Effect of Music on Sleep Efficiency in Active Adults

Joanna Kantilierakis, Emily Wasson MPH, Andrea Spaeth PhD

RUTGERS
Aresty Research Center for Undergraduates

Abstract

The overall purpose of this study was to test if using a music-relaxation technique at bedtime improves sleep efficiency in adults who are physically active in the evening. Sleep and exercise are both important for health, so addressing/examining strategies to improve sleep after evening-exercise would be beneficial for many adults with busy schedules. To our knowledge, no one has examined if music relaxation therapy improves sleep in adults who exercise in the evening. Additionally, previous studies examining the impact of music relaxation therapy have measured sleep using self-report questionnaires/diaries which may result in user bias, whereas my approach uses objective measures of sleep. This study was structured as a randomized, within-subject, cross-over experimental design. Each participant participated in the study for two weeks with each condition (music vs. no music) lasting one week. During the music condition, participants listened to a 30-minute standardized music track while in bed at bedtime. Sleep efficiency was measured using wrist-actigraphy devices which tracked sleep-wake patterns based on activity counts. Eight individuals met the inclusion criteria and completed the study. Following evening exercise, music did not affect sleep efficiency or any other sleep variables (all $p > 0.05$). However, we found that music led to a significantly later sleep offset (p=0.02) and a marginally longer total sleep time (p=0.11) on nights following no exercise. In healthy adult exercisers, listening to music on nights when they did not exercise may be beneficial for sleep.

Background

Exercise and sleep share a reciprocally positive relationship such that adults who exercise are more likely to exhibit better-quality sleep and less like to suffer from sleep-disordered breathing. Those with better sleep (increased sleep efficiency, shortened sleep onset latency, fewer awakenings after sleep onset, and more deep sleep) exhibit greater exercise exertion and higher physical activity levels.

However, the timing of exercise is important because physiologically, sleep is typically initiated by a decrease in an individual's core body temperature and an increase in peripheral temperature, which may be altered by evening exercise. There is evidence that strenuous exercise done within 4-6 hours of the start of the sleep period could ultimately disrupt sleep (1). For many people, late night exercising is unavoidable, but subsequently, their sleep may be impaired in the process.

Music therapy is an easily implemented relaxing agent that may foster sleep and improve sleep quality (2). Studies show that music has a positive effect on the brain that decreases an individual's heart rate through its positive influence on increasing Peripheral Nervous System and decreasing activation of the Sympathetic Nervous System, which decreases one's body temperature and eases the onset of sleep (3).

The purpose of the current study is to determine if evening exercise impacts sleep and if music therapy is efficacious for improving sleep after evening exercise. It is hypothesized that participants will exhibit lower sleep efficiency on nights after they exercise compared to nights after they do not exercise and that listening to music before bed will increase sleep efficiency on all nights compared to control (no music) condition.

References

1. Atkinson G, Davenne D. Relationships between sleep, physical activity and human health. *Physiology & Behavior.* 2007;90(2):229-235.
2. Warth M, Kessler J, van Kampen J, Ditzen B, Bardenheuer HJ. 'Song of Life': music therapy in terminally ill patients with cancer. *BMJ supportive & palliative care.* 2018;8(2):167-170.
3. Chang E-T, Lai H-L, Chen P-W, Hsieh Y-M, Lee L-H. The effects of music on the sleep quality of adults with chronic insomnia using evidence from polysomnographic and self-reported analysis: A randomized control trial. *International Journal of Nursing Studies.* 2012;49(8):921-930.

Methods and Materials

Study Design: Randomized, within-subject, cross-over experimental, two week design. Each condition (music vs. no music) lasted one week. Participants (n=8, see **Table 2** for participant information) were randomly assigned to the order of conditions.

Procedure:

- After being screened for eligibility and providing consent to participate (**Figure 1 and Table 1**), participants completed a demographic questionnaire and were given study instructions.
- During the music condition, participants listened to music each night for 35 minutes at bedtime for one week whereas during the no-music condition, participants did not listen to any music at bedtime for one week.
- The music was standardized and provided to participants. Music ranged from R&B/soul ballad, light rock, smooth jazz, country, classical and peaceful Buddhist pieces that lasted 35 minutes. Each song was carefully chosen based on its tempo; all songs were between 60 to 80 beats/minute.
- During both conditions, participants engaged in evening exercise at least 3 times per week (Brazilian Jiu-jitsu). Participants attended the same number of Jiu-jitsu sessions on the same nights during both conditions.

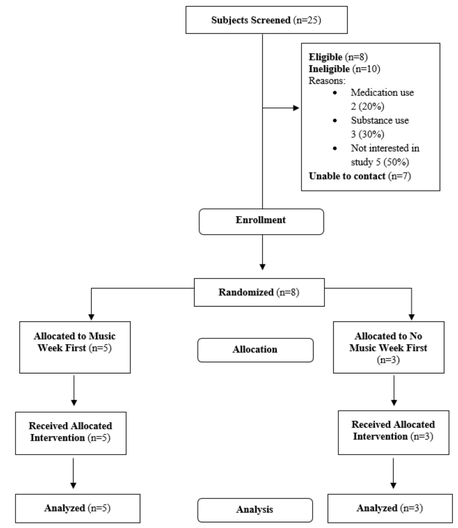
Outcome Variable: Nightly sleep was measured objectively using a wrist-worn Actigraph GT3X accelerometer. The device was worn 24/7 for the entire 2-week study. Participants also completed a daily sleep diary. Sleep efficiency was the primary outcome variable (actigraphically determined total sleep time / sleep period [bedtime to wake time]).

Statistical Analysis: Paired-sample t-tests were used to compare sleep parameters during the music condition and no-music condition and during nights following exercise or no exercise. A p value < 0.05 was considered a statistically significant difference.

Table 1. *Timetable/Schedule of Events*

Day	Activities
Day 0: 20-30 minute group orientation	Informed Consent Receive procedure instructions Complete brief demographic questionnaire
Day 1-7: First Condition Week (i.e. with or without music)	Wear wrist actigraphy device 24/7 Complete daily sleep diary Listen to music at bedtime (if applicable for condition) Go to BJJ three times during the 5-day work week
Day 7: Check-in Visit	Return sleep diary from week 1 Receive refresher on procedure instructions Return/receive music device
Day 8-14: Second Condition Week (i.e. with or without music)	Wear wrist actigraphy device 24/7 Complete daily sleep diary Listen to music at bedtime (if applicable for condition) Go to BJJ the same three days as the first condition week and repeat their other exercise schedule.
Day 14: End-of-study Visit	Return wrist actigraphy device Return sleep diary from week 2 Return music device (if applicable)

Figure 1. Consort Diagram of Participant Flow



Results

Table 2. *Participants' characteristics (N = 8)*

Variables	N (%) or Mean ± SD
Age	33.8 ± 11.42
Education Completed	
Greater than High School	7 (87.5)
Less than or equal to High School	1 (12.5)
Gender	
Male	5 (62.5)
Female	3 (37.5)
Ethnicity	
Hispanic or Latino	2 (25.0)
Not Hispanic or Latino	6 (75.0)
Race	
American Indian or Alaska Native	0 (0.0)
Asian	3 (37.5)
Black or African-American	0 (0.0)
Native Hawaiian or Other Pacific Islander	0 (0.0)
White or Caucasian	4 (50.0)
Other	1 (12.5)
Employment Status	
Not Working	0 (0.0)
Working Part-time (20 hours/week)	1 (12.5)
Working Full-time	7 (87.5)
Shift-Work	
Yes	3 (37.5)
No	3 (37.5)
N/A	0 (0.0)
Caffeinated Beverage Intake	1.8 ± 1.5
Caffeinated Medication Intake	0 (0.0)
Sleep or Circadian Disorder	
Yes	0 (0.0)
No	8 (100)
Medication Intake	
Yes	3 (37.5)
No	5 (62.5)

Figure 2. Sleep Efficiency by Exercise and Music Conditions

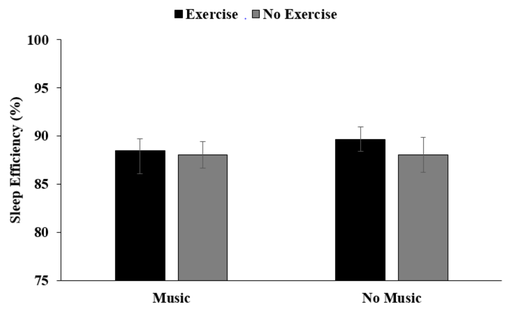


Figure 2. Sleep Efficiency by Exercise and Music Conditions

There were no differences across conditions in Sleep Efficiency (all $p > 0.05$).

Table 3. *No Exercise*
Mean objective sleep parameters in the two conditions during the study night (N = 8).

Objective Sleep Parameters	Condition	Mean ± SD	p
Sleep Onset (hh:mm)	Music Condition	23:07 ± 1:40	0.77
	No Music Condition	23:14 ± 1:46	
Sleep Offset (hh:mm)	Music Condition	07:03 ± 1:46	0.02
	No Music Condition	06:35 ± 1:43	
Total Sleep Time (min)	Music Condition	401.05 ± 51.78	0.11
	No Music Condition	389.59 ± 45.16	
Wake After Sleep Onset (min)	Music Condition	52.51 ± 15.88	0.87
	No Music Condition	51.53 ± 18.06	
Sleep Efficiency[a] (%)	Music Condition	88.05 ± 3.99	0.98
	No Music Condition	88.02 ± 5.15	
Sleep Fragmentation Index[b]	Music Condition	12.09 ± 6.03	0.83
	No Music Condition	11.47 ± 4.70	

Note: [a]Sleep Efficiency = Total Sleep Time/Time in Bed x 100; [b]Sleep Fragmentation Index = Total number of 1 min sleep bouts / Total number of all sleep bouts x 100

Table 4. *Exercise*
Mean objective sleep parameters in the two conditions during the study night (N = 8).

Objective Sleep Parameters	Condition	Mean ± SD	p
Sleep Onset (hh:mm)	Music Condition	23:23 ± 1:42	0.34
	No Music Condition	22:51 ± 1:27	
Sleep Offset (hh:mm)	Music Condition	6:43 ± 1:28	0.86
	No Music Condition	6:39 ± 1:34	
Total Sleep Time (min)	Music Condition	388.75 ± 54.79	0.28
	No Music Condition	417.77 ± 42.35	
Wake After Sleep Onset (min)	Music Condition	48.49 ± 27.72	0.91
	No Music Condition	47.31 ± 11.93	
Sleep Efficiency[a] (%)	Music Condition	88.46 ± 6.79	0.60
	No Music Condition	89.68 ± 3.63	
Sleep Fragmentation Index[b]	Music Condition	7.38 ± 5.68	0.46
	No Music Condition	8.84 ± 4.52	

Note: [a]Sleep Efficiency = Total Sleep Time/Time in Bed x 100; [b]Sleep Fragmentation Index = Total number of 1 min sleep bouts / Total number of all sleep bouts x 100

Discussion

We found that sleep parameters, including sleep efficiency, were not different on nights following exercise or no exercise. Furthermore, we did not observe differences by music condition in sleep efficiency (**Figure 2, Tables 3 & 4**). However, we did find that on nights when participants did not exercise, listening to music before bed led to a significantly later wake time and 11.5 more minutes of sleep (**Table 3**). In conclusion, the data did not support our hypothesis.

Previous studies have shown poorer sleep following evening exercise; however, these studies measured sleep using self-report. Therefore, music and exercise may impact an individual's perception of their sleep without impacting objective measures of sleep. Previous studies have shown that subjective and objective measures of sleep do not always align and this is particularly true for women.

The current study had the following strengths and limitations.

- First, the sample size was small due to difficulty with recruitment. We chose to enroll adults who were regular exercisers at moderate-to-high intensity. Therefore, future studies should determine the effect of music and exercise on sleep in those who are not as physically active to increase generalizability.
- Second, sleep was measured using wrist actigraphy. Music and exercise may influence aspects of sleep (e.g., sleep architecture) that are not captured by this method. Future studies should measure sleep using multiple methods to determine how music and exercise impact sleep.
- Finally, the music playlist was pre-determined rather than selected by participant. Therefore, music may benefit sleep to a greater degree if participants are able to select music they like.
- The well-controlled experimental design, carefully selected participants based on inclusion/exclusion criteria, and objective measurement of sleep were all study strengths.

Acknowledgements

Thank you to the following for making this research opportunity possible: Rutgers University School of Environmental & Biological Sciences; Rutgers University Department of Kinesiology & Health; Rutgers Sleep Lab: Lab Director: Dr. Spaeth & Lab Coordinator: Emily Wasson; Aresty Research for Undergraduates/Fellowship Grant Program; the participants; Jaguar Brazilian Jiujitsu (site of recruitment and orientations); my Mom, Dad, brother and sister.

RUTGERS