% to 4.74% however, both studies did not reach statistical significance. Overall, there was no significant improvement in sleep quality (MD = -0.29; p = 0.77) as seen in Figure 5.

Sleep Quality

Four studies with a control group utilized the PSQI to measure sleep quality. There was a significant improvement in sleep quality in the group with low to moderate exercise as intervention. (MD = -3.87 points; 95% CI -5.56, -2.19; p < 0.001) as seen in Figure 6. The Forest plot showed significant heterogeneity ($I^2 = 91\%$, $x^2 < 0.001$). An adhoc subgroup analysis for sex difference was performed to assess if sex affected heterogeneity. There were significant improvements in sleep quality in both sexes (MD = -2.39 points; 95% CI -3.26, -1.52; p < 0.001 in males, as seen in Figure 7 and MD = -5.51 points; 95% CI -7.50, -3.5; p < 0.001 in females, as seen in Figure 8) after low to moderate exercise however the improvement was greater among females (MD -5.51 vs -2.39). Two studies showed an improvement in sleep quality but did not attain statistical significance (MD = -0.83 points; 95% CI -1.88 to 0.22; p = 0.12) as seen in Figure 9.

Discussion

Summary of Evidence

Four studies with a total of 112 participants showed a statistically significant improvement in sleep

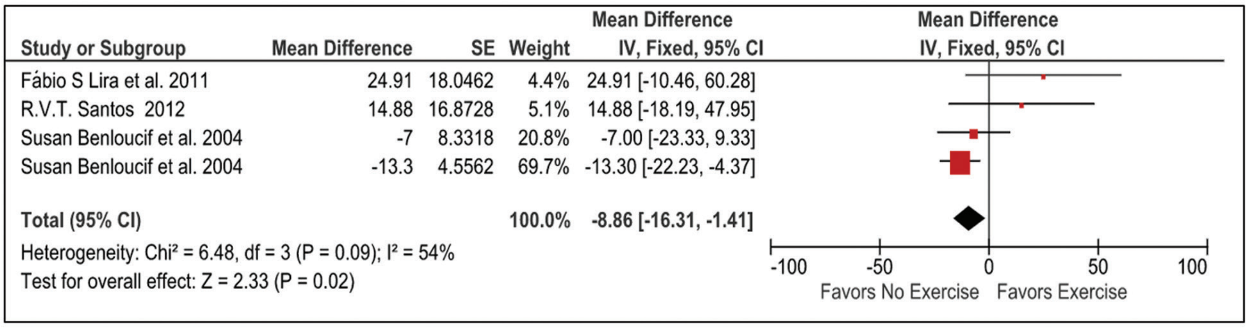

Figure 4. Forest plot of total sleep time using polysomnography.

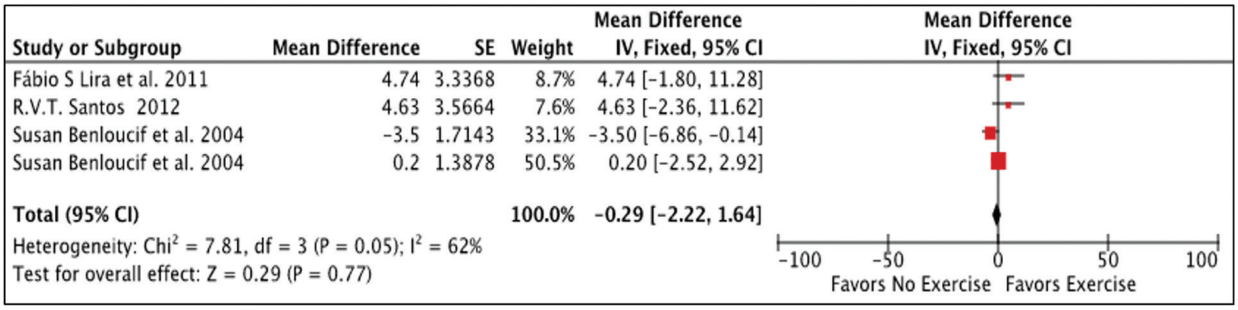

Figure 5. Forest plot of sleep efficiency using polysomnography

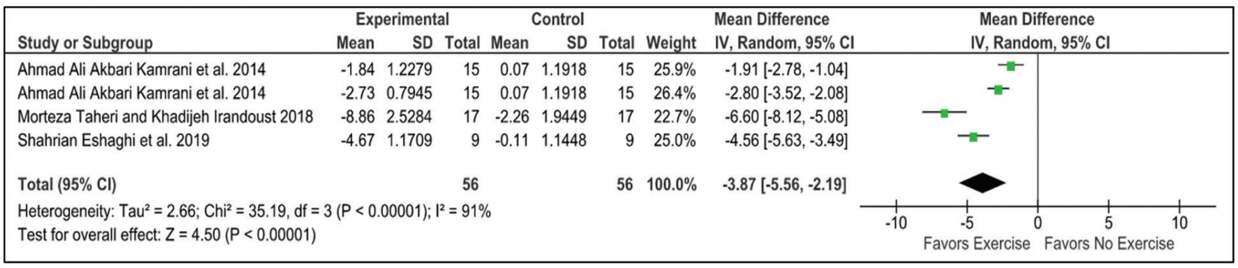

Figure 6. Forest plot of sleep quality using PSQI (studies with control)

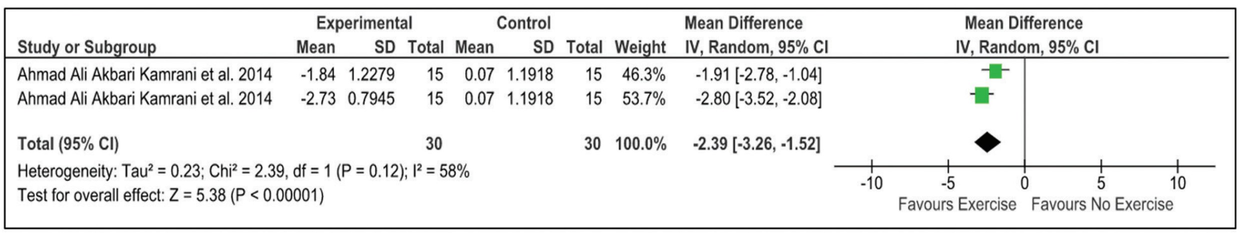

Figure 7. Forest plot of sleep quality of males using PSQI

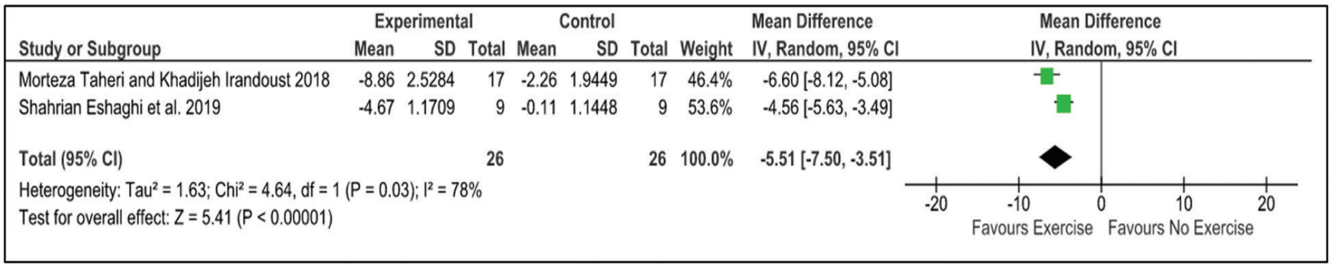

Figure 8. Forest plot of sleep quality of females using PSQI

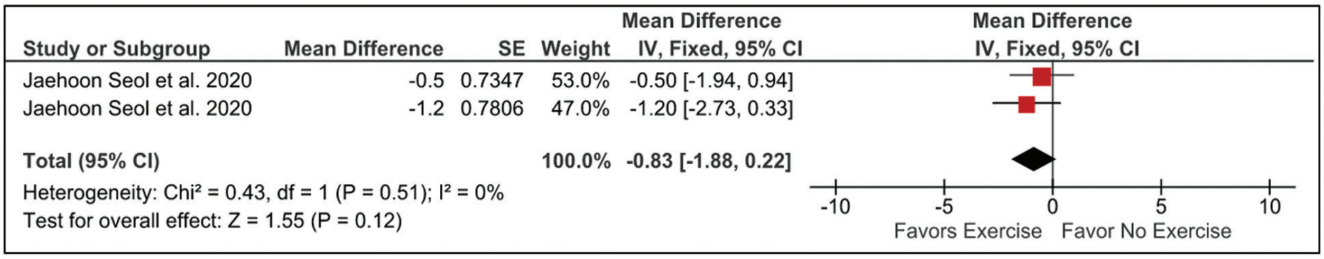

Figure 9. Forest plot of sleep quality using PSQI (studies without control)

quality among those who engaged in low to moderate intensity aerobic exercise (MD = -3.87 points; 95% CI -5.56, -2.19; $p < 0.001$), with a 3.24-point decrease. The mean difference falls within the established minimal clinically important difference (MCID) of 1.54 to 3-point decrease in PSQI scores to indicate that the improvement in sleep quality is clinically significant.

A subgroup analysis was done on the studies which used PSQI due to substantial heterogeneity. Two groups, comprised of 30 elderly males, showed a mean difference of -2.39 (95% CI -3.26, -1.52; $p < 0.001$), while the other two groups, comprised of 26 elderly females, showed a mean difference of -5.51 (95% CI -7.50, -3.51; $p < 0.001$). Despite both groups showing statistically and clinically significant mean differences, the analysis showed a larger decrease in PSQI global scores in the female subgroup compared to the male subgroup. Available literature regarding sex-based differences in sleep quality among the elderly show that females tend to have poorer sleep quality and have a greater tendency to develop insomnia and other sleep disorders.[15,16] Possible reasons for this include hormonal and behavioral differences between women and men such as the loss of estrogen during menopause and prevalence of anxiety and worry in elderly women. Thus, the greater prevalence of poor sleep quality in elderly women accounts for the greater effect of the intervention in their sleep quality.

For the total sleep time, an overall statistically significant decrease of 8.86 minutes (95% CI -16.31, -1.41; $p = 0.02$) occurred after low to moderate intensity aerobic exercise. However, this decrease in total sleep time was not clinically significant as literature indicates that a clinically significant threshold for total sleep time change should be at least 20 minutes.[7] Sleep efficiency was not significantly increased among those who engaged in low to moderate intensity exercise. However, two studies with 36 participants showed an increase in sleep efficiency with a mean increase range of 4.63% to 4.74%. The overall effect of exercise on sleep efficiency showed a 0.29% (95% CI, -2.22 to 1.64; $p = 0.77$) decrease which was not clinically significant as literature indicates that a change of at least 5% in sleep efficiency is required.[7]

Aerobic exercise is said to increase the duration of slow wave Sleep Stages 3 and 4 or deep sleep. Chronic exercise has been shown to enhance parasympathetic control by its effects on heart rate. It enhances vagal modulation resulting in improvement of sleep and mood. Blood temperature before sleep brought about by exercise can promote slow wave sleep. In addition to physical changes, exercise can also improve mood state, which is also a factor in improving sleep quality.[17] Exercise is an activity recommended for a holistic improvement of health and well-being for both healthy and unhealthy individuals. It has been part of many lifestyle modification regimens as it contributes to patient recovery and an improved state of health. Since exercise is one of the most common recommendations for patients, including the older population, a meta-analysis specific on the contribution to the improvement of sleep quality of elderly patients is a valid evidence-based guide for physicians. Disease indications of exercise include, but are not limited to, heart disease, diabetes, asthma, back pain, arthritis, and dementia.

Comparison with Prior Studies

A meta-analysis in 2015 on the effects of physical activity on sleep included 66 studies categorized into 41 acute exercise studies and 25 regular exercise studies. Acute exercises were those with a duration of less than a week while regular exercises were those done for a week or more. Among these, only four in the acute exercise studies were used in the correlation of the low intensity exercises to sleep. In the 2015 study, low intensity exercises resulted in no significant difference in total sleep time, sleep efficiency and sleep quality.[18] In the present meta-analysis of seven studies, the duration of low or moderate exercise was more than one week. The result was decreased total sleep time, an improvement in sleep quality, and no significant effect on sleep efficiency, similar to the findings of the 2015 study. There were no common studies in the two meta-analyses.

The latest meta-analysis on sleep quality and exercise was in 2018 and included nine studies with a total of 557 participants aged 18 to 60 years and older.[19] The present meta-analysis covered only studies with participants 60 years and older. There were no common studies used in this meta-analysis and 2018 study. The findings on sleep quality and sleep efficiency were similar to those of the 2018 meta-analysis. The present meta-analysis resulted in a statistically significant decrease in sleep time which was not clinically significant, while the previous study showed no significant improvement. The 2018 meta-analysis reflects the general sleep quality of the whole adult group. The present meta-analysis yielded more specific information on sleep quality among the elderly.

Conclusions

The findings suggest that low to moderate intensity exercise improves sleep quality in persons aged 60 years and above. Low and moderate intensity exercise may be used as a non-pharmacologic intervention to enhance sleep quality of elderly, however, each patient's condition should be assessed for other factors that may affect sleep such as living conditions, comorbidities, chronic illnesses, disability, and risk of injury.

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