

Conference Paper

Interaction Between Exercise and Sleep Quality Through Melatonin Synthesis: A Literature Review

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Abstract.

Irregular exercise or insufficient physical activity may disrupt the biological clock and secretion of the melatonin hormone, which is important in sleep regulation. Regular exercise with a certain intensity and duration can help the body to increase melatonin production which can reduce sleep disorders. A search of full-text articles relevant to exercise and sleep quality was conducted in this literature review. We used four international databases: PubMed, PMC, Wiley Library, and ProQuest. We searched for articles published from 2017 to 2021. After screening the collected articles, only 12 articles were included. The articles were assessed using the JBI appraisal tools and the data were analyzed using descriptive methods. It was found that regular exercise at a certain intensity and duration affects the production of the melatonin hormone in humans. 6 out of the 12 articles revealed that melatonin levels changed in the study participants after doing exercise. Furthermore, 6 other articles mentioned that exercise had an impact on improving sleep quality.

Keywords: physical activity, exercise, sleep quality, melatonin hormone

1. INTRODUCTION

Exercise is the body's ability to move for physical and psychological stabilization. Exercise that is applied irregularly causes fatigue and poor control of emotions. Less physical activity may disrupt the biological clock and secretion of the melatonin hormone, which is important in sleep regulation. A person with deficit hormone melatonin affects the quality of his sleep [1].

The prevalence in the world who have poor sleep quality due to lack of exercise amounts to 30-50% of the total population. Male respondents aged 13-19 years, 63.3% experienced insomnia due to fatigue due to irregular physical activity [2]. In Indonesia, insomnia affects more than 10% of the population, and has increased by 20%-40% every year [3].

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Aerobic exercise can activate parasympathetic nerves and decrease sympathetic nerve activity, resulting in fatigue that causes drowsiness. Exercise stimulates the pineal gland in the process of secreting the hormone melatonin. Optimal synthesis of the hormone melatonin can improve sleep satisfaction for the body. Smooth oxygen distribution also has an impact on increasing sleep relaxation [4].

In this literature study, researchers wanted to understand and find out in more detail about the impact of exercise that affected sleep quality based on melatonin levels in humans. Researchers aim to investigate the impact of exercise with various intensities on sleep quality for the body.

2. METHODS

A literatur review method was used to examine previously published articles on the topic of the interaction between exercise and sleep quality: focused on melatonin synthesis.

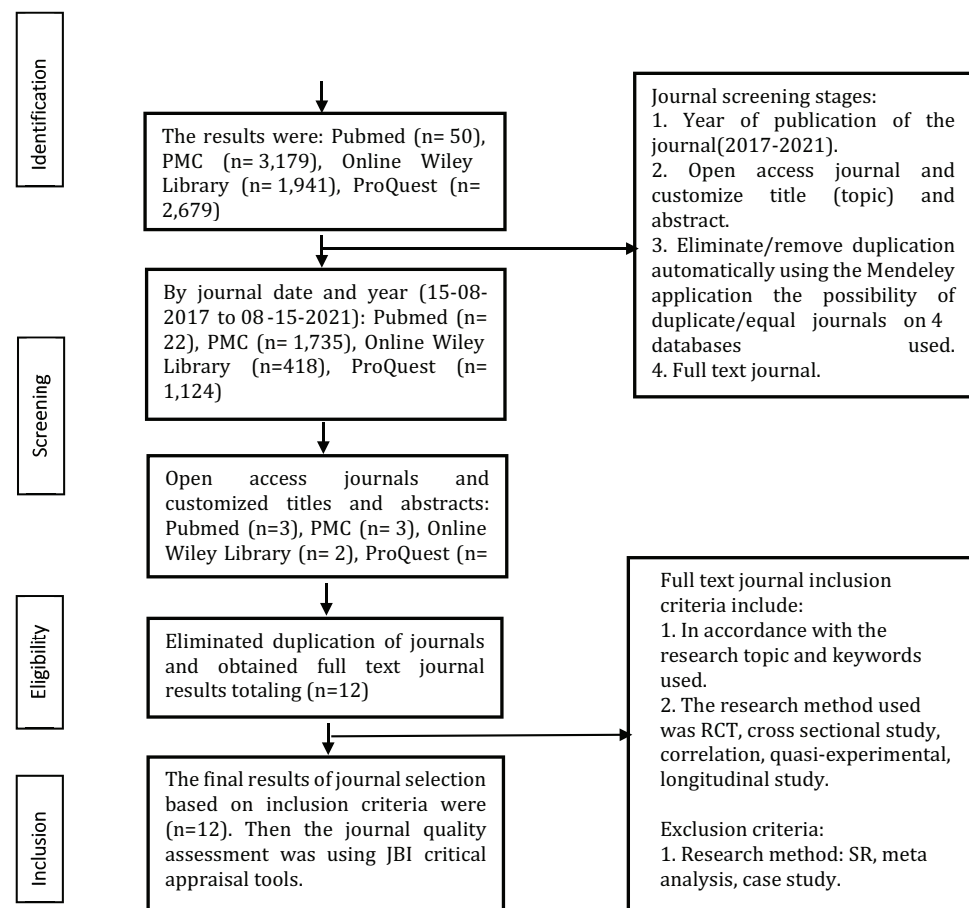


Figure \ PRISMA diagram showing literature selection

Figure 1: PRISMA diagram showing literature selection and exclusion process.

The inclusion criteria for full text journals were selected through the suitability of keywords and research topics. Full text journal with design methods in the form of RCT, cross sectional study, correlation, quasi-experimental and longitudinal study. Full text journal articles published from 2017 to 2021 were included.

The following question was posed: 'how does the interaction between exercise and sleep quality: focused on melatonin synthesis'. The researcher uses the PICO method in solving the problem formulation in the journal that has been obtained. The search terms were key word extracted from the research question that related to specific topic, combined using Boolean operator to obtain all the articles relevant to such topic. Full text journal articles published from 2017 to 2021 were included..

Researchers selected journals based on keywords and produced 7849 articles from 4 international database sites. After screening by selecting full text journals, according to topic, removing duplication and JBI value assessments, the final result of the selected process led to the inclusion of twelve articles in the literature review from several database sites, including PubMed (n= 2), PMC (n= 3), Online Wiley Library (n= 1), ProQuest (n= 6).

Extraction of data from selected journals through the stages of literature screening and JBI journal quality assessment. Researchers collect information from journals and present it in table form containing design, population, intervention, compare, results and limitations. Quasi-experimental methods design dominated the included articles. Journal quality assessment in data extraction is carried out using JBI critical appraisal tools. Assessment with JBI checklists according to the research design of each journal.

3. RESULTS

4. DISCUSSIONS

In this research, an increase in post-exercise levels of the hormone melatonin was obtained in 3 journal studies which stated that laboratory tests through the salivary glands and blood showed a significant increase [5, 7, 10]. Melatonin levels in sclerosis patients increased after moderate-intensity aerobic exercise from 106.65 pg/mL to 113.01 pg/mL [5]. Individuals that do high-intensity exercise cause an increase in melatonin concentrations from 10 pg/mL to 16 pg/mL [10]. Moderate physical activity can to increase the secretion of the hormone melatonin, but the timing and type of exercise must be considered [17].

Differences in melatonin hormone levels occur due to exercise with a certain duration [16]. Treadmill exercise for 30 minutes by male athletes showed an increase in the hormone melatonin at night after exercise 16.5 pg/mL [7]. Another study revealed that female baseball athlete's melatonin levels increased after 24 hours of long-duration exercise for 2 hours, post-exercise hormone levels reached 25 pg/mL [13]. Jogging for a short duration of 30 minutes believed to improve the deficit of the hormone melatonin in children aged 9-12 years who suffer from autism in terms of urine laboratory tests [15].

Physical activity exercise, high-intensity aerobic exercise, increases the body's ability to sleep and increases the production of the hormone melatonin at 20.00-03.00, as evidenced by an improvement in PSQI scores [12]. The intensity of exercise that normalizes melatonin helps the body to adapt to the circadian rhythm cause sleep quality improves. Exercise in adults can shift sleep latency [18]. Short duration walking exercise in patients with kidney disorders reduces the percentage of sleep disorders from 90% to 53.3% [6].

Based on the literature study results, levels of the hormone melatonin in the human body fluctuate due to several other factors such as physical conditions, body temperature, environment, lifestyle [19]. Age is a factor in melatonin deficit [20]. Dark and bright light also affects the quality of sleep because when it is dark the pineal will produce melatonin, therefore a person feels more sleepy at night [21]. The increase in the hormone melatonin can be influenced by fat oxidation due to long-duration exercise, the impact is an increase in the plasma concentration of tryptophan so that serotonin increases which causes fatigue and drowsiness [14]. This literature review study found that there is a relationship between exercise and sleep quality in terms of melatonin hormone levels. Future research is expected to more attention to aspects of sleep disorders, especially in further education and in the clinical area.

A limitation of this study is the search for full text journals. Unfortunately, there are still many journals published in the latest year that cannot be accessed for free. The selected journals have several demographic aspects that are not explained. Furthermore, the study setting was too broad (child, young adult, adult and older people) without distinguishing their age and medical medication, which could impact on the validity of this review.

5. CONCLUSION

This literature review study concluded that sleep disturbances can be reduced by exercise. The hormone melatonin, which increases due to exercise, can improve the circadian rhythm cycle. Exercise routine shows the effect of improving sleep quality parameters. Exercise can be implemented for all ages as needed to help sleep disorders based on the analysis of literature review studies in several related articles.

References

- [1] F. Wang and S. Boros, "Effects of a pedometer-based walking intervention on young adults' sleep quality, stress and life satisfaction: Randomized controlled trial,." *Journal of Bodywork and Movement Therapies*. vol. 24, no. 4, pp. 286–292, 2020.
- [2] R. Manggopa and R. Kundre, "Aktivitas Fisik Dengan Kejadian Insomnia Pada Atlet Gym,." *Aktivitas Fisik Dengan Kejadian Insomnia Pada Atlet Gym*. vol. 7, no. 2, pp. 1–6, 2019.
- [3] F. Marlinda, I. Herawati, and S. Fis, "Hubungan Aktivitas Fisik Dengan Kualitas Tidur Pada Dewasa Awal Di Jakarta Timur,." p. 2021.
- [4] L. Jurado-Fasoli, A. De-la-O, C. Molina-Hidalgo, J.H. Migueles, M.J. Castillo, and F.J. Amaro-Gahete, "Exercise training improves sleep quality: A randomized controlled trial,." *European Journal of Clinical Investigation*. vol. 50, no. 3, pp. 1–11, 2020.
- [5] A. Al-Sharman, H. Khalil, K. El-Salem, M. Aldughmi, and A. Aburub, "The effects of aerobic exercise on sleep quality measures and sleep-related biomarkers in individuals with Multiple Sclerosis: A pilot randomised controlled trial,." *NeuroRehabilitation*. vol. 45, no. 1, pp. 107–115, 2019.
- [6] A. Sharma and N. Mehta, "Effectiveness of Exercise Regimen on Sleep Quality in Patients With End Stage Renal Disease on Maintenance Hemodialysis,." *Kidney International Reports*. vol. 4, no. 7, pp. S367–S368, 2019.
- [7] L.A. Carlson, K.M. Pobocik, M.A. Lawrence, D.A. Brazeau, and A.J. Koch, "Influence of exercise time of day on salivary melatonin responses,." *International Journal of Sports Physiology and Performance*. vol. 14, no. 3, pp. 351–353, 2019.
- [8] A. Honma, V.L. Revell, P.J. Gunn, et al., "Effect of acute total sleep deprivation on plasma melatonin, cortisol and metabolite rhythms in females,." *European Journal of Neuroscience*. vol. 51, no. 1, pp. 366–378, 2020.
- [9] X. Li, X. Gao, and J. Liu, "Cross-sectional survey on the relationship between occupational stress, hormone levels, and the sleep quality of oilfieldworkers in

- Xinjiang, China.,” *International Journal of Environmental Research and Public Health*. vol. 16, no. 18, p. 2019.
- [10] P. Kaylee M, R. Seth A Von, L. Abigail J, D. Amber N, and E. Elizabeth S, “Influence of Aerobic Exercise on Sleep and Salivary Melatonin in Men.,” *International Journal of Sports and Exercise Medicine*. vol. 6, no. 2, p. 2020.
- [11] J.M. Thomas, P.A. Kern, H.M. Bush, et al., “Circadian rhythm phase shifts caused by timed exercise vary with chronotype.,” *JCI Insight*. vol. 5, no. 3, pp. 12–14, 2020.
- [12] S.D. Youngstedt, J.A. Elliott, and D.F. Kripke, “Human circadian phase–response curves for exercise.,” *Journal of Physiology*. vol. 597, no. 8, pp. 2253–2268, 2019.
- [13] S.O. Donnell, C.M. Beaven, G.M. Jacobson, S. Bird, and M.W. Driller, “Melatonin and sleep responses following exercise in elite female athletes.,” *The Journal of Sport and Exercise Science*. vol. 3, no. 2, pp. 8–13, 2019.
- [14] C. Rafie, Y. Ning, A. Wang, X. Gao, and R. Houlihan, “Impact of physical activity and sleep quality on quality of life of rural residents with and without a history of cancer: Findings of the day and night study.,” *Cancer Management and Research*. vol. 10, pp. 5525–5535, 2018.
- [15] A.C.Y. Tse, P.H. Lee, J. Zhang, and E.W.H. Lai, “Study protocol for a randomised controlled trial examining the association between physical activity and sleep quality in children with autism spectrum disorder based on the melatonin-mediated mechanism model.,” *BMJ open*. vol. 8, no. 4, p. e020944, 2018.
- [16] G. Mitrou, C. Giannaki, C. Karatzaferi, et al., “Nocturnal Activity Is Not Affected by a Long-Duration, Low-Intensity Single Exercise Bout.,” *Sports*. vol. 7, no. 3, p. 56, 2019.
- [17] B. Murawski, R.C. Plotnikoff, A.T. Rayward, et al., “Efficacy of an m-Health Physical Activity and Sleep Health Intervention for Adults: A Randomized Waitlist-Controlled Trial.,” *American Journal of Preventive Medicine*. vol. 57, no. 4, pp. 503–514, 2019.
- [18] E.J.L. Widiyantini, S. Sugiharto, and O. Andiana, “Pengaruh Olahraga Selama Puasa Terhadap Hormon Melatonin Pada Tikus Putih Jantan Jenis Wistar.,” *Jurnal Sport Science*. vol. 9, no. 1, p. 84, 2019.
- [19] A. Wendt, I.C.M. da Silva, H. Gonçalves, A. Menezes, F. Barros, and F.C. Wehrmeister, “Short-term effect of physical activity on sleep health: A population-based study using accelerometry.,” *Journal of Sport and Health Science*. vol. 00, pp. 1–9, 2020.
- [20] X. Li and X. Gao, “Cross-Sectional Survey on the Relationship Between Occupational Stress , Hormone Levels , and the Sleep Quality of Oilfield Workers in Xinjiang , China.,” p. 2019.
- [21] P. Larsen, F. Marino, K. Melehan, K.J. Guelfi, R. Duffield, and M. Skein, “Evening high-intensity interval exercise does not disrupt sleep or alter energy intake despite

changes in acylated ghrelin in middle-aged men.,” *Experimental physiology*. vol. 104, no. 6, pp. 826–836, 2019.

Author, Country	Year	Design	Study Setting	Intervention	Compare	Results	Limitation
Al-Sharman (2019) Jordan	et al., (2019)	RCT	Patients with a median diagnosis of multiple sclerosis in Jordan.	The intervention group in the form of moderate-intensity aerobic exercise was given for 40 minutes (5 minutes warming up, 30 minutes of core movement, 5 minutes of cooling down).	The control group was given non-aerobic exercise with low and slow intensity.	The moderate-intensity aerobic exercise intervention group experienced a significant increase in PSQI scores and levels of serotonin and melatonin biomarkers significantly increased during the 6-week intervention period. The score changes melatonin from 106.65 to 113.01 with a p-value of 0.39.	The intervention in this study was of short duration (six weeks) with no period of follow-up.
Sharma & Mehta (2019) India		Quasi Experimental	Patient suffering from end-stage renal disease in the dialysis unit of Fortis Mohali Hospital India.	Exercise intervention in the form of walking in the afternoon serial with a duration of 25-30 minutes carried out 5 days a week for 2 weeks. Researchers evaluated PSQI scores in association with laboratory blood tests including platelets, calcium, melatonin and albumin.	-	The PSQI score of sleep quality before and after the intervention had a significant difference in sleep improvement. The laboratory test values for melatonin and albumin had a significant relationship with sleep quality, p-value 0.042 using regression analysis.	Small sampel size
Carlson (2019) UK	et al., (2019)	Longitudinal study	Male runner athlete.	Exercise intervention on the treadmill in the morning at 09.00 and in the afternoon at 16.00. Salivary sampling was carried out after the intervention 3 times, namely at 20.00, 22.00 and 03.00.	-	Post-hoc analysis revealed that melatonin levels at 22.00 were significantly higher after treadmill exercise in the morning than in the afternoon (p > 0.05). Evening exercise can reduce melatonin secretion compared to morning exercise.	Subject were permitted to move freely.
Honma (2020) UK	et al., (2020)	Quasi Experimental	Young woman in good health around Surrey United Kingdom.	Controlled laboratory intervention for 92 hours by observing activity, food and environment including light. Blood samples were taken for 70 hours of observation to monitor plasma melatonin and cortisol.	-	Melatonin levels at night increased (102.1 pg/ml) and returned to normal during sleep recovery (81.5 pg/ml).	-
Li (2019) China	et al., (2019)	Cross-sectional study	All employees of national petroleum corporation in Karamay City of Xinjiang.	The intervention was carried out by measuring the stress scale, sleep quality according to international standards, the blood sampling process started at 9 to 11 am to measure plasma melatonin.	-	The concentration of glucocorticoids in the positive sleep group in workers was lower than in the negative sleep/sleep deprivation group. The difference between cortisol and melatonin was not statistically significant (p > 0.05).	-

Author, Country	Year	Design	Study Setting	Intervention	Compare	Results	Limitation
Kaylee M et al., (2020) USA		Quasi Experiment	Male 18-44 years old at Elon university.	The intervention was given by doing moderate-intensity exercise for 8 weeks. with a duration of 30-45 minutes per day performed 3-4 days a week. Salivary melatonin levels were assessed before intervention, mid-intervention and post-intervention taken at 20.00, 22.00 and 03.00.		PSQI scores increased significantly post-intervention (p= 0.046). Salivary melatonin levels increased significantly from before intervention to post intervention at 20.00 to 03.00 (p = 0.015 - 0.037).	Participants were encouraged to reach out to study investigators with question or further guidance throughout the duration of the study
Thomas et al., (2020) USA		RCT	A total of 400 males aged 18-45 years in Lexington Kentucky.	Aerobic exercise intervention in the morning and measured delayed latency melatonin onset (DLMO) before and after 5 days of intervention 10 hours after exercise.	A control group of 26 participants was given aerobic exercise in the afternoon and mild onset of melatonin (DLMO) was taken after 20 hours post-exercise.	The sleep duration phase shift in the morning exercise group was significantly greater than the sleep duration phase shift in the afternoon exercise group (-0.02 +- 0.18 hours, p= 0.01). The results suggest that participants with impaired circadian rhythm may benefit from advancing sleep duration with exercise in the morning.	
Youngstedt et al., (2019) USA		Quasi Experiment	Physically healthy and active individuals range from young adult to old age in Arizona.	Exercise for 1 hour. Exercise is done for 3 days during the day or night. To describe the phase response curve (PRC) urine melatonin was taken.		PRC was significant at onset, acrophase and sulphatoxymelatonin duration earlier (p < 0.001), onset (p < 0.001) and offset (p = 0.02).	Less intensity duration of exercise
Donnell et al., (2019) Zealand		Quasi Experiment	New Zealand national netball women's athlete.	Sports one netball training session for 6 days and 1 day of rest. Saliva samples were taken before and after exercise.		Melatonin levels were lower in both pre and post exercise training sessions (6.2 and 17.6 pg/mL) than melatonin levels on rest days (14.8 and 24.3 pg/mL). Netball exercise at night has been shown to suppress salivary melatonin levels and affect sleep the next day.	Small sample size and small number of measured time points where saliva collected

Author, Country	Year	Design	Study Setting	Intervention	Compare	Results	Limitation
Rafie et al., USA	(2018)	Cross-sectional study	Individuals in the villages in the Southwest Virginia areas without a history of cancer and cancer patients in the oncology clinic.	Exercise walking every day. Blood and urine samples were taken in the morning to analyze creatinine and sulphatoxymelatonin.		Cancer patients were more likely to be less active and had significantly worse sleep quality and mental health than healthy individuals ($p < 0.05$). There is no significant relationship between melatonin levels and quality of life.	Relatively small sample size
Tse et al., China	(2018)	RCT	Children with ASD diagnosis from a psychiatrist.	12 week jogging workout program with 24 training sessions with a duration of 30 minutes. Urine samples were taken 24 hours after jogging to measure sulphatoxymelatonin and creatinine.	The control group received the usual medical care without jogging but also had urine samples taken to measure their sulphatoxymelatonin and creatinine.	The results potentially have 2 significant implications. The mechanism of melatonin in the body can manipulate the frequency of sleep quality in children with ASD.	
Mitrou et al., Greece	(2019)	Quasi Experimental	Young individuals in Thessaly Greece.	Jogging on a treadmill for 3 hours at a low speed (5 km/hour). Biochemical examination was carried out during fasting conditions at 08.00 am to assess urea, creatinine, melatonin and cholesterol.		All indices were within the normal range including sleep statistical assessments including biochemical differences were found in pain scores ($p = 0.047$).	The biochemical blood test took place only before the exercise