Age-Related Changes in Objectively Measured Sleep-Wake Are Not Associated With Diurnal Preference: A Big Data Analysis of 18,100 Users

Elie Gottlieb[1], Luke Gahan[1], Samantha Wilson[1], Sharon Danoff-Burg[1], Holly M. Rus[1], Colin Burke[1], Nathaniel F. Watson[2], Roy J. Raymann[1]
[1]SleepScore Labs, Carlsbad, CA [2]Department of Neurology, University of Washington School of Medicine, Seattle, WA

Introduction

- The circadian system and sleep homeostasis are altered in aging populations[1], yet it remains unclear whether changes in sleep-wake functioning across the lifespan are associated with diurnal preference (i.e., morningness-eveningness).
- Here, we examined whether the slopes of objectively measured sleep changes across the lifespan differed between diurnal preferences.

Materials & Methods

Data

- Data from 18,100 users (mean age: 51.4 + 16.6, 58% female) across 741,738 nights (mean nights recorded: 45) were included in the analysis from the PSG-validated SleepScore Mobile Application.
- Diurnal preference was subjectively assessed with a 5-item questionnaire ranging from *definitely morning-type* to *definitely evening-type.*

Analysis

- Linear mixed effect models were employed to test whether, across age, morningness-eveningness was associated with total sleep time, wake after sleep onset, sleep onset latency, and sleep efficiency.

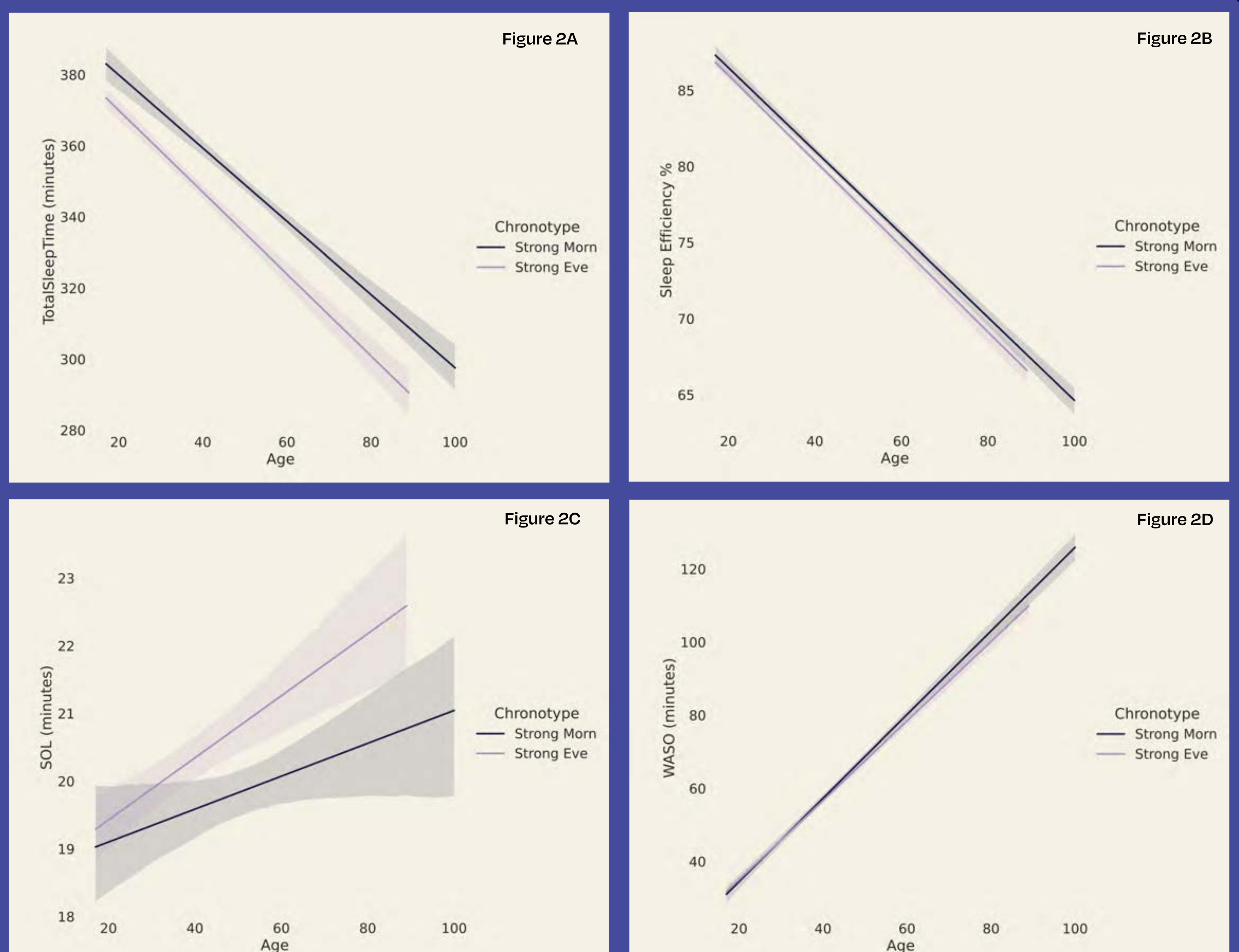
Conclusion

- While sleep-wake variables declined linearly with age, the slope of this decline did not differ between strong morning versus strong evening types.
- Age-related sleep impairments are unlikely to be driven by inter-individual differences in morningness-eveningness, despite previous work indicating that diurnal preference reflects dimensions related to circadian periods, sleep homeostasis, and ontogeny.

Results

	Strong Morning	Slight Morning	Neither	Slight Evening	Strong Evening
Users	2811 (17%)	3504 (21%)	3300 (19%)	3609 (21%)	3757 (22%)
Age	51 ± 16	46 ± 16	43 ± 17	41 ± 16	37 ± 17
Female %	53	60	59	59	60
Nights recorded	149,965	167,038	159,301	153,487	135,342
Bed Time	22:37 ± 1:14	22:55 ± 1:09	23:19 ± 1:13	23:43 ± 1:13	00:29 ± 1:33
Wake Up Time	06:09 ± 1:13	06:35 ± 1:09	06:59 ± 1:15	07:18 ± 1:18	07:49 ± 1:32
Total Sleep Time (min)	348 ± 56	362 ± 54	363 ± 58	362 ± 56	350 ± 60
Sleep Efficiency (%)	78 ± 8	80 ± 8	80 ± 8	81 ± 8	81 ± 8
Sleep Onset Latency (min)	19.8 ± 9.5	20.1 ± 9.7	20.5 ± 10.0	20.6 ± 10.3	20.2 ± 10.3
Wake After Sleep Onset (min)	69.4 ± 32.9	64.4 ± 31.6	61.7 ± 32.0	58.6 ± 31.3	53.5 ± 30.0

Table 1. Demographic and average sleep-wake characteristics for all diurnal preferences.



Figures 3A-3D. Although total sleep time (TST, **Figure 2A**) and sleep efficiency (SEF, **Figure 2B**) declined linearly with age (TST: ß=-1.03, SE=0.062, p<0.0001; SEF: ß=-0.27, SE=0.008, p=<0.0001), the slopes of this decline were not significantly different between strong-morning and strong-evening types (TST: ß=-0.078, SE=0.079, p=0.32; SEF: ß=-0.001, SE=0.010, p=0.91). Similar null findings between strong-morning versus strong-evening types were observed for sleep onset latency (SOL, **Figure 2C**) and wake after sleep onset (WASO, **Figure 2D**), with both increasing linearly with age across all diurnal preferences (WASO: ß=0.40, SE=0.012, p=<0.0001; SOL: ß=0.026, SE=0.011, p=0.013), but no significant differences in the slopes over age between strong-morning versus strong-evening types could be observed (WASO: ß=-0.005, SE=0.015, p=0.74; SOL: ß=-0.014, SE=0.014, p=0.28).

Reference

1. Fischer D, Lombardi DA, Marucci-Wellman H, Roenneberg T. (2017) Chronotypes in the US – Influence of age and sex. *PLoS ONE,* 12(6).

Assessing the Impact of Race and Income on Changes in Self-Reported Sleep Quality During the COVID-19 Pandemic

Colin Burke[1], Luke Gahan[1], Holly M. Rus[1], Sharon Danoff-Burg[1], Nathaniel F. Watson[2], Roy J. Raymann[1], Elie Gottlieb[1]
[1]SleepScore Labs, Carlsbad, CA [2]Department of Neurology, University of Washington School of Medicine, Seattle, WA

Introduction

- Early evidence suggests that the COVID-19 pandemic has differentially impacted sleep-wake functioning[1].
- Here, we examined the association between socioeconomic factors and changes in self-reported sleep quality from before to during the COVID-19 pandemic.

Materials & Methods

Data

- A cross-sectional survey of 2,154 users from the SleepScore database (mean age: 46.8 +- 16.1, 56% female; 28% minority race/ethnicity) was conducted in January 2022.

Analysis

- Proportional odds (ordinal) logistic regression was employed to test the significance of race/ethnicity and annual household income for the likelihood of changes to pre-pandemic self-reported measures of sleep quality, wake after sleep onset (WASO), and sleep onset latency (SOL).

Conclusion

- Significant changes in self-reported sleep quality during the COVID-19 pandemic were seen across social and economic groups.
- Results suggest that the COVID-19 pandemic may exacerbate pre-pandemic sleep inequalities among individuals with low household incomes.
- A differential impact of the COVID-19 pandemic on self-reported SOL among Hispanic/Latino individuals was observed, though no significant changes to self-reported measures of sleep quality were observed for other racial/ethnic groups.

Results

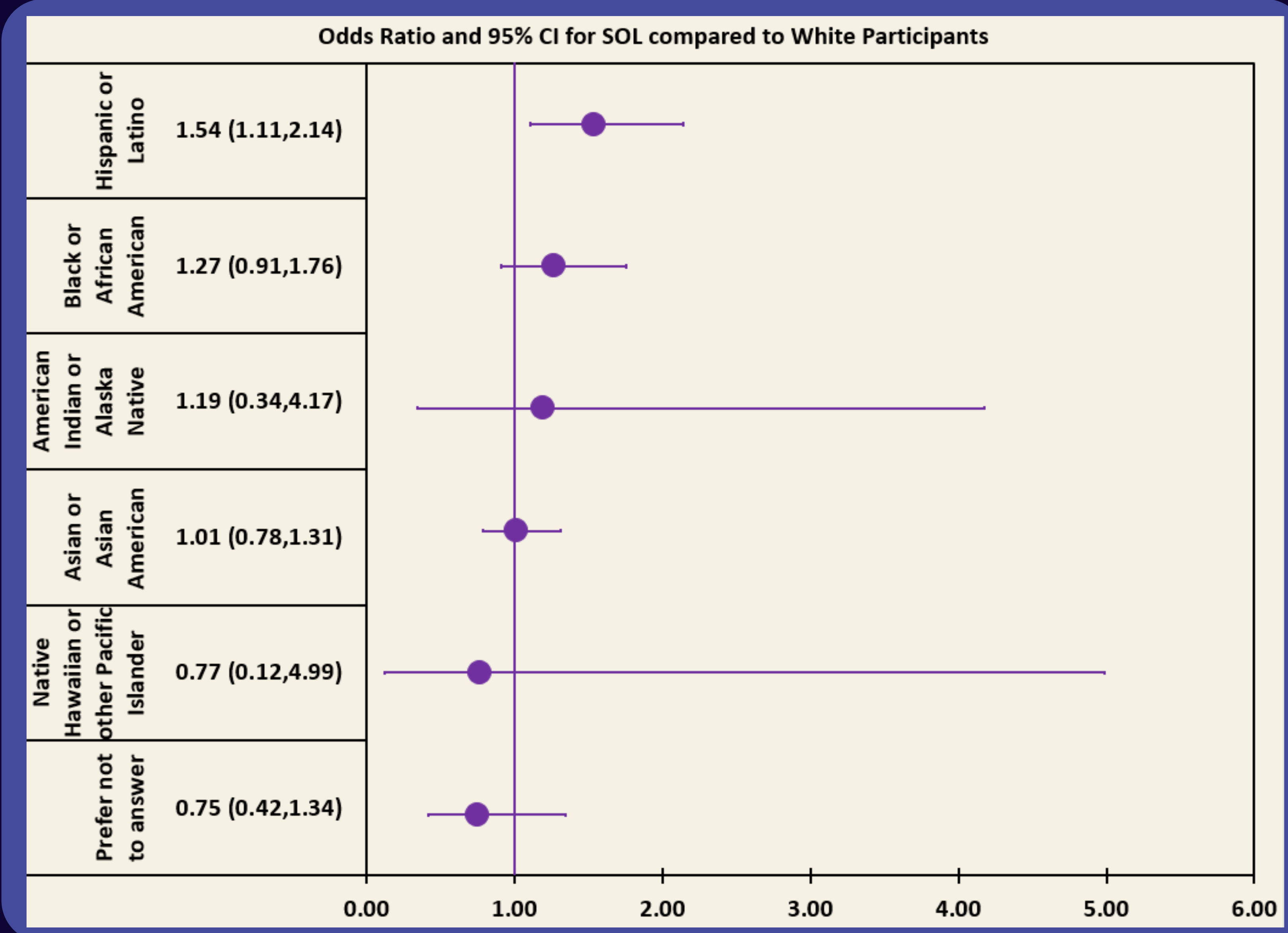


Figure 1. Hispanic or Latino participants were 1.54 times (95%CI 1.11-2.14, p = .007) more likely than White participants to report increased sleep onset latency. No significant changes in self-reported overall sleep quality, SOL, or WASO were observed for other racial/ethnic groups.

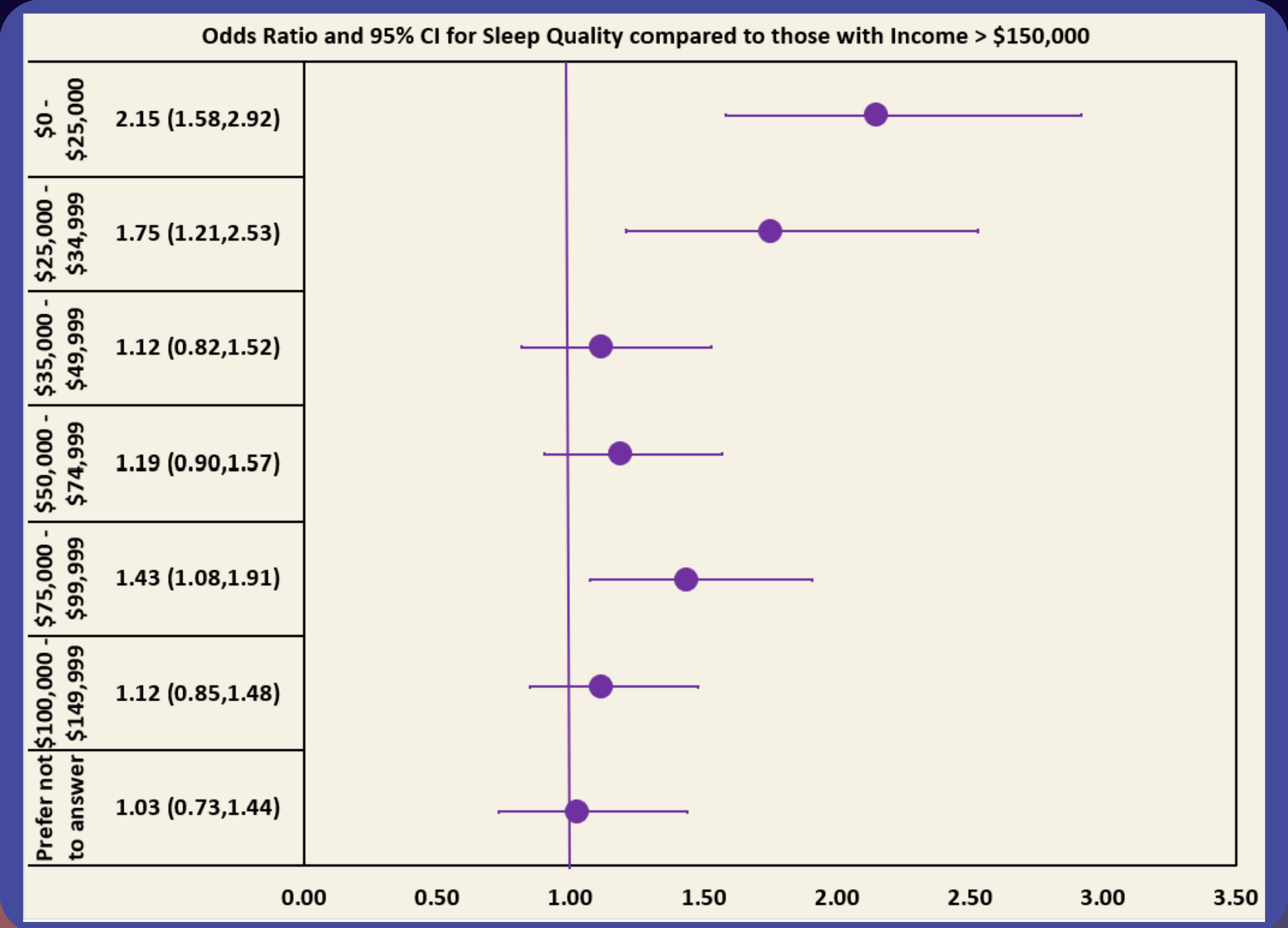


Figure 2. Compared to high-income ($150,000+ USD) participants, low-income ($0-$25,000 USD) participants were 2.15 times (95%CI 1.58-2.92, p <.001) more likely to report decreased overall sleep quality. Participants with income levels of $25,000-$34,999 USD were also 1.75 times (95%CI 1.21-2.53, p = .002) more likely than high-income participants to report decreased overall sleep quality.

Reference

1: Cheng, P., Casement, M. D., Cuellar, R., Johnson, D. A., Kalmbach, D., Cuamatzi Castelan, A., & Drake, C. L. (2022). Sleepless in COVID-19: racial disparities during the pandemic as a consequence of structural inequity. *SLEEP*, 45(1).

The Association Between Self-Reported Electronic Device Usage and Objectively Measured Sleep in Adults

Aman Aman[1], Luke Gahan[1], Colin Burke[1], Samantha Wilson[1], Nathaniel F. Watson[2, 3], Roy J. Raymann[1], Elie Gottlieb[1]
[1]SleepScore Labs, Carlsbad, CA [2]Department of Neurology, [3]University of Washington School of Medicine, Seattle, WA

Introduction

- Use of light emitting electronic devices in bed before sleep has been associated with sleep disruption in children and adolescents[1].
- Wavelength and intensity of emitted light, and cognitive and emotional engagement with device, have been proposed as explanations for sleep disruption.
- Here, we examined association between self – reported electronic device usage and objective sleep parameters in an adult population of consumer sleep technology users.

Materials & Methods

Data

- Data from 231 users across 25,315 nights from the PSG-validated SleepScore mobile app.
- Device usage was subjectively assessed with a 4-item questionnaire ranging from *0 days* to *7 days in a week*.

Analysis

- A mixed effect model was used for this analysis.

Conclusion

- Self–reported use of electronic devices in bed before sleep was associated with shorter time in bed, later bed time and shorter total sleep time.
- These results suggest that electronic device usage before bed reduces the sleep opportunity window and shortens time in bed and total sleep time.

Results

	Full Sample	0 Days	1-3 Days	4-6 Days	7 Days
Number of Users	231	34	29	70	98
Nights Recorded	25,315	3,868 (15.2%)	5,601 (22.1 %)	5,828 (23%)	10,018 (39.6 %)
Age (years)	48.8 ± 16.6	60.2 ± 11.1	57.1 ± 13.9	55.5 ± 13.7	56 ± 15.2
Nights Recorded	-	15.2%	22.1%	23%	39.5%
Bedtime	23:25 hr ± 96 mins	23:10 hr ± 63 mins	23:45 hr ± 96 mins	23:46 hr ± 132 mins	23:18 hr ± 89 mins
Wake Up Time	7:25 hr ± 120 mins	7:10 hr ± 64 mins	7:10 hr ± 100 mins	8:04 hr ± 186 mins	7:17 hr ± 88 mins
Total Sleep Time	352 mins ± 75 mins	364 mins ± 62 mins	356 mins ± 71 mins	341 mins ± 80 mins	352 mins ± 78 mins
Sleep Efficiency (%)	76 ± 12	76 ± 9	77 ± 11	76 ± 11	74 ± 13

Table 1. Demographic and average sleep-wake characteristics for all groups.

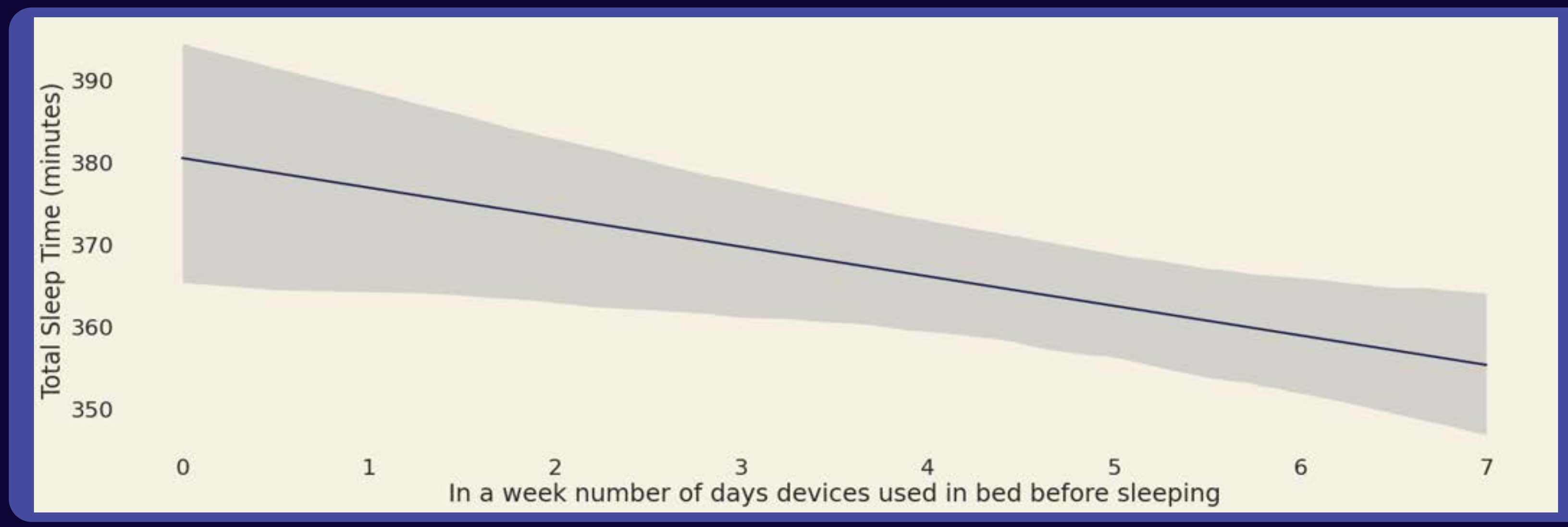


Figure 1. Regression plot of total sleep time for frequency of device use before sleeping (days per week). Higher electronic device usage was associated with a reduction in total sleep time (ß=-9.2, 95%CI [-15.9, -2.5], p=0.007).

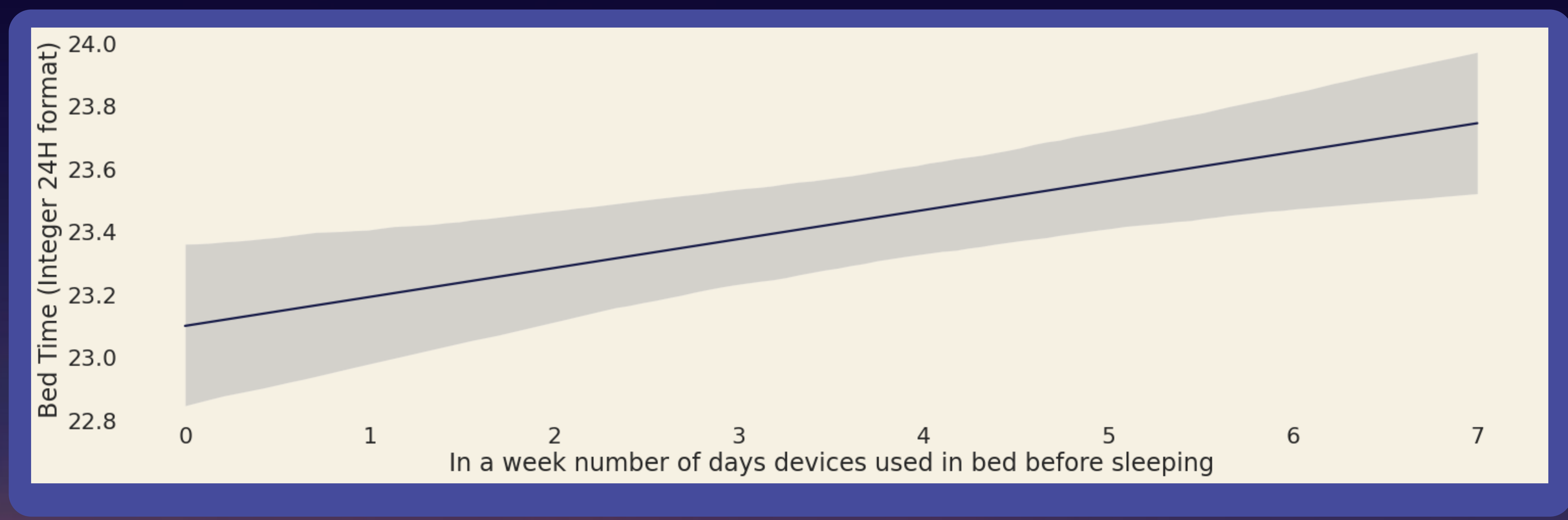


Figure 2. Regression plots of bed time for frequency of device use before sleeping (days per week). Higher electronic device usage was associated with later bedtimes (ß=0.17, 95%CI [0.029, 0.324], p=0.019).

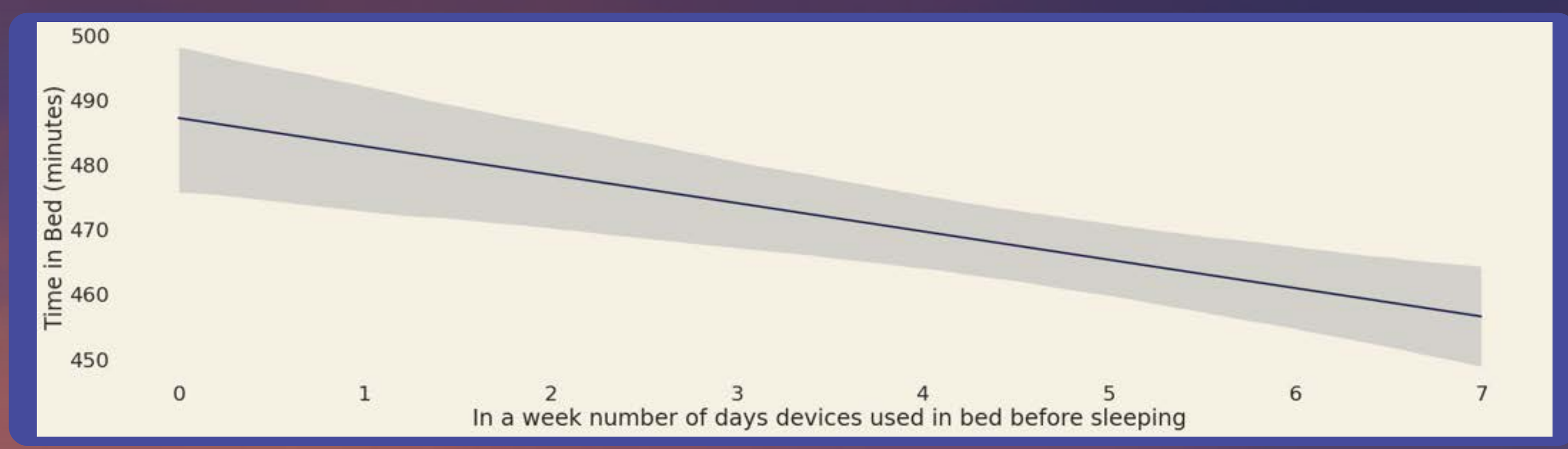


Figure 3. Regression plot for time in bed for frequency of device use before sleeping (days per week). Higher electronic device usage was associated with a reduction in time in bed (ß=-8.8, 95%CI [-14.75, -2.87], p<0.005).

Reference

Bhat, S., Pinto-Zipp, G., Upadhyay, H., & Polos, P. G. (2018). "To sleep, perchance to tweet": in-bed electronic social media use and its associations with insomnia, daytime sleepiness, mood, and sleep duration in adults. Sleep health, 4(2), 166–173.

SleepScore Labs™

Alcohol And Caffeine Associated With Poorer Sleep: A Big Data Analysis Of Self-reported Consumption And Objectively Measured Sleep

Luke Gahan[1], Samantha Wilson[1], Aman[1], Colin Burke[1], Holly Rus[1], Sharon Danoff-Burg[1], Nathaniel Watson[2], Roy Raymann[1], Elie Gottlieb[1]
[1]SleepScore Labs, Carlsbad, CA [2]Department of Neurology, University of Washington School of Medicine, Seattle, WA

Introduction

- The direct effects of caffeine and alcohol consumption on subsequent sleep have largely been confined to in-lab protocols with cross-sectional measurements and relatively small samples, thus limiting the ecological validity and generalisability of findings.
- This present analysis leveraged longitudinal and naturalistic data from active consumer sleep technology users to examine whether daily self-reported alcohol and caffeine consumption was associated with objectively measured sleep.

Materials & Methods

Data

- Data from 26,2448 users across 316,555 nights (mean nights per user: 12.0 +/- 38.8)
- Users aged 16 - 90 (mean: 38.6 +/- 15.4) were included in the study. 51.0 % of users were female
- Self-reported questionnaires were used to capture
  - Alcoholic beverages consumed
  - Caffeine drinks consumed

Analysis

- Mixed effect modelling was used for the analysis
- Models were adjusted for age and gender

Conclusion

- Alcohol and caffeine consumption is associated with shorter sleep durations and impaired sleep efficiency, suggesting an overall reduction in sleep quality.
- Alcohol consumption is also associated with a reduction in sleep onset latency
- Our findings suggest that a reduction in alcohol and caffeine consumption by the general public may positively impact sleep health and subsequent general health.

Results

Parameter	TST			SOL			WASO			Sleep Efficiency		
	Coef	SE	p	Coef	SE	p	Coef	SE	p	Coef	SE	p
Intercept	419.45	1.45	<0.001	19.30	0.29	<0.001	12.52	0.64	<0.001	91.87	0.17	<0.001
Gender[M]	-17.24	2.06	<0.001	1.49	0.41	<0.001	3.75	0.91	<0.001	-1.17	0.25	<0.001
Age	-0.95	0.04	0.007	0.04	0.01	<0.001	1.02	0.02	<0.001	-0.24	0.00	<0.001
Age:Gender	-0.01	0.05	<0.001	-0.04	0.01	<0.001	0.07	0.02	0.001	-0.02	0.01	0.002
Drinks	-5.94	0.47	<0.001	-1.02	0.12	<0.001	-0.55	0.22	0.012	-0.03	0.06	0.649
Gender[M]:Drinks	2.61	0.58	<0.001	0.02	0.15	0.905	0.75	0.27	0.006	-0.08	0.07	0.254
Age:Drinks	0.13	0.01	<0.001	0.01	0.00	0.021	0.03	0.01	<0.001	0.00	0.00	0.619
Age:Drinks:Gender[M]	-0.06	0.01	<0.001	0.00	0.00	0.697	-0.02	0.01	0.001	0.00	0.00	0.343

Table 1 : Regression results for alcohol model

Parameter	TST			SOL			WASO			Sleep Efficiency		
	Coef	SE	p	Coef	SE	p	Coef	SE	p	Coef	SE	p
Intercept	422.29	1.60	<0.001	18.68	0.33	<0.001	12.50	0.71	<0.001	92.03	0.19	<0.001
Gender[M]	-16.94	2.27	<0.001	1.44	0.47	0.002	3.73	1.01	<0.001	-1.10	0.27	<0.001
Age	-0.92	0.04	<0.001	0.03	0.01	<0.001	1.04	0.02	<0.001	-0.24	0.01	<0.001
Age:Gender	-0.03	0.05	0.553	-0.04	0.01	0.001	0.08	0.02	0.001	-0.02	0.01	<0.001
Cups	-5.82	0.59	<0.001	0.19	0.14	0.193	-0.47	0.27	0.084	-0.15	0.07	0.03
Gender[M]:Cups	1.28	0.76	0.093	-0.11	0.19	0.57	0.31	0.35	0.386	-0.05	0.09	0.576
Age:Cups	0.06	0.01	<0.001	0.00	0.00	0.953	0.00	0.01	0.622	0.00	0.00	0.35
Age:Cups:Gender[M]	-0.01	0.02	0.407	0.00	0.00	0.844	-0.01	0.01	0.171	0.00	0.00	0.178

Table 2 : Regression results for caffeine model

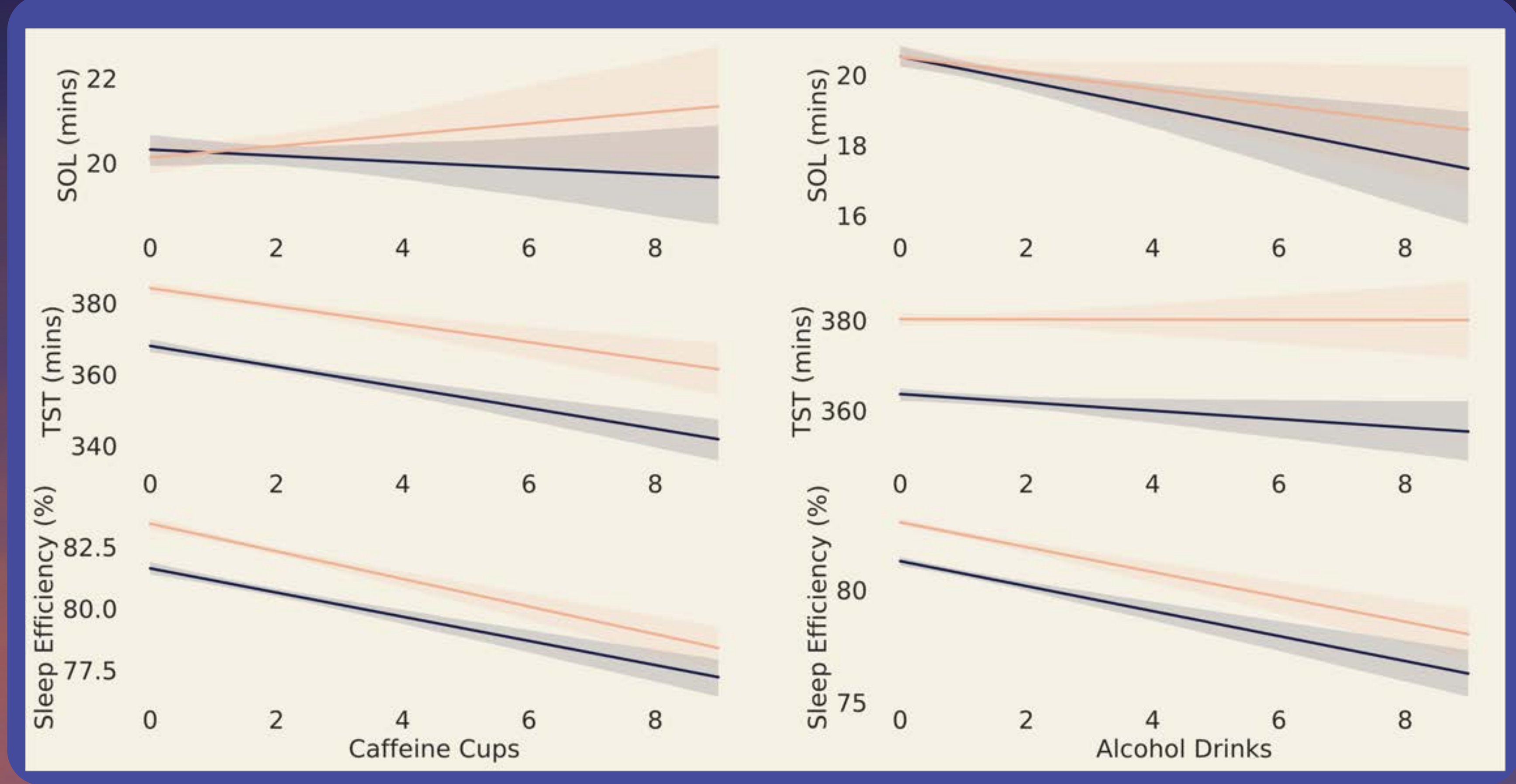


Fig 1: Non-adjusted regression plots. Purple: Male, Orange: Female

Reference

1. Clark I, Landolt HP. Coffee, caffeine, and sleep: A systematic review of epidemiological studies and randomized controlled trials. Sleep Med Rev. 2017 Feb;31:70-78. doi: 10.1016/j.smrv.2016.01.006. Epub 2016 Jan 30. PMID: 26899133.