PEER REVIEWED

Assessing COVID-19 Sleep Patterns in Optometry Students: Implications for Learning

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Abstract

This study evaluated the impact of COVID-19 lockdowns on student sleep patterns. Sleep data collected in a cohort of third-year optometry school students (OPT III) were compared with sleep data from a similar cohort (OPT III) during the same time frame, 1 year prior (summer 2019). During lockdown, subjects averaged 30 more minutes of sleep per night (7:37 vs. 7:07, $p = 0.03$), with the greatest difference observed on weekdays (7:37 vs. 6:41, $p < 0.001$). Weekday average wake time shifted significantly later in 2020 (7:57 a.m. vs. 7:14 a.m., $p = 0.01$). Increased sleep duration was attributed to delayed wake times and may play a role in improved learning and memory processing.

Key Words: *accelerometer, activity tracker, COVID-19, learning, lockdown, sleep, students, learning, sleep logs*

Introduction

As many countries began implementing restrictions aimed at reducing the transmission of COVID-19, there was concern these measures may have unintended consequences on the mental and physical health of affected populations. Disruptions in sleep patterns and mental health issues had previously been linked with restriction of movement, psychological distress, limited social engagement and modified daily routines.[1-3] Chronic sleep issues can eventually develop into sleeping disorders resulting from the body's inability to regulate its natural sleep mechanism and negatively impact learning and memory.[4-5] Through this research, we looked to better understand changes in sleep/wake behavior as a result of the COVID-19 lockdowns among a cohort of optometry school students.

Circadian rhythm, the body's biological clock, is responsible for controlling the sleep/wake cycle corresponding to the 24-hour light/dark phases of the Earth.[6-7] In addition, it can be influenced by physiological changes, diet, social/physical activity and artificial lighting.[7-9] The COVID-19 lockdowns dramatically altered daily structure and daily routines, leaving no aspect untouched. This led to an abrupt convergence of personal and professional life as "work from home" and remote learning responsibilities intersected with caregiving and self-care needs.[10] This unexpected shift in daily activities requires further analysis to determine whether such changes affect individual sleep behavior and learning potential.

Sleep metrics such as time to bed (TTB), wake time (WAKE) and duration (DUR) have often been utilized to quantify sleep quality and differentiate between sleeping disorders.[11] These values are closely connected to societal pressures (e.g., meal times, work responsibilities, social events, etc.) and are generally synchronized with the body's sleep-wake rhythm.[12-13] Earlier sleep research found less WAKE variability during the week among college-aged students, corresponding to the start of the academic day.[14] Would home confinement, growing anxiety and less daily structure lead to the development of abnormal sleep patterns and potentially impact student learning?

Methods

Participants

This longitudinal study was conducted during the summer semester of 2020 during a period of remote learning at University of the Incarnate Word Rosenberg School of Optometry. Seventeen full-time (greater than 16 credit hours) optometry students in their third year (OPT III) were recruited using flyers placed in their school mailboxes and in common-use areas. Participation was voluntary and had no impact on students' grades. No compensation was provided beyond participants being allowed to keep their activity trackers upon completion of the study. Enrollment required students to complete a pre-study questionnaire and wear a wrist-based accelerometer (WBA) for 30 days (21-day minimum). Exclusion criteria included pregnancy or nursing.

Study approval

This study was approved by the Institutional Review Board and was in compliance with the Declaration of Helsinki. All subjects provided written informed consent.

Data collection

Two sets of passively recorded sleep data, from summer 2019 (n_{19} = 34) and summer 2020 (n_{20} = 15), were analyzed and compared. All subject data were de-identified, and unique identification numbers were used to track each participant. No subjects were duplicates in the 2019/2020 cohorts. Data were stored on password-protected cloud systems.

Pre-study questionnaire

Pre-study questions included demographics, perceived sleep patterns, subjective sleep quality and various social behavior metrics (e.g., meal regularity, caffeine consumption and exercise). Only gender and age were considered in this assessment of WBA-based data.

Wrist-based accelerometers

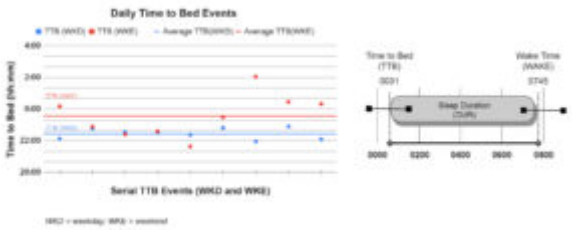

Figure 1. Example of serial (i.e., does not correspond to a specific date) WKD and WKE sleep event data (time to bed) collected using wrist-based accelerometers (left) for a single subject, including average TTB WKD (blue line) and average TTB WKE (red line). The information was used to create subject and cohort sleep profiles (right). Click to enlarge

Participants were provided a WBA, commonly referred to as an activity tracker. The WBAs (Xiaomi Mi Band 2, Taipei, TW) in this study utilized movement and heart rate to measure TTB, DUR and WAKE events for all subjects.[15] All participants were encouraged to wear the WBA throughout the day and night for the duration of the study. Passive data collection was then used to create sleep profiles for each participant and cohort **(Figure 1)**.

Statistical analysis

The data were collected and analyzed using Google Sheets (Mountain View, CA) and XLMiner Analysis ToolPak (Incline Village, NV). Jarque-Bera test was applied to confirm the data were normally distributed, and F-test was used to confirm equal variance ($p > 0.05$ for all data sets). Therefore, an unpaired t-test was utilized for comparison with a similar cohort (OPT III) during the same time frame, 1 year prior (summer 2019). Findings were considered statistically significant if the p-value was less than the pre-specified alpha of 0.05 for the various categories.

Results

Twenty subjects (out of 68) completed the pre-study questionnaire, of which 15 (2 male and 13 female; mean [SD] age, 25.3 [1.6] years) successfully wore the WBA and tracked their sleep for 30 days (minimum: 25 days, average: 28.8 days). The data were then compared to a cohort of 45 (out of 61) students, of which 34 (13 males and 21 females; mean [SD] age, 25.6 [1.9] years) successfully completed the study during summer 2019 (in-person learning), using the same method described above.

Mean sleep duration

TABLE 1
Mean Sleep Metrics 2019 vs. 2020

Event	2019	2020	Diff	p-value
DUR WKD	6h41m±57m	7h37m±44m	+56m	*<.001**
DUR WKE	8h05m±58m	7h35m±40m	-30m	*0.05**
DUR Avg	7h07m±44m	7h37m±40m	+30m	*0.03**
TTB WKD	00:33±74m	00:20±65m	-13m	0.53
TTB WKE	01:19±90m	00:48±57m	-31m	0.17
TTB Avg	00:43±72m	00:31±60m	-12m	0.57
WAKE WKD	07:14±43m	07:57±54m	+43m	*0.01**
WAKE WKE	09:24±86m	08:23±63m	-61m	*0.01**
WAKE Avg	07:50±52m	08:08±55m	+18m	0.28

** indicates a statistically significant change during lockdown*

Table 1. Summary sleep metrics comparing the 2019 and 2020 cohorts (mean±SD). Click to enlarge

WBA data showed mean [SD] DUR to be 7h37m [40m] during the lockdown **(Table 1)**. The 2020 subjects received significantly more sleep than the 2019 subjects (7:07 [44m] vs. 7:37 [40m], $p = 0.03$). WBAs allowed for differentiating between weekday (WKD – Sunday, Monday, Tuesday, Wednesday, Thursday) and weekend (WKE – Friday and Saturday) sleep patterns. Each measure consisted of the night they fell asleep (TTB) and their WAKE. For example, Friday sleep data would consist of TTB Friday evening and WAKE Saturday morning. Mean WKD DUR was 56 minutes more than pre-pandemic values (6h41m [57m] vs. 7h37m [44m]). Mean WKE DUR was 30 minutes less than pre-pandemic values (8h05m [58m] vs. 7h35m [40m]). Students were getting significantly more sleep during the week ($p < 0.001$), significantly less sleep during the weekend ($p = 0.05$) and significantly more sleep overall ($p = 0.03$) as compared to 2019 sleep data **(Figure 2)**.

Time to bed

WBA data showed the overall mean [SD] TTB to be 00:31 [60m], which was 12 minutes earlier than in 2019 (00:43 [72m]). WKD TTB was measured to be 00:20 [65m], which was 13 minutes earlier than in 2019 (00:33 [74m]) and not statistically significant ($p = 0.53$). Subjects went to bed 29 minutes earlier during the WKE with TTB being 01:19 [90m] and 00:48 [57m] in 2019 and 2020, respectively ($p = 0.17$). TTB metrics were consistent between cohorts with no statistically significant differences for WKD, WKE or overall average as compared to 2019 sleep data **(Figure 3)**.

Wake time

WBA data showed an overall mean [SD] WAKE of 07:50 [52m] and 08:08 [55m] in 2019 and 2020, respectively (p = 0.28). WKD WAKE was delayed by 43m (07:14 [43m] vs. 07:57 [54m], p = 0.01) in 2020 compared to 2019. Conversely, WKE WAKE was earlier (09:24 [86m] vs. 08:23 [63m], p = 0.01) during the pandemic as compared to 1 year prior. Students' WAKE was significantly later during the week, significantly earlier during the weekend and held steady on average as compared to 2019 sleep data **(Figure 4)**.

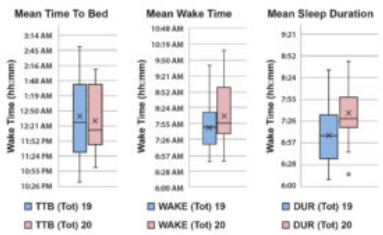

Figure 2. Mean TTB (left), WAKE (middle) and DUR (right) sleep metrics comparing 2019 with 2020. Students had earlier mean bedtimes (p = 0.57), later wake times (p = 0.28) and received significantly more sleep (p = 0.03) during the pandemic. The "x" represents the mean, the solid line denotes the median, the "?" represents potential outliers and the whiskers indicate the maximum and minimum range for each data set. Click to enlarge

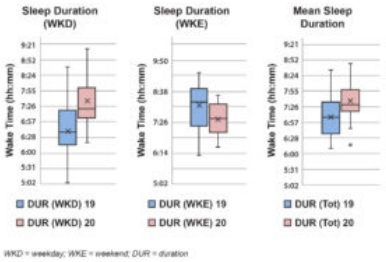

Figure 3. Compared to the 2019 cohort, students in the 2020 cohort were getting significantly more sleep during the week (p < 0.001), significantly less sleep during the weekend (p = 0.05) and significantly more sleep overall (p = 0.03). The "x" represents the mean, the solid line denotes the median, the "?" represents potential outliers and the whiskers indicate the maximum and minimum range for each data set. Click to enlarge

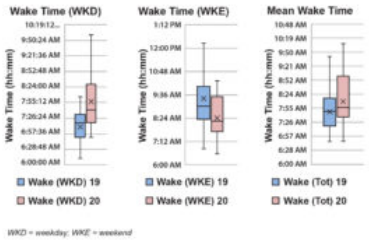

Figure 4. Compared to 2019, students' wake time in 2020 was significantly later during the academic week (p = 0.01), significantly earlier during the weekend (p = 0.01) and held steady overall (p = 0.28). The "x" represents the mean, the solid line denotes the median and the whiskers indicate the maximum and minimum range for each data set. Click to enlarge

Discussion

To the best of our knowledge, this is the first study to examine sleep patterns in optometry students during the COVID-19 lockdowns through passive means over an extended period. To better understand how lockdowns affected optometry school students, we observed an increase in DUR, a delay in WAKE and consistent TTB compared to pre-pandemic sleep patterns. This contrasts with prior studies that found declined sleep quality, elevated levels of stress and insomnia among other university student populations during the COVID-19 pandemic.[16-17]

Sleep duration

Overall DUR during the lockdown was longer and more in line with the recommended 7-8 hours of sleep per night.[18] The greatest increase was observed in WKD DUR as students increased their average sleep time by 56 minutes compared to pre-pandemic values. This was accompanied by a WKE DUR sleep decrease of 30 minutes. This shift between WKD and WKE DUR was likely due to a lack of sleep debt accrual during the academic week.

Time to bed vs. wake time

Studies have also found sleep timing events (TTB and WAKE) to be important metrics in overall sleep quality that correlate with academic performance.[13-15] Minimal change was observed in overall TTB from 2019 to 2020, with TTB being slightly more consistent in 2020. Observed increases in DUR were primarily attributed to shifts in WKD and WKE WAKE. The observed delay in WAKE WKD and advanced WAKE WKE were both statistically significant and consistent with prior research looking into the benefits

of delayed school start times.[19] Watson et al. found no significant change in bedtimes but an increase in overall sleep duration as a result of delayed wake times.[19] The American Academy of Sleep Medicine has since stated its support of delayed academic start times for adolescents to reduce sleep deprivation and improve mental health.[19-20] These findings could be used to help guide future discussions related to academic start times and best practices for optimal learning among optometry school students.

Learning and memory processing

The implications for this sleep study go beyond simple behavioral differences. Prior studies have linked sleep duration and consistency with better academic performance.[11-12] Although the mechanism is not well-understood, it is believed the act of sleeping facilitates information restructuring, memory processing and information retrieval.[21] Better sleep has also been linked to stress management, which is a common issue in various health professions.[22] Future efforts to create a well-rounded approach to academic success should incorporate positive sleep habits.

Pandemic's disparate impact

From the outset, public health officials have had concerns around the unequal challenges facing various populations during the COVID-19 pandemic. Depending on one's vocation, socio-economic and pre-pandemic sleep quality status, the impact may differ significantly.[20, 23-24] The first step in managing the potential problems facing optometry students was to evaluate what changes were taking place during this time. Quantitatively, it would appear our subjects improved in some sleep metrics (e.g., TTB and DUR), which have previously been linked to better mental health and a reduction in stress/anxiety during a highly stressful time.[25]

Limitations

These findings should be considered within the context of the following limitations. As with many sleep studies, reliance on proprietary algorithms that have not been validated introduces a degree of systematic error for all measurements. Sleep onset, duration and wake events are calculated through heart rate and movement, which may not consistently differentiate being "in bed" from being "asleep." Unequal sample sizes were also considered as it may limit the statistical power. We look to compare more equal cohorts in future studies. Additionally, the WBAs used in our study were also unable to capture naps, which may have played a larger role during the pandemic due to fewer daytime constraints, as one study suggests.[16]

Conclusion

This study was able to highlight a significant shift in wake times for optometry school students during the COVID-19 lockdowns. The observed increase in sleep duration can be directly correlated with the delayed wake times, most likely due to the flexibility of virtual learning (i.e., asynchronous lectures and increased productivity) and lack of commuting time. Future studies are needed to investigate the relationship between increased sleep duration and academic performance.

Acknowledgments

This study was funded by an internal faculty development grant at University of the Incarnate Word Rosenberg School of Optometry.

The authors would like to thank Jeff C. Rabin, OD, MS, PhD, Dipl. Vis. Science, for his support of this study.

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