# Student Exercise and Sleep Timing (SiESTa) Study

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## Introduction

Approximately 50% of college students report daytime sleepiness and drowsiness as a result of insufficient sleep [1]. Although exercise can be used as an effective non-pharmacologic treatment to improve sleep health [2-4], it may impair sleep if performed too close to bedtime [3, 5-6, 8]. Late-night exercise is common among college students as this is often the only time they have in their schedule due to classes and other activities. A previous survey study in Rutgers Sleep Lab examined the relationships between exercise timing and sleep quality and found that evening exercisers had later bedtimes, longer time in bed, lower sleep efficiency, and scored worse on the Pittsburgh Sleep Quality Index (PSQI) subscales for sleep quality and efficiency compared to morning exercisers (Manuscript Submitted for Publication). Experimental studies have been limited protocols that assess same-night acute effects of exercise on sleep, and no studies focus on college students [9, 10]. This study aims to fill the gap in the knowledge about the effects of exercise timing on sleep by assessing the feasibility of a morning-exercise intervention in college students. It is hypothesized that shifting exercise timing from the evening to the morning will improve sleep efficiency, mood, and productivity and decrease stress.

## Methods and Materials

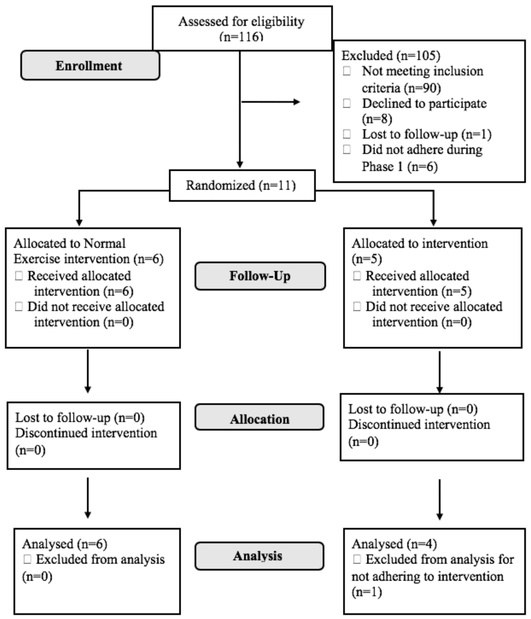


**Figure 1**. *Diagram of Participant Flow*

Participants:

College students (Age 18-23y, N=11; See **Figure 1**) were recruited in-person from the lobby of Rutgers University campus fitness centers. Subjects were regular exercisers ( at least 3 nights/week; 6pm-11pm) had no diagnosed sleep disorder and were Poor sleepers (PSQI Global Score ≥5).

Protocol:

**See Figure 2;** Mood, Stress and Productivity Questionnaires administered at Randomization and Follow-up Visits.

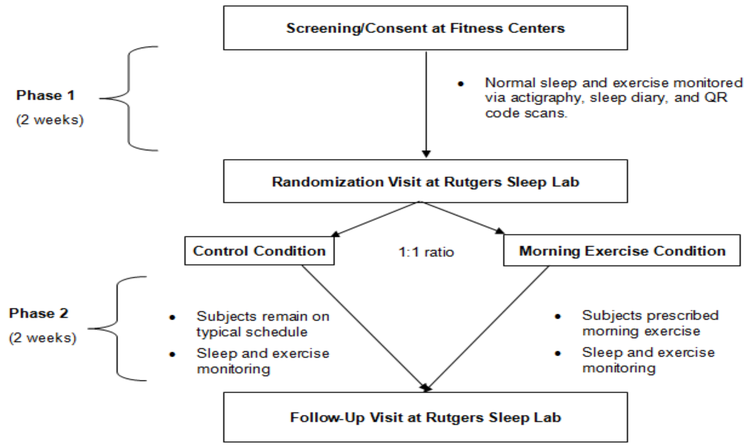


**Figure 2**. *Study Protocol and Randomization*

Outcome Measures:

- *Sleep*: Data was recorded 24h/day via a wrist-worn Actiwatch Spectrum Plus device (Murrysville, PA); Subjective sleep characteristics (e.g. naps) via online sleep diaries.
  - Sleep Period (Sleep Onset to Sleep Offset), Total Sleep time (time spent asleep during Sleep Period), Sleep Efficiency [(Total Sleep Time/Sleep Period)*100], and Wake After Sleep Onset.
- *Mood and Stress:* PROMIS Mood Measures (Positive Affect, Depression, Anxiety, Anger); Perceived Stress Scale Total Score.
- *Productivity:* "How would you rate your (overall productivity, class attendance, time management, memory and attention span)?" (1=poor, 2=fair, 3=good, 4= excellent).

Statistical Analysis: Descriptive statistics (means and frequencies) and between-subjects and Mixed-model ANOVAs.

## References

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## Results

**Table 1**. *Demographic characteristics (N=10).*

| Variables/Category | M(SD) or *f* (%) |
|---|---|
| Age | 20.3 (1.5) |
| Year of Study | |
| Freshman | 3 (30.0) |
| Sophomore | 1 (10.0) |
| Junior | 1 (10.0) |
| Senior | 5 (50.0) |
| Gender | |
| Woman | 4 (40.0) |
| Man | 6 (60.0) |
| Race | |
| American Indian or Alaska Native | 0 (0.0) |
| Asian | 3 (30.0) |
| Black or African American | 0 (0.0) |
| Native Hawaiian or Other Pacific Islander | 0 (0.0) |
| White or Caucasian | 4 (40.0) |
| Other | 3 (30.0) |
| Ethnicity | |
| Hispanic | 1 (10.0) |
| Non-Hispanic | 9 (90.0) |
| International Student | |
| Yes | 0 (0.0) |
| No | 10 (100.0) |
| Residential Status | |
| On Campus | 6 (60.0) |
| Off Campus | 4 (40.0) |
| Employment Status | |
| Yes | 7 (70.0) |
| No | 3 (30.0) |
| Chronotype Status | |
| Morning Type | 0 (0.0) |
| Neither Type | 3 (30.0) |
| Evening Type | 7 (70.0) |
| Global PSQI Score | 8.9 (3.0) |

**Table 2**. *Mean Scores* ± SD *for Productivity, Stress and Mood*

| Variable | Control (Mean ± SD) | | | Intervention (Mean ± SD) | | | p-value |
|---|---|---|---|---|---|---|---|
| | Pre | Post | (Post-Pre) | Pre | Post | (Post-Pre) | |
| Productivity | | | | | | | |
| Productivity | 2.00 ± 0.63 | 2.17 ± 0.98 | 0.17 | 2.50 ± 1.29 | 3.00 ± 0.00 | 0.50 | 0.65 |
| Attendance | 3.00 ± 1.10 | 2.83 ± 0.98 | -0.17 | 2.75 ± 0.96 | 2.50 ± 0.58 | -0.25 | 0.85 |
| Time Mgmt. | 2.00 ± 1.10 | 2.00 ± 0.89 | 0.00 | 2.00 ± 0.82 | 2.75 ± 0.96 | 0.75 | 0.17 |
| Attention | 2.17 ± 1.17 | 2.33 ± 0.82 | 0.16 | 2.50 ± 0.58 | 3.00 ± 0.82 | 0.50 | 0.48 |
| Memory | 2.67 ± 0.82 | 2.67 ± 0.52 | 0.00 | 3.75 ± 0.50 | 3.75 ± 0.74 | 0.00 | 1.00 |
| PSS | 30.67 ± 3.08 | 30.83 ± 4.40 | 0.16 | 25.00 ± 4.08 | 29.00 ± 3.16 | 4.00 | 0.27 |
| Mood | | | | | | | |
| Anxiety | 53.12 ± 5.42 | 53.28 ± 5.45 | 0.16 | 51.73 ± 1.16 | 53.18 ± 4.12 | 1.45 | 0.54 |
| Depression | 47.83 ± 6.27 | 49.05 ± 7.10 | 1.22 | 52.33 ± 4.28 | 53.35 ± 1.50 | 1.02 | 0.92 |
| Anger | 51.20 ± 4.60 | 56.47 ± 5.53 | 5.27 | 55.75 ± 8.42 | 59.85 ± 6.82 | 4.10 | 0.84 |
| Positive Aff. | 44.35 ± 5.89 | 42.70 ± 8.13 | -1.65 | 44.73 ± 4.82 | 44.58 ± 5.15 | -0.15 | 0.52 |

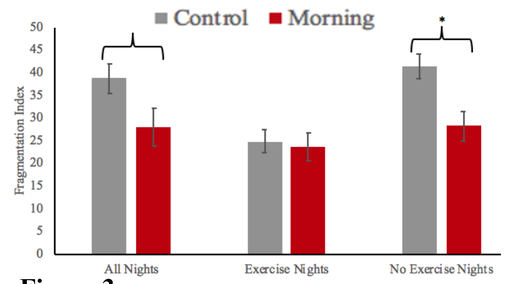


**Figure 3.**

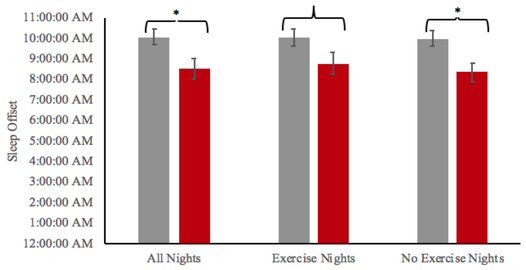


**Figure 4.**

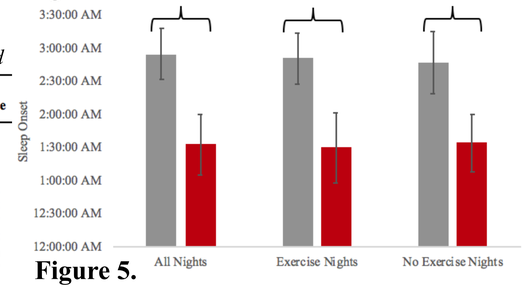


**Figure 5.**

**Figures 3-5** . *Sleep Data for All, Exercise, and No Exercise nights by Morning Intervention and Control Condition. Bar indicates Mean ± SE*

## Discussion

- All Nights: Morning Exercise associated with earlier Sleep Offset ($F(1,8) = 5.90$, $p = 0.04$, **Figure 3**). Trends towards earlier Sleep Onset ($F(1,8) = 5.00$, $p = 0.06$, Figure 5) and decreased fragmentation ($F(1,8) = 4.20$, $p = 0.08$, **Figure 4**).
- Non-Exercise Nights: Morning Exercise was associated with earlier Sleep Offset ($F(1,8) = 7.23$, $p = 0.03$, Figure 3) and decreased fragmentation ($F(1,8) = 9.53$, $p = 0.02$, Figure 4). Trend towards earlier Sleep Onset ($F(1,8) = 3.86$, $p = 0.09$, **Figure 5**)
- Exercise Nights: Morning Exercise showed trends toward earlier Sleep Onset ($F(1,8) = 3.83$, $p = 0.09$).
- The randomization condition had no effect on sleep variables, stress, productivity or mood. Limitations of this study included a small sample size and self-reported data assessments (e.g. productivity). Future studies should consider matching subjects between control and intervention based on intensity and duration. Morning exercise may lead to better sleep on nights that exercise is not performed.

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