Physical Fitness and Sleep in College Students

Kirsten Sutterlin, Emily Glavin, Andrea M. Spaeth

Department of Kinesiology and Health, Division of Life Sciences, School of Arts and Sciences Rutgers University New Brunswick

RUTGERS Aresty Research Center for Undergraduates

Background

Approximately, 44% of college students report insufficient sleep (<7h/night on average)(1) . Insufficient sleep is associated with Type 2 Diabetes, cardiovascular disease, depression and obesity, all which may be treated/modulated with physical activity (2-5). However, in addition to sleep deprivation, college students also report a lack of physical activity (6).

One measure of health that has been studied in relation to sleep health is physical fitness. Health-related physical fitness is broken down into cardiorespiratory fitness, muscular strength, muscular endurance, and flexibility. One study found that as the academic year progresses, sleep disturbances in young adults increase, and physical activity decreases (7). Additionally, sleep disturbances in teenagers were associated with poor performances on sprinting tests, flexibility, muscular strength, and poor academics (1, 8)

Previous studies on sleep and fitness have primarily focused on combative professions, such as those in the military, firefighters, or athletes (2, 9, 10). These studies showed that there is an insignificant effect of sleep deprivation on exercise, however, the subjects used in these studies were accustomed to sleep deprivation due to their professions. Previous studies that examined this relationship in young adults relied on subjective measures of sleep, and also have not examined the relationship between sleep architecture and lower extremity endurance. The present study aimed to evaluate the relationship between sleep architecture and physical fitness.

It was hypothesized that Rapid Eye Movement (REM) sleep, sleep duration and Wake After Sleep Onset (WASO) are negatively associated with cardiorespiratory fitness, muscular strength and endurance, and flexibility in young adults. It was also hypothesized that worse scores for subjective sleep quality are associated with worse performance on cardiorespiratory fitness, muscular strength and endurance, and flexibility tests in young adults

Methods and Materials

Young adults ages 18-26 years (N= 28; See **Figure 1** and **Table 1**) were recruited from the Sleep Architecture and Body Composition parent study via flyer advertisement and in-person referral. Data collection occurred between November 2019 and March 2020 in Loree Classroom Building on the Rutgers Cook/Douglass Campus (**Figure 2**).

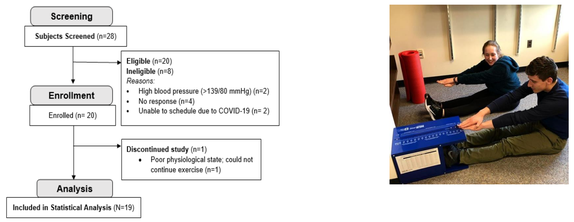

Figure 1: Participant Consort Diagram

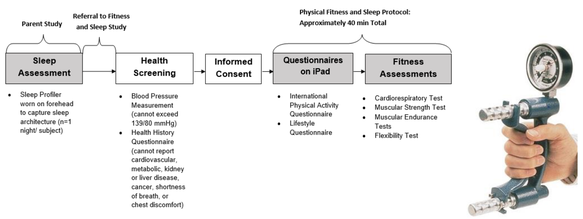

Figure 2: Study Protocol

Methods and Materials

Measures:

- Sleep: actigraphy and quality data collected in the parent study were linked to fitness data via a subject identification number.
  - Participants wore a wrist Actiwatch for 2 weeks to track sleep-wake patterns.
  - A sleep profiler device was worn on 2 non-consecutive nights to analyze sleep-wake patterns and the amount of time spent in sleep stages (NREM1-4 and REM), and other sleep variables (WASO, total sleep time, sleep quality). Subjects were then categorized as Sufficient Sleepers (>=7 hrs) or Insufficient Sleepers (<7 hrs).
  - Subjective sleep quality was measured through the Pittsburgh Sleep Quality Index. Subjects were categorized as Good Sleepers (Global Score <=5) or Poor Sleepers (Global Score >5),

Outcomes:

- Cardiorespiratory fitness: VO2 Max; calculated from Heart Rate (beats per minute; measured via pulse-oximeter) after 3-min Step-up Test.
  - Men: VO2 Max (mL x kg^-1 x min^-1) = 111.33 – (.42 x Heart Rate)
  - Women: VO2 Max (mL x kg^-1 x min^-1 = 65.81 – (.1847 x Heart Rate)
- Muscular strength: Hand-grip Strength Test via hand-held dynamometer [Total Maximal Force (kilograms) = sum of left and right hand].
- Muscular endurance: Push-up Test (until maximum fatigue), Curl-up Test (until maximum fatigue) and Squat test (as many as possible in one minute).
- Flexibility: Sit-and-Reach Test via flexometer (distance reached in forward trunk flexion, centimeters)

Statistical Analysis:

- Multiple Linear Regressions were run to evaluate the relationship between sleep architecture variables and physical fitness outcomes.
- Separate between-subjects ANOVAs were run to examine differences in physical fitness outcomes between Sufficient Sleepers vs. Insufficient Sleepers and Good vs. Poor Sleepers, respectively.

Results

Table 1: **Descriptive Statistics for Study Sample N=19**

Variable	*M* (SD)
Age	19.9 (1.8)
Year of Study	
Freshman/First Year	8 (41.1)
Sophomore/ Second Year	4 (21.1)
Junior/ Third Year	2 (10.5)
Senior/ Fourth Year	3 (15.8)
Graduate/ Professional Student	1 (5.3)
Other	1 (5.3)
Gender	
Male	6 (31.6)
Female	13 (68.4)
Race	
Asian	10 (52.6)
Black/African American	1 (5.3)
White/Caucasian	6 (31.6)
Middle Eastern	2 (10.5)
Caffeine Servings/day	1.0684 (1.7)
Body Mass Index (kg/m^2)	23.6 (2.9)
Epworth Sleepiness Scale Total Score	8.4 (4.1)
Sleep Status	
Insufficient Sleep (<7h)	8 (42.1)
Sufficient Sleep (≥ 7h)	11 (57.9)
Global PSQI Score Category	
Good Sleeper (≤5)	6 (31.6)
Poor Sleeper (>5)	13 (68.4)
Chronotype	
Morning Type	1 (5.3)
Evening Type	6 (31.6)
Neither Type	12 (63.6)

Note: PSQI= Pittsburgh Sleep Quality Index

Table 2. Sleep Architecture Variables for Normal Night of Sleep and 9 Hours Time in Bed

Sleep Variable	Normal Sleep M (SD)	9h Time in Bed M(SD)
REM Time	1.97 (.58)	1.42 (.69)
NREM2 Time	3.27 (.80)	2.52 (.99)
WASO	44.26 (33.21)	65.32 (47.04)
Sleep Time	6.18(1.33)	7.768 (.79)

Note: REM= Rapid Eye Movement, NREM= Non-Rapid Eye Movement, WASO= Wake After Sleep Onset

Table 3: Sleep Architecture and Fitness Variable Linear Regression Data

	VO2 Max		*Grip Strength*		*Push-ups*		*Curl-ups*		*Squats*		*Flexibility*	
Normal Sleep	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*
REM Time	.70 ± 3.42	0.84	3.18 ± 9.30	0.74	3.30± 4.46	0.47	-6.28± 8.32	0.45	3.96 ± 3.58	0.28	-5.01 ± 2.23	0.04
NREM2 Time	-1.51± 2.43	0.54	-1.85± 6.67	0.79	1.19± 3.23	0.72	5.36± 5.96	0.38	.72± 2.61	0.79	-1.05 ± 1.74	0.55
WASO	.10 ± .05	0.09	.33 ± .14	0.03	.12 ± .07	0.12	.05 ± .15	0.73	.03 ± .06	0.66	-.03 ± .05	0.53
Sleep Time	-.64 ± 1.48	0.67	3.60± 3.96	0.38	.17± 1.97	0.93	1.04 ± 3.68	0.78	1.38± 1.55	0.39	-2.01 ± 1.22	0.12
9 HRTIB	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*
REM Time	.10± 2.87	0.97	8.26± 7.56	0.29	4.10± 3.66	0.28	1.85± 7.11	0.80	5.59± 2.75	0.06	.49 ± 3.03	0.87
NREM2 Time	-.91±1.97	0.65	3.24±2.62	0.87	-.44± 2.63	0.87	-2.42± 4.90	0.63	.62± 2.11	0.77	4.72 ± 1.85	0.02
WASO	.01 ± .04	0.86	.01 ± .11	0.93	-.02± .06	0.73	-.02 ± .10	0.88	-.01 ± .05	0.79	-.05 ± .04	0.15
Sleep Time	1.06 ± 2.47	0.67	1.75 ± 6.76	0.80	1.55 ± 3.27	0.64	4.76 ± 6.06	0.44	1.93 ± 2.61	0.47	3.04 ± 2.07	0.16
PSQI	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*	*B±SE*	*p-value*
Subjective Sleep Quality	-3.65± 3.18	0.27	-5.66± 8.89	0.05	-8.27± 3.88	0.05	-4.13± 8.14	0.62	-3.25± 3.44	0.36	-2.37± 2.87	0.42
Global PSQI	-.33± .67	0.63	-6.18± .85	0.74	-.78± .88	0.39	.67± 1.68	0.69	-1.03± .68	0.15	-.14± .60	0.82

Note: REM= Rapid Eye Movement; NREM= Non-Rapid Eye Movement; WASO= Wake After Sleep Onset; PSQI= Pittsburgh Sleep Quality Index

Results

Figure 3: *VO2 Max by Good and Poor Sleeper Status. Bar indicates mean measurement ± Standard Error*

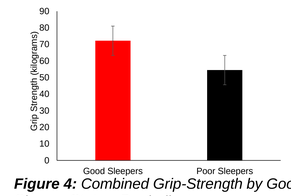

Figure 4: *Combined Grip-Strength by Good and Poor Sleeper Status. Bar indicates mean measurement ± Standard Error*

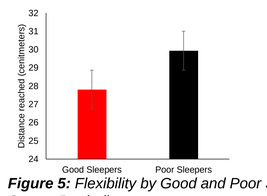

Figure 5: *Flexibility by Good and Poor Sleeper Status. Bar indicates mean measurement ± Standard Error*

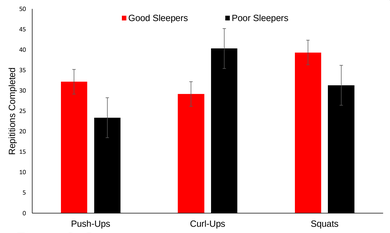

Figure 6: *Curl-up, push-up, and squat tests results by Good and Poor Sleeper Status. Bar indicates mean measurement ± Standard Error.*

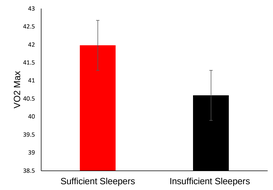

Figure 7: *VO2 Max by Sufficient and Insufficient Sleeper Status. Bar indicates mean measurement ± Standard Error*

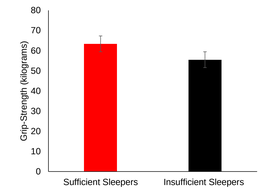

Figure 8: *Combined Grip-Strength by Sufficient and Insufficient Sleeper Status. Bar indicates mean measurement ± Standard Error*

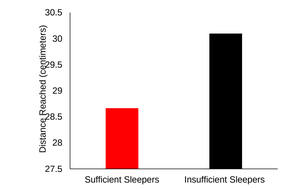

Figure 9: *Flexibility by Sufficient and Insufficient Sleeper Status. Bar indicates mean measurement ± Standard Error*

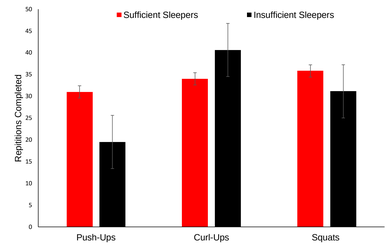

Figure 10: *Curl-up, push-up, and squat tests results by Sufficient and Insufficient Sleepers. Bar indicates mean measurement ± Standard Error. Sufficient sleepers performed significantly more push-ups compared to Insufficient Sleepers (F (1, 16), 6.404, p= .022).*

Discussion

Normal Sleep:

- There was a positive relationship between hand-grip strength and WASO (.331 ± .14, p= .031).
- There was a negative relationship between REM time and forward trunk flexion (-5.014 ± 2.232, p= .038).

9 Hour Time in Bed:

- There was a positive relationship between forward trunk flexion and NREM2 time (4.721 ± 1.849, p= .021).

PSQI:

- There was a negative relationship between subjective sleep quality and hand-grip strength (-5.664 ± 8.894, p= .048).
- There was also a negative relationship between the number of push-ups performed and subjective sleep quality (-8.270 ± 3.880, p= .048).
- This study was the first of its kind to evaluate the relationship between sleep architecture and lower extremity muscular endurance.
- It was found that those who slept for longer and had better sleep quality were able to perform more push-ups.
- Limitations of this study include a small sample size, and that due to the nature of the parent study and scheduling, participants could not have their fitness measured closely to the time that their sleep was measured.
- Longitudinal studies should be conducted to determine the causality of the relationship between sleep and physical fitness.
- Health initiatives designed to educate college students on the benefits of sleep for physical fitness may help induce positive lifestyle changes in this population.

Acknowledgements

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References

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