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Long weekend sleep is linked to stronger academic performance in male but not female pharmacy students

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Abstract

Introduction. Poor sleep hygiene portends loss of physical and mental stamina. Therefore, maintaining a regular sleep/wake schedule on both weekdays and weekends is highly recommended. However, this advice runs contrary to the habits of university students, who may only experience recovery sleep if they "sleep in" on weekends. Pharmacy students at Duquesne sit for frequent examinations, typically commencing at 7:30 AM, and they complain about fatigue. Thus, we tested the hypothesis that longer sleep durations on both weekdays and weekends are linked to stronger academic performance.

Methods. Students in their third year at Duquesne University were administered three surveys to collect daily data on sleep habits and factors that might influence sleep quality, such as having roommates, long commute times, and sleep interruptions. GPAs were collected from the Dean's office, with permission from the students.

Results. Longer weekend—but not weekday—sleep durations were significantly correlated with higher GPAs in men and not in women. Women achieved slightly higher cumulative GPAs than men. Students who fell asleep within 15 minutes of going to bed had higher GPAs than those who fell asleep after an hour or more.

Conclusion. The present observations do not establish causal links, but, given the body of prior evidence on the salutary properties of sleep, men in this cohort may have reaped benefit from recovery sleep on weekends. Rather than recommending that students force themselves awake on weekends in an attempt to maintain a consistent sleep routine, the real-life habits of students should be considered.

Keywords: academic performance, gender, grade point average, grades, sleep

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Introduction

"Sleep . . . Balm of hurt minds . . . Chief nourisher in life's feast."

Macbeth (2.2.46-51) by William Shakespeare

During the sleep phase of the activity/rest rhythm, the glymphatic system of the mammalian brain performs its janitorial duties and clears the accumulated metabolites via the cerebrospinal fluid.[1-3] Sleep deprivation studies further suggest that sleep loss-induced attentional deficits are preceded by electrophysiological lapses in neuronal function, and that the association between sleep loss and cognitive impairment is causal.[4-10] Thus, sleep is linked to superior memory consolidation and academic performance,[11-13] including in students enrolled in Pharmacy programs.[14]

In the Pharmacy program at Duquesne University, exams are administered at 7:30 AM in the morning (6:30 or 7:00 AM for special needs students), and classes commence at 8:00 AM. Despite the need for early-morning awakenings and awareness of the benefits of good sleep hygiene, anecdotal comments from Pharmacy students suggest that they often stay up late at night, cramming for the 7:30 AM examinations, and then "crash" on weekends by oversleeping. Thus, the central hypothesis was that longer sleep durations and consistent sleep habits would be associated with better academic performance in first-year pharmacy students.

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Methods

Study Design: Ethics approval for three surveys was granted by the Institutional Review Board at Duquesne University. First, a homework assignment was administered in the Ability Based Laboratory Experience (ABLE) course at Duquesne University. Students register for this course in the second semester of Year 1 of the four-year professional phase, after completion of the two-year preprofessional phase. Out of 152 enrolled students, all completed the daily online Survey 1 (**Appendix 1**) to record bedtimes, sleep times, and awakenings for three consecutive weeks mid-semester. Survey 2 was voluntary. In Survey 2, demographic information and permission to publish the data from Survey 1 (on a separate page from demographic data) were collected from 125 students (**Appendix 2**).

A third, voluntary survey was deployed two months later to the same student body in their Continuous Professional Development course, to continue to assess additional lifestyle factors hypothesized to impact sleep quality and academic performance, such as participation on an athletic team, nap frequency and duration, hours spent working at a job, *etc*. (**Appendix 3**). One-hundred and twenty-five students participated in the latter survey. In Survey 3, permission was collected to acquire individual grade-point averages (GPAs) from the Dean's office. Students could refuse to have their data analyzed and published at any time. Data were deidentified to protect the students' anonymity.

Statistics: Data were analyzed in GraphPad Prism (Prism 8 for MacOS) and subjected to Prism's default tests for heteroscedasticity (Bartlett's, Brown-Forsythe, and Spearman's test) and

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normality (Anderson-Darling, D'Agostino-Pearson omnibus, Shapiro-Wilk, and Kolmogorov-Smirnoff tests). When parametric assumptions were met, Pearson correlations, Student *t* tests, or ANOVAs were performed on data sets. Bonferroni *post hoc* tests were used for multiple comparisons after the appropriate ANOVA. For non-Gaussian data sets, the Kruskal-Wallis test was followed by the Dunn's *post hoc* correction for multiple comparisons. Alpha was set at 0.05 (two-tailed).

Inclusion/Exclusion Criteria: Data were included in the analyses and graphs only if the student granted permission. Data were excluded only if the student did not grant permission, or failed to complete that specific part of the survey (*i.e.*, some students did not answer every single question on each survey). Therefore, the number of students per group were added to every figure. No outliers were removed.

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Results

Demographic data and a frequency histogram of GPAs are illustrated in **Figure 1**. The majority of participants were women, 21 years of age, not part of an athletic team, and had not transferred from another school to Duquesne University. More women commuted than men, but among the women, a larger percentage lived on campus.

Weekend sleep duration was significantly associated with cumulative GPAs collected from the Dean's office (**Figure 2A**; one-way ANOVA; $F(4, 107) = 2.621$; $p = 0.0389$; passed heteroscedasticity and normality tests). Students who slept 10 or more hours per weekend night had significantly higher cumulative GPAs than students who slept 6 hours per weekend night. Weekday sleep was not significantly associated with GPAs. Women had slightly higher GPAs than men (**Figure 2B**; two-tailed *t* test; $t = 2.418$; df = 118; $p = 0.0171$; passed heteroscedasticity and normality tests). Thus, the impacts of gender and weekend sleep duration on GPAs were analyzed by two-way ANOVA (**Figure 2C**; passed heteroscedasticity and normality tests). A significant interaction between gender and hours of sleep on the weekend was observed ($p = 0.0235$, $F(4, 102) = 2.954$), as well as a significant effect of weekend sleep duration ($p = 0.0059$; $F(4, 102) = 3.851$). However, Bonferroni *post hoc* comparisons revealed that the potential impacts of longer weekend sleep durations were observed in men and not women (**Figure 2C**). Therefore, correlation analyses between weekend sleep and GPAs were plotted separately for men and women. These latter analyses confirmed a significant correlation between weekend sleep duration and GPA for men, but not women (**Figure 2D-E**; passed normality tests). In contrast, weekday sleep duration was not associated with GPA in men (Pearson $r = 0.1468$; two-tailed $p = 0.3661$) or women (Pearson $r = 0.1772$; two-tailed $p = 0.1183$).

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The average standard deviation in sleep duration for each student across the survey period (adapted from Okano *et al.* as "inconsistency in sleep duration from day to day"[11]) did not differ between men and women (**Figure 2F**; passed heteroscedasticity but failed normality tests; Mann-Whitney U statistic 1588; two-tailed $p = 0.7788$) and was not correlated with GPA (not shown). Other notable measures were not statistically significantly related to GPAs, including the number and duration of naps, sleep interruptions, and the number of hours of job-related work per week. GPAs were also not significantly associated with commute duration. One exception was that the number of minutes to fall asleep after entering bed was significantly associated with GPAs from the professional phase, in a U-shaped pattern (**Figure 2G**; one-way ANOVA; $F(4, 116) = 2.763$; $p = 0.0308$; passed heteroscedasticity and normality tests). Subjects who fell asleep within 15 minutes, on average, had significantly higher professional GPAs than those who needed one or more hours. This advantage, however, was not observed in those who reported falling asleep immediately upon entering bed.

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Discussion

The main finding of the present study is that weekend sleep duration explained a significant proportion of the variance in the GPAs of men, but not women. Our students diverge from other studies in that we failed to observe a correlation between academic performance and weekday sleep duration,[11, 14] perhaps due to early exam schedules, combined with a high frequency of assignments and exams (four exams/semester for multiple courses). Given the lack of significant correlations between academic performance and weekday sleep durations, our central hypothesis was only partially supported. However, it should be noted that the other studies did not distinguish weekday from weekend sleep, and that the Zeek *et al.* study did not report the impact of gender.[14]

Given the collective findings, we speculate that men enrolled in our program may benefit from sleeping longer on the weekend, although it seems reasonable to recommend that both sexes catch up on lost sleep whenever weekday schedules are particularly hectic. It is known that women outperform men in academics, and they may enjoy a greater cognitive buffer against the negative sequelae of sleep loss.[15] In contrast to previous studies,[11] we did not observe higher sleep inconsistency in men compared to women. Thus, gender differences in academic performance in our student cohort are not readily explained by differences in sleep inconsistency.

The second main finding of the present study is the U-shaped graph of GPAs plotted as a function of the reported time to fall asleep. Taking one hour or more to fall asleep was associated with lower professional-phase GPAs than for those who required, on average, 15 minutes. Those who fell asleep as soon as their heads hit the pillow enjoyed no such advantage. These

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observations suggest that additional information on sleep-delaying factors, such as blue light exposure from electronic devices and anxiety-related insomnia, should be investigated in this cohort, particularly during the professional phase.

The major limitation of the current study was the reliance on self-reported survey data to assess sleep duration (due to financial constraints), rather than more expensive methods such as heartrate/activity-based sleep monitors (*e.g.*, Fitbits) or electroencephalograms. On the other hand, sleep data were collected on a daily basis for three weeks, and are therefore independent of lapses in long-term memory recall, which can compromise survey data integrity.

Conclusion

Based on the current findings and a large body of sleep literature, we speculate that setting an early alarm on weekends in an effort to maintain the same sleep schedule as during the week may be counterproductive, especially in male students enrolled in academic programs with early-morning examinations or classes.

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Acknowledgements

RKL conceived the study, wrote the paper, interpreted and analyzed data, and constructed figures. SLW entered and analyzed all the data, constructed figures, and contributed to experimental design, interpretation, and manuscript editing. MNC contributed to experimental design, collected survey data, and edited the manuscript. DCR contributed to experimental design and interpretation and edited the manuscript. We are indebted to the School of Pharmacy for their generous support of Dr. Leak's lectures on the epidemiology and biological impact of sleep. We are also grateful to the Duquesne pharmacy students, for their kind participation. The authors have no conflicts to declare.

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Figure Captions

Figure 1. Demographic Data on First Professional Year Pharmacy Students at Duquesne University. Pie charts of gender percentages (**A**), age (**B**), participation on an athletic team (**C**), transfer status (**D**), and commuter or campus resident status (**E**). Frequency histogram of GPAs (**F**).

Figure 2. Longer durations of weekend sleep are associated with higher GPAs in pharmacy students. Students in the first year of the professional-phase pharmacy program at Duquesne University were asked to closely monitor their sleep schedules, on a daily basis, for three weeks (Survey 1). (**A**) Hours of sleep on weekends were plotted against cumulative GPAs (acquired from the Dean's office, with signed permission from the student). Data are illustrated as violin plots. The number of participants per group is listed above the X axis. (**B**) Women had slightly higher cumulative GPAs than men. (**C**) Violin plots of cumulative GPA as a function of gender and hours of sleep per night on weekends. (**D-E**) Pearson correlation of GPAs with hours of sleep per weekend night in men or women. (**F**) Scatterplots of sleep inconsistency, defined as the average standard deviations of sleep duration per student across three weeks, as a function of gender. (**G**) Violin plots of professional-phase GPA, as a function of the number of minutes to fall asleep on weekdays. For bracketed comparisons, *two-tailed $p < 0.05$; **two-tailed $p < 0.01$; n.s. = not significant.

Figure 1

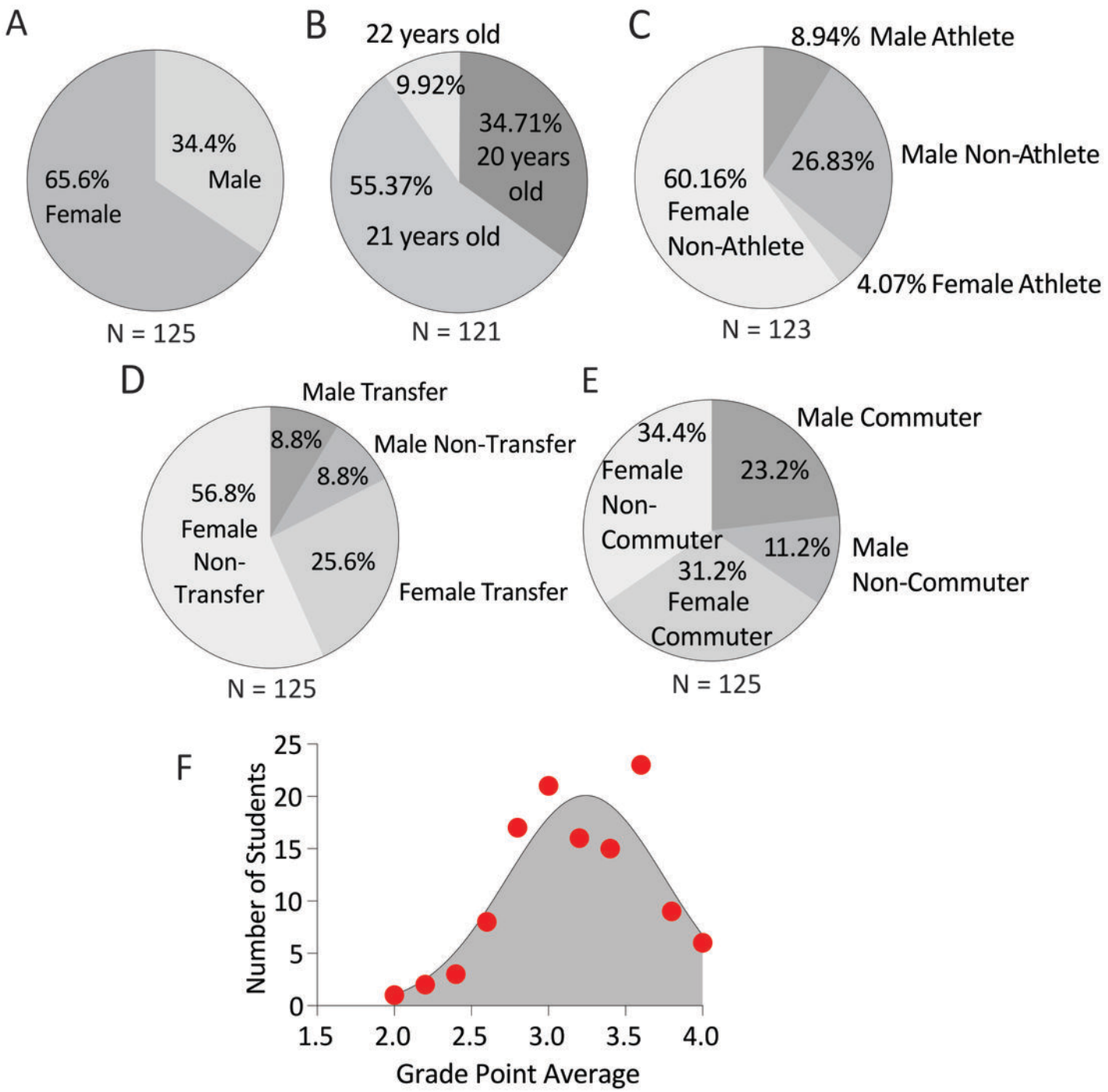
A
34.4%
Male
65.6%
Female
N = 125
B
22 years old
9.92%
34.71%
20 years
old
55.37%
21 years old
N = 121
C
8.94% Male Athlete
26.83%
Male Non-Athlete
60.16%
Female
Non-Athlete
4.07% Female Athlete
N = 123
D
Male Transfer
8.8%
Male Non-Transfer
8.8%
56.8%
Female
Non-
Transfer
25.6%
Female Transfer
N = 125
E
Male Commuter
34.4%
Female
Non-
Commuter
23.2%
11.2%
Male
Non-Commuter
31.2%
Female
Commuter
N = 125
F
Number of Students
25
20
15
10
5
0
1.5
2.0
2.5
3.0
3.5
4.0
Grade Point Average

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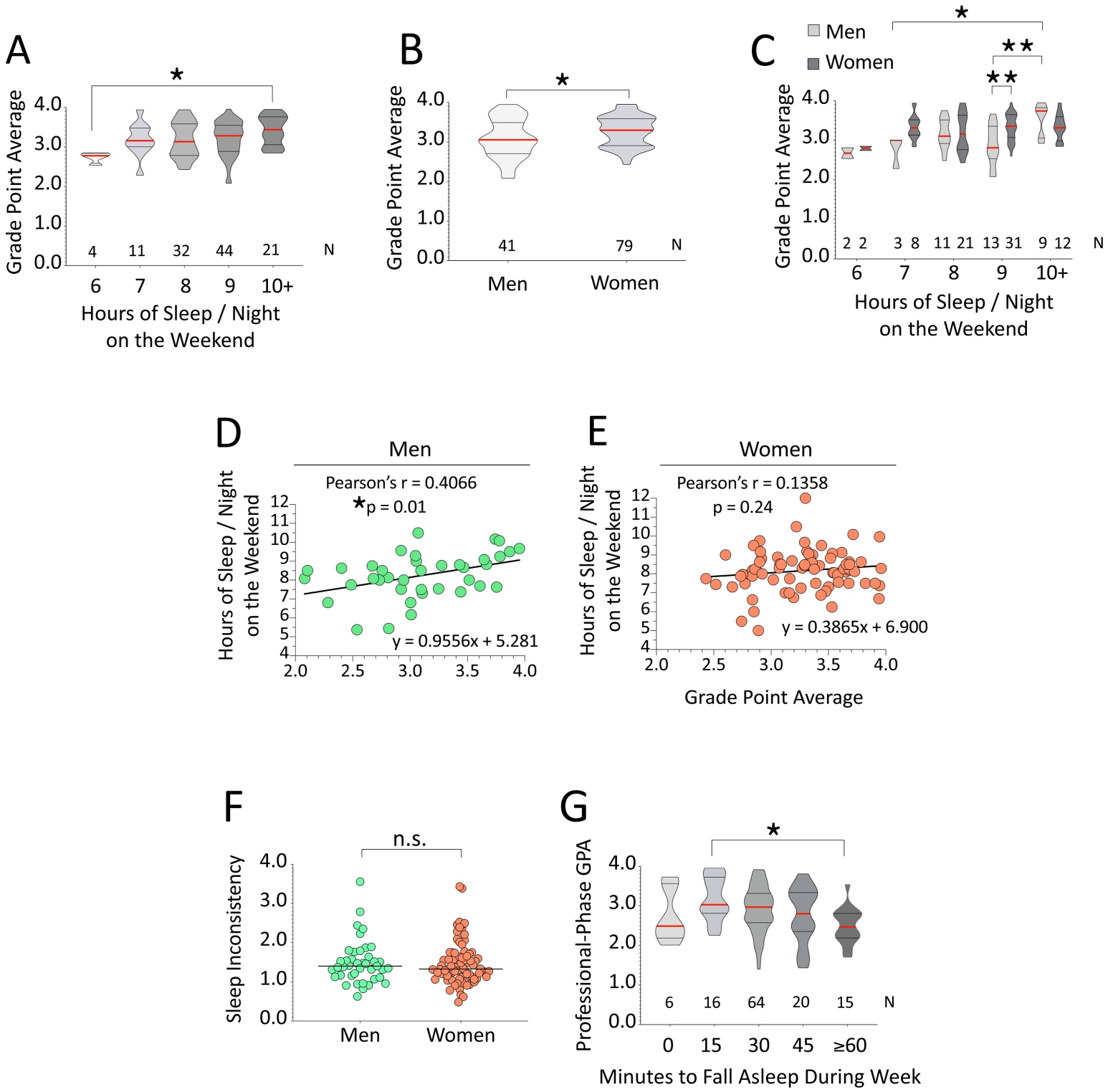
Figure 2



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Appendix 1:

Survey One

(via Survey Monkey)

Question 1: What time did you go to bed?

Question 2: What time did you fall asleep?

Question 3: How many times did you wake up in the middle of the night? Why did you wake up?

Question 4: What time did you wake up in the morning?

Question 5: Did you feel refreshed within 30 minutes of waking up?

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Appendix 2:

DUQUESNE UNIVERSITY

600 FORBES AVENUE ♦ PITTSBURGH, PA 15282

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

TITLE:	The Influence of Sleep Disruption on Academic Performance
INVESTIGATOR:	Rehana K. Leak
SOURCE OF SUPPORT:	This study is supported by the School of Pharmacy.
PURPOSE:	You are being asked to participate in a research project that seeks to investigate the role of sleep and other factors on academic performance in the Pharm.D. program at Duquesne. We have collected detailed data from all students in the ABLE laboratories and would like to be able to disseminate and publish the deidentified, aggregate results in graphical format.
RISKS AND BENEFITS:	**There are no risks greater than those encountered in everyday life.**
COMPENSATION:	Participation in the project will require no monetary cost to you.
CONFIDENTIALITY:	Your name will never appear on any graph or publication. All written materials and consent forms will be stored in a locked file. Your response(s) will only appear in statistical data summaries. All materials will be destroyed at the completion of the research.
RIGHT TO WITHDRAW:	You are under no obligation to participate in this study. You are free to withdraw your consent to participate at any time.
SUMMARY OF RESULTS:	A summary of the significant results of this research will be supplied to you, at no cost, upon request, when the analyses are ready.

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VOLUNTARY CONSENT:

I hereby allow all the data I entered into Survey Monkey in the ABLE labs and the paper surveys in HPP class to be analyzed for dissemination and publication. I additionally authorize data regarding my course grades and GPA to be analyzed for dissemination and publication. I understand that my data will only appear in aggregate form and that my identity will not be revealed in any publication or public format. I understand that my participation is voluntary and that I am free to withdraw my consent at any time, for any reason. On these terms, I certify that I am willing to participate in this research project.

I understand that if I have any further questions about my participation in this study, I may call Rehana Leak at 412.396.4734 and Dr. Paul Richer, Chair of the Duquesne University Institutional Review Board, at 412-396-6326.

Participant's Name	Participant's Signature	Date
	Rehana Khan Leak	
Researcher's Signature	Researcher's name	Date

The following survey was stapled to this consent form, only for purposes of data entry, and then detached and stored separately to de-identify all the data

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Survey 2

ANONYMOUS QUESTIONNAIRE

Please do not add personal identifiers; this evaluation is entirely anonymous.

Please circle one of the following choices

1. I often study late at night even though I am tired and it is hard to concentrate

   Strongly disagree ---------- Strongly agree

   1 2 3 4 5

2. I can most readily understand difficult material at these times of day:

   Mornings (8 AM to noon)

   Afternoons (noon to 4 PM)

   Evenings (4 PM to 8 PM)

   Early Nighttime (8 PM to midnight)

   Late Nighttime (midnight to 4 AM)

3. During the week, I typically sleep the following hours if there is an exam the next day:

   4-5 5-6 6-7 7-8 8-9 9-10 10-11 11+

4. During the week, I typically sleep the following hours if I ***don't*** have any exam the next day:

   4-5 5-6 6-7 7-8 8-9 9-10 10-11 11+

5. During the weekend, if I don't have to get up early, I typically sleep the following hours:

   4-5 5-6 6-7 7-8 8-9 9-10 10-11 11+

6. Please add a comment about whether your sleep feels refreshing or you feel it is not sufficient:

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7. My sleep is often interrupted by roommates or other sources of noise

Strongly disagree ---------- Strongly agree

1 2 3 4 5

8. My current GPA is

2.5 or less 2.51 – 3.0 3.01 – 3.5 3.51 – 3.70 3.71 – 4.0

9. My grade in Dr. Meng's exam in Human Physiology and Pathology was the following:

0-60% 61-70% 71-80% 81-90% 91-100%

10. My grade in Dr. Leak's exam in Human Physiology and Pathology was the following:

0-60% 61-70% 71-80% 81-90% 91-100%

11. My age is

21 or below 22 23 24 25 or older

12. My gender is _____

13. I commute to school: Yes No (If the answer is "no," skip to question 15)

14. My commute time is, on average, about _____ minutes

15. I prefer exams early, such as at 7:30 AM, rather than later in the day after other classes

Strongly disagree ---------- Strongly agree

1 2 3 4 5

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RISKS AND BENEFITS:	**There are no risks greater than those encountered in everyday life.**
COMPENSATION:	Participation in the project will require no monetary cost to you.
CONFIDENTIALITY:	Your name will never appear on any graph or publication. All written materials and consent forms will be stored in a locked file. Your response(s) will only appear in statistical data summaries. All materials will be destroyed at the completion of the research.
RIGHT TO WITHDRAW:	You are under no obligation to participate in this study. You are free to withdraw your consent to participate at any time.
SUMMARY OF RESULTS:	A summary of the significant results of this research will be supplied to you, at no cost, upon request, when the analyses are ready.

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VOLUNTARY CONSENT:

I hereby allow all the data I entered into Survey Monkey in the ABLE labs to be analyzed for dissemination and publication. I understand that my data will only appear in aggregate form and that my identity will not be revealed in any publication or public format. I understand that my participation is voluntary and that I am free to withdraw my consent at any time, for any reason. On these terms, I certify that I am willing to participate in this research project.

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Participant's Name	Participant's Signature	Date
	Rehana K. Leak	
Researcher's Signature	Researcher's name	Date

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Survey 3

1. Are you a transfer student? Yes No

2. Are you a commuter? Yes No

If yes, do you live: Alone With parents/family With friends With significant other

3. The area I live in is very noisy at night

Strongly disagree ----------Strongly agree

1 2 3 4 5

4. Do you have roommates? Yes No

5. How many hours a day do you spend studying/doing homework when you don't have an exam?

_____ hours

6. How many hours a day do you spend studying/doing homework when you do have an exam?

_____hours

7. How many days a week do you take naps? _____days

8. When you take a nap, how long do you typically nap? _____minutes

9. I usually feel refreshed after my nap

Strongly disagree ----------Strongly agree

1 2 3 4 5

10. How many hours a week do you work? _____

11. How many credits are taking this semester? _____

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12. Are you on an athletic team? _____

11. Do you agree to allow Dr. Leak access to your GPA and grades in other classes?

Yes No

Signature: _____