HIGH SCHOOL EDITION
Journal of Student Research
Volume 12 Issue 4 (2023)

Analysis on the Application of Exercise in Resolving Increased Sleep-Onset Latency

Anke Li

No. 2 High School of East China Normal University – International Division, China

ABSTRACT

As insufficient sleep has been coined a "public health epidemic" by the U.S Centers for Disease Control and Prevention (CDC), interventions should be executed as to ease the global crisis. Currently, considerable accounts of research have been done using various outcome measures to help put a stop to the health crisis. Moreover, a decrease in sleep quality and times is often times caused by the delay in overall sleep-onset latency. Exercise and sleep are thought to be interconnected; however, uncertainty is present around the debate of whether exercise may affect sleep-onset latency. This article examines the various accounts of research done on the topic by analyzing current studies through literature review, attempting to form a comprehensive and thorough conclusion based on current findings, while simultaneously introducing the severity, background, and biological basis behind the issue to provide further insight on the correlation between exercise and sleep-onset latency. However, conflicting results and conclusions were found, most likely due to multivariate aims, creating a variety of contrasting variables such as differing demographics, settings, and outcome measures. Nonetheless, through compilation of various sources, new insight can be made regarding how an increase in sleep-onset latency can be combated with consideration of definitive demographics and settings. Moreover, while a generalization cannot be made based on the research conducted in this article, exercise can still be utilized and applied in specific circumstances.

Introduction

Our generation today faces a growing and intensifying crisis surrounding the topic of insufficient sleep. This is evident in how the issue has grown to become a public health debate, with the insufficiency of sleep becoming a widespread and prevalent issue across the nation, due to numerous factors such as work and academic pressure, industrialization and the collective disregard towards the harms of insufficient sleep. Furthermore, to illustrate its severity and ubiquity across the country, this crisis has been coined as a "public health epidemic" by the U.S Centers for Disease Control and Prevention (CDC). Moreover, the contributing factors of sleep often relate and have a direct link to the way in which we have altered our biological clock, or in other words, our circadian rhythm. Longer duration of the circadian period over 24 hours is a result of a delayed sleep schedule, in which there occurs a deficit in sleep duration caused by an increased sleep-onset latency along with forced wake due to social circumstances. Correspondingly, the delayed sleep schedule causes our circadian system to be interrupted. Under continuous reoccurrence, the delay may lead to Circadian Rhythm Sleep Disorders (CRSD). This occurs when the external environment or social circumstances aren't aligned to the circadian clock (Zhu, Lirong et al, 2012). Thus, it illustrates the need for a solution to this national health crisis.

Literature Review

To propose a solution to easing the epidemic, several comprehensive studies have been conducted on how daily habits and routines can be incorporated in an individual's life as to decrease the occurrence of insufficient sleep and

disruption as caused by the burdens and pressures put on by our increasingly arduous modern lifestyles. A reoccurring finding was that there existed a correlation between exercise and sleep quality. To illustrate, in a study looking at postpartum women ages 18-35 and the effects of Pilates exercise on their sleep quality, it was discovered through open trial meta-analysis that sleep-onset latency decreased with 30 minute exercises, five days a week for 8 consecutive weeks. (Ashrafinia et al. 2014) Through another comprehensive meta-analysis, results showed that acute exercise has a small but measurable effect on decreasing sleep-onset latency, while regular exercise has a small-to-moderate impact on sleep-onset latency. (Kredlow et al, 2015) These studies indicate a negative correlation between exercise and sleep-onset latency as increased exercise resulted in a decrease in sleep-onset latency. Furthermore, in a single group study on adults 55 or older, using wrist actigraphy and the Pittsburgh Sleep Quality Index as outcome measures, a session of moderate intensity exercise was shown to have led to a decrease in sleep-onset latency. However, in the same study, it was found that after one night following a series of high-intensity exercises or moderate-intensity exercises, no significant changes were recorded in the participants' sleep-onset latency. (Baron et al, 2013)

As shown, the data derived from the literature used display various contrasting findings regarding the topic of exercise and sleep latency. This may be a result of multivariate aims in the studies. Due to said multivariate aims, variables across experiments and studies may alter, resulting in conflicting results. In that case, this paper will be analyzing the various sources to create a structured conclusion in reference to patterns and re-occurrences, as well as relying on the biological basis of sleep and our circadian rhythm.

Table 1. Various studies regarding the correlation between exercise and sleep onset latency, broken down with demographics, settings, and outcome measures.

Study	Demographic	Setting	Outcome Measure(s)	Results (Increase, decrease or no change in sleep-onset latency)
Ashrafinia et al. 2014	80 primigravida postpartum women ages 18-35	30 minute pilates exercises, 5 days a week for 8 consecutive weeks	Trial meta-analysis	Decreased
Kredlow et al, 2015	Varying sex and age	Varying types of acute exercise	Meta-analysis	Decreased (small but measurable effect)
Kredlow et al, 2015	Varying sex and age	Varying types of regular exercise	Meta-analysis	Decreased (small-to-moderate effect)
Baron et al, 2013	11 healthy, community-dwelling sedentary older adults (Ages ≥55) with sleep disturbance ≥3 months, as well as meeting the DSM-IV criteria for primary insomnia.	Moderate aerobic exercise	Wrist actigraphy and Pittsburgh Sleep Quality Index	Decreased
Baron et al, 2013	11 healthy, community-dwelling sedentary older adults (Ages ≥55) with sleep disturbance ≥3 months, as well as meeting the DSM-IV criteria for primary insomnia.	High-intensity exercise and moderate-intensity resistance training	Wrist actigraphy and Pittsburgh Sleep Quality Index	No significant changes were observed

Melatonin and its effect on Sleep-Onset Latency

An important factor to take into account in empirically measuring and determining the effect of exercise on sleep is melatonin, otherwise known as *N*-acetyl-5-methoxytryptamine, the key hormone in regulating the sleep-wake cycle of our circadian rhythm. As photoreceptors of the retina detect a dark environment, neural signals are transferred by the optic nerve to the suprachiasmatic nucleus of the anterior hypothalamus and finally transferred to the pineal gland through a multi-synaptic pathway. Due to its location outside of the Blood Brain Barrier (BBB), the pineal gland receives a large uptake of the amino acid Tryptophan, and through a series of enzymatic processes, melatonin is then produced by the pineal gland as the hormone, norepinephrine situated in the gland stimulates the secretion. (Masters, Alina et al, 2014) The hormone is subsequently transferred to all areas of the body through the blood stream, from the brain and spinal cord surrounding cerebrospinal fluid. Lastly, melatonin signals the body to enter sleep. (Doghramji, Karl, 2007)

Thus, Melatonin is the primary hormone responsible for regulating our circadian rhythm, by indicating to the brain when it is time to enter sleep. In that sense, the increase in sleep-onset latency and the decrease in production of melatonin are related, with a negative correlation as the decrease of melatonin will increase sleep-onset latency, while, in the same fashion, the increase of melatonin will decrease sleep-onset latency. With this relationship established, melatonin production will be analyzed in this paper in correspondence to varying levels and intensities of physical exercise as to formulate a structured conclusion on the effect of exercise on sleep-onset latency.

Effect of Exercise on Melatonin Production

As the link between exercise and sleep-onset latency has been proven to be integral on the idea of the production of melatonin during exercise, a proportionate amount of research has been conducted and published in order to monitor and determine the effect that exercise has on the production and secretion of melatonin. For instance, it has been found that moderate-intensity aerobic exercise has been shown to increase melatonin secretion after 8 weeks of continuous activity. This was demonstrated with the significant increase of melatonin from salivary sample concentrations, measured pre-intervention and post-intervention in a study on participants aged 18-44. Moreover, using the Pittsburgh Sleep Quality Index as outcome measures, significant changes and an increase in sleep quality was assessed in this test. (Pobocik, Kaylee M et al, 2020) However, a consensus for the studies regarding the study of exercise and melatonin production is that it is an open topic with many variables. For instance, the study shown above was only tested on men, thus, it can not account for the production of melatonin for women during exercise. Moreover, in another study, it was found that late evening exercise, in which the body is in the rising phase of secreting melatonin, actually brings about adverse effects on melatonin production. What's more, in the same study, it was found that high-intensity exercise during the night, when melatonin levels have reached their elevated status, resulted in nearly a 50% increase of melatonin levels. (Buxton, O M et al, 1997) Hence, the conflicting results indicate that the time of day is a vital factor in determining the efficiency of melatonin secretion the night following exercise. As shown, the field is too broad to make a generalized conclusion of whether exercise definitely results in an increase in melatonin production.

Table 2. Various studies regarding the correlation between exercise and melatonin production, broken down with demographics, settings, and outcome measures.

Study	Demographic	Setting	Outcome Measure(s)	Results (Increase, decrease or no change in melatonin production)
Pobocik, Kaylee M et al, 2020	Men ages 18-44	8 weeks of continuous of moderate-intensity aerobic exercise	Pittsburgh Sleep Quality Index, Salivary samples	Increase
Buxton, O M et al, 1997	n/a	late evening exercise	Meta-analysis	Decrease
Buxton, O M et al, 1997	n/a	high-intensity exercise during the night	Meta-analysis	Increase (nearly 50%)

Discussion

The results of the analysis across varying sources regarding and acknowledging the relation between exercise and sleep offer new insight on ways to prevent an increasing sleep-onset latency through the use of exercise. It was found through literature review based on current findings and correlations that exercise can be utilized in specific settings and manners to decrease an individual's sleep-onset latency. To illustrate these findings, in a discrete demographic group of postpartum women situated between the ages of 18-35, research through open trial meta-analysis indicated that with the integration of 30 minute exercises, engaged five days a week, sleep-onset latency can be decreased. (Ashrafinia et al. 2014) Furthermore, these insights provide opportunities in application for specific demographics. The study aimed towards investigating the effects of Pilates exercise can be applied in further endorsement of Pilates programs in assistance for the recovery of postpartum women. As prolonged exposure to poor sleep can affect a postpartum woman's ability to recover and provide maternal and familial care, it may be necessary to provide Pilates exercise as an intervention in such a critical period.

However, it is important to consider the limitations surrounding the research done on this topic. The most significant limitations are the multivariate aims of the research discussed in this article, as variables remain inconstant across research and studies that assess different groups and situations with varying usages of outcome measures. Hence, as literature review covers a variety of studies with multivariate aims, it is unsuitable to form a generalized consensus about exercise's effect on decreasing sleep-onset latency. Although, it has been found that in certain situations considering one's demographic and settings, exercise has been proved to be successful as an application in decreasing an individual's sleep-onset latency.

Conclusion

The crisis involving the disruption in the generation's circadian clock is a concern worldwide, due to work and academic pressure, industrialization and the collective disregard towards the harms of insufficient sleep. As a result, we are faced with more cases of increased sleep-onset latency, resulting in a delayed and disrupted circadian rhythm. The conclusion that can be made is that there is potential in treating disrupted circadian rhythms through the process of exercise. However, many variables are involved in the results. On the other hand, when analyzing trends within the given studies, it can be concluded that with the right definitive approach in exercising, sleep-onset latency has the potential to be shortened. Some examples of approaches can include exercising when melatonin levels are at or near their peak or participating in regular exercises instead of acute exercises. (Buxton, O M et al, 1997) (Kredlow et al, 2015) Thus, while the results show data of increasing melatonin levels under specific circumstances, it is difficult

to make a generalized statement about whether or not exercise is an absolute solution to delayed circadian cycles and the "public health epidemic" of our generation.

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