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ORIGINAL ARTICLE

Changes in sleep patterns of college students in Israel during COVID-19 lockdown, a sleep diaries study

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Abstract
To prevent and reduce the spread of COVID-19, governments around the world apply social restrictions and lockdowns. Such lockdowns significantly alter daily routine and habits. A growing body of research indicates that lockdowns affect sleep and circadian rhythms. The current study further explores this effect using sleep logs for a relatively long duration including lockdown and post-lockdown periods in Israel. For two consecutive months, both during lockdown and during post-lockdown periods, from March 13th, 2020 to May 12th, 2020, Israeli students were asked to fill out daily sleep logs in which they report their sleep and wake times. The participants were also asked to fill out the Morningness–Eveningness Questionnaire (MEQ) in the beginning of the study. Data show increase in sleep duration and a delayed midsleep point during lockdown, compared to post-lockdown periods, both on workdays and on weekends. An interaction between chronotype and lockdown was also observed; morning types sleep more both during lockdown and during post-lockdown periods. Interestingly, the midsleep point of late chronotypes is later during both workdays and weekends even during lockdown when social constrains on sleep time are in part removed. Overall, the current results based on detailed and relatively long-term sleep logs analysis confirm previous work using limited measures, such as one-time questionnaires. A lockdown period affects sleep–wake behavior: during lockdown people sleep duration is increased and their sleep onset is delayed. Nevertheless, the circadian preference of individuals is conserved across conditions.

Keywords Sleep · Circadian rhythm · SARS-CoV-2 · COVID-19 · Chronotype

Introduction

The outbreak of the global COVID-19 pandemic has altered the world in many ways with most countries imposing lockdowns and social distancing regulations as a mean to prevent the spread of the disease [1]. A lockdown situation induces a considerable change in our schedules, including when and where we work, study, and sleep [2]. A recent meta-analysis indicates an increase in sleep duration during lockdowns [3], whereas other meta-analyses suggest increased sleep disturbances [4, 5].

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One factor that may interact with the effects of lockdown on circadian sleep–wake behavior is the individual chronotype. Chronotypes describe the sleep/wake timing preference of individuals relative to the population. Regarding timing of sleep, early chronotypes prefer to wake up early in the morning and go to bed early at night, while late chronotypes prefer to wake up late in the morning (or noon) and go to sleep late at night or early morning. Most of the population is somewhere in-between [6]. A large number of studies explored the effects of chronotypes on behavioral and biological variables. The general findings of these studies are that people with late chronotypes tend to sleep less, perform worse in multiple tasks, and be less healthy compared with individuals with early or intermediate chronotypes [7–12]. It is suggested that late chronotype individuals need to adapt to the standard social clock, whether it is school or work hours, an adaptation that results in a constant disturbance to their innate timing preferences and leads to chronic sleep deprivation, which negatively affects health [13]. This misalignment can be easily demonstrated by the differences between sleep times and duration during work days and weekends of individuals with late chronotype and is described in the literature as “social jet lag” (SJL) [14].

In Israel, the response to the COVID-19 pandemic included a variety of measures with some strict lockdown periods for the entire population. The lockdown measures relevant to the period of this study involved a home quarantine for the entire population (with exceptions for essential workers, for buying food or medicine, and staying within 100-m away from home to allow some activity). Consequent to the quarantine order most people stopped working (except essential workers and some that switched to distant work from home). School and university students did not attend school but institutions made significant efforts to switch to distant learning and teaching.

We suggest that the changes to sleep patterns induced by the COVID-19 lockdowns may interact with chronotypes. Moreover, previous data indicate gender effects in the expression of chronotypes [15] and it is therefore possible that the interactions between lockdown and chronotype could be dissimilar for females and males. Accordingly, the current study utilizes sleep diaries of college students to explore differential effects of lockdowns on students with different chronotypes with further examination of possible effects of gender. In the present study, college students were asked to fill out daily sleep logs in which they report their sleep and wake times for two consecutive months that include a lockdown period and a post-lockdown period and the results were compared between different chronotypes.

Materials and methods

Participants

Ninety-one (91) undergraduate college students (74 women and 17 men, mean $\pm$ SEM for age $= 25 \pm 0.4$, age range 19–53) from the Tel-Aviv-Yaffo Academic College (Tel-Aviv, Israel) volunteered for this two-month long study which started on March 13th, 2020 and ended on May 12th, 2020. Participants filled out daily sleep logs and completed the Morningness–Eveningness questionnaire (MEQ) [16]. Demographic information, including age, gender, employment status, and living conditions, were also collected. For analysis purposes, we considered two time periods in the study: (1) A lockdown period: March 13th to April 25th and (2) a post-lockdown period: April 26th to May 12th (specific restrictions for the lockdown period are detailed below). Procedures used in this study were approved by the ethics committee at Tel-Aviv-Yaffo Academic College (protocol 2020058) and participants signed an informed consent form at the beginning of the study.

Instruments

Sleep logs

Participants were instructed to fill sleep logs every day, immediately after they woke up. A daily reminder was sent at 12:00 PM using a WhatsApp group message to participants' cellular phones. In the sleep logs, participants reported the time they went to sleep and the time they woke up.

Morningness–Eveningness Questionnaire (MEQ)

Chronotype was assessed with the Hebrew version of the MEQ questionnaire [16]. The questionnaire includes 19 auto-evaluating questions with a total score ranging from 16 to 86. The higher the score the more morning oriented the person is. The global score was converted to a three-level scale: morning type (50–86), intermediate type (43–49), and evening type (16–42).

Calculated measures and statistical analysis

Sleep duration was calculated as the difference (in hours and minutes) between reported sleep onset time and reported sleep offset time. Midsleep point was calculated as halfway point between sleep onset and sleep offset [17]. Data for each individual were averaged separately for workdays and free days of each period. The distribution of data was normal (chi-square goodness-of-fit test). A mixed ANOVA was used to test the interaction between chronotypes and lockdown with chronotype as a main factor and time period (lockdown and post-lockdown) as repeated measure factor. Further analysis also included gender as a main factor. Data were separately analyzed for workdays and weekends. Significant results were followed by Bonferroni post hoc analysis. Paired student's t tests were used to compare lockdown to post-lockdown times for the entire cohort. Significance level for all analyses was set at $p \leq 0.05$.

Results

Analysis of the entire cohort

For the entire cohort we found a significant reduction in sleep duration from lockdown to post-lockdown period for workdays [Table 1; paired t test $t(74) = 3.44$, $p = 0.001$] and weekends [Table 1; $t(74) = 2.47$, $p = 0.016$]. Midsleep time was later during lockdown compared with post-lockdown for workdays [Table 1, $t(74) = 6.29$, $p < 0.001$] and weekends [$t(74) = 4.51$, $p < 0.001$]. Interestingly, lockdown had no

Table 1 Sleep measures for the entire cohort (mean ± SEM)

	Lockdown	No-lockdown	Statistics
Sleep duration—workdays (min)	474.2 ± 5.02	456.7 ± 5.82	$t(74)=3.44$, $p=0.001$
Sleep duration—weekends (min)	503.5 ± 5.7	489.9 ± 6.5	$t(74)=2.47$, $p=0.016$
Midsleep point—workdays (time)	5:39 ± 0:05	5:10 ± 0:04	$t(74)=6.29$, $p<0.001$
Midsleep point—weekends (time)	6:04 ± 0:05	5:41 ± 0:05	$t(74)=4.51$, $p<0.001$

Table 2 Sleep duration workdays—lockdown and chronotype interaction

	Lockdown	Post-lockdown
Morning	480.6 ± 44.5	473.7 ± 47.5
Evening	462.9 ± 46.4	440.8 ± 54.3

Table 3 Midsleep point—lockdown and chronotype (hour:minutes)

	Lockdown	Post-lockdown
Morning—workdays	5:05 ± 0:34	4:35 ± 0:25
Evening—workdays	6:24 ± 0:42	5:05 ± 0:38
Morning—weekends	5:23 ± 0:35	5:00 ± 0;37
Evening—weekends	6:55 ± 0:45	6:28 ± 0:42

Table 4 Sleep duration—lockdown and gender

	Lockdown	Post-lockdown
Women—workdays	477.4 ± 42.8	459.2 ± 50.0
Men—workdays	460.3 ± 45.5	445.7 ± 52.8
Women—weekends	510.4 ± 46.2	495.7 ± 53.1
Men—weekends	473.7 ± 54.1	464.2 ± 64.9

effects on social jetlag [$t(74)=1.36$, $p=0.18$]. Neither work [not working, working up to 15 h/week, working more than 15 h/week; $F(2,87)=1.01$, $p=0.37$] nor living conditions [living alone versus living with others; $t(88)=0.95$, $p=0.35$] had an effect on sleep time during workdays or any of the other measures (data not shown).

Analysis of chronotypes

A mixed ANOVA was used to test the interaction between chronotypes and lockdown. There was a significant effect of lockdown and chronotype on sleep duration during workdays: lockdown effect [$F(1,44)=5.49$, $p=0.02$]; chronotype effect [$F(1,44)=3.88$, $p=0.05$]; and lockdown X chronotype interaction [$F(1,44)=1.481$, $p=0.23$]. In general, participants slept more during lockdown compared to a post-lockdown period and morning types slept more than evening types (Table 2). These effects were not demonstrated during weekends: lockdown effect [$F(1,44)=3.1$, $p=0.085$]; chronotype effect [$F(1,44)=0.55$, $p=0.46$]; and lockdown X chronotype interaction [$F(1,44)=0.34$, $p=0.56$].

Similarly, when testing the entire cohort, there was a significant correlation between sleep duration and MEQ score during workdays both during lockdown [$r=0.23$, $p=0.04$] and post-lockdown [$r=0.305$, $p=0.01$], but no such correlation was demonstrated during weekends [for lockdown: $r=0.055$, $p=0.63$, for post-lockdown $r=0.15$, $p=0.24$]. Early chronotype correlated with longer sleep duration on workdays, both during lockdown and on a post-lockdown time.

Chronotypes and midsleep point

Midsleep point was later for evening chronotypes compared with morning chronotypes and was later during lockdown compared with post-lockdown periods (Table 3). For workdays, lockdown effect—$F(1,44)=28.68$, $p<0.001$]; chronotype effect—$F(1,44)=22.4$, $p<0.001$]; and interaction: $F(1,44)=0.2$, $p=0.68$]. For weekends, lockdown effect—$F(1,44)=11.87$, $p<0.001$]; chronotype effect—$F(1,44)=24.05$, $p<0.001$]; and interaction—$F(1,44)=0.12$, $p=0.73$].

Chronotype and gender

Women had a lower MEQ score compared with men, a finding suggesting a later chronotype [Women—43.9 ± 1.2; Men—50.1 ± 1.9; $t(76)=2.29$, $p=0.025$].

Sleep duration and gender

A mixed ANOVA was used to test the interaction between gender and lockdown on sleep duration (Table 4). For workdays, the results of the ANOVA show significant effect of lockdown [$F(1,73)=6.2$, $p=0.015$], but no effects of gender [$F(1,73)=1.55$, $p=0.22$] and no interaction [$F(1,73)=0.07$, $p=0.79$]. A different outcome was shown for weekends with no significant effect (albeit a non-significant trend) of lockdown [$F(1,73)=2.83$, $p=0.096$], but a significant effect for gender with women sleeping more than men [$F(1,73)=6.37$, $p=0.014$] and no interaction [$F(1,73)=0.13$, $p=0.72$].

Midsleep point and gender

Midsleep point for women was later than for men during lockdown for both workdays and weekends, but this difference disappeared in the post-lockdown period. For workdays, lockdown effect [$F(1,73) = 12.4$, $p < 0.001$]; gender effect [$F(1,73) = 0.66$, $p = 0.42$]; interaction [$F(1,73) = 6.04$, $p = 0.016$; post hoc: women lockdown ≠ women no-lockdown ($p < 0.001$); and women lockdown ≠ men lockdown ($p = 0.041$)]. For weekends, lockdown effect [$F(1,73) = 4.6$, $p = 0.035$]; gender effect [$F(1,73) = 1.58$, $p = 0.21$]; interaction [$F(1,73) = 5.56$, $p = 0.021$; post hoc: women lockdown ≠ women no-lockdown ($p < 0.001$); and women lockdown ≠ men lockdown ($p = 0.024$)].

Discussion

A significant number of studies regarding COVID-19 related to the effects of social restrictions and lockdowns on well-being were published since the COVID-19 pandemic interfered with the life of most people in the world. From these studies, quite a few evaluated measures related to sleep and circadian rhythms [2, 4, 5, 17–25]. However, most studies explored these questions using surveys and questionnaires administered once or twice. Only a few studies utilized continuous data collection whether with sleep logs [22, 23] or wearable devices [17, 24, 25]. In the current study we used a well-practiced, albeit quite demanding, method to follow sleep in a cohort of college students sleep logs for a relatively long period. Sleep logs have been used in sleep research as well as clinical practice for many years and are considered a highly reliable method. Yet, the use of sleep logs demands high level of cooperation from subjects and therefore many studies prefer other methods. For two consecutive months, which included lockdown and post-lockdown periods, students were asked to fill out daily sleep logs in which they reported their sleep onset and offset times. Up to now, to the best of our knowledge, sleep logs were used to investigate the effects of lockdowns on sleep–wake behavior in only few published studies [22, 23, 26, 27]. In the first and last participants filled out sleep logs for one week before lockdown and again one week during lockdown, in the second, participants used a smartphone sleep app, and in the third participants used modified versions of sleep logs. In the current study, participants filled out daily sleep logs for two consecutive months, therefore allowing the exploration of continuous changes. We suggest that the current study presents a more accurate evaluation of sleep variables compared with other studies especially most studies based on single administration of surveys.

Despite the differences in methodology, it appears that the current results are in agreement with recent studies using surveys and questionnaires [21, 22, 24, 28–30] and clearly show an increase in sleep duration and delayed midsleep point during lockdown periods. Interestingly, both during lockdown and post-lockdown periods, individuals with early chronotypes maintained longer sleep duration compared with late chronotype during workdays. This difference between the groups disappeared during weekends. These findings may suggest that despite the lockdown, the schedules of the subjects were not completely flexible and that they may still have reasons to wake up at specific times, possibly to attend online courses or for essential work. In this context, it is important to note that classes were online throughout the study period (lockdown and post-lockdown) and therefore the difference between the two situations should be attributed to additional social demands and not directly to physically attending college.

Both lockdown and chronotype had significant effects on midsleep point, with later point in late chronotype individuals and later point during lockdown. Recent studies showed that in general people maintain their circadian preference during lockdowns, despite the significant change in social schedules and in light exposure [17, 21, 29]. This suggests that even when social constrains are at least in part removed, the behavioral manifestations of the chronotype are preserved.

While some studies indicated a reduction in social jetlag (SJL) during lockdown, especially in late chronotypes [21, 22, 24, 29, 30], we did not find this effect. Overall, the SJL found in our study was relativity small compared to other studies. This difference can be easily explained as our entire study was conducted during some level of COVID-19 restrictions and all participates were students who did not have to physically attend classes during the time of the study as all courses were given online.

Our results indicate some gender differences: First, MEQ for women was lower than for men, indicating that on average, women had a later chronotype than men did. This finding stands in contrast with some previous studies suggesting that in general men have later chronotype compared with women. However, this is not a rare finding and it was suggested that the differences between chronotypes of men and women are not stable and are highly influenced by age of sample and by publication year [15]. Furthermore, women in our cohort slept more than men during weekends. This is in line with a growing body of literature that found that on average women sleep more than men do [31, 32]. It was hypothesized that women sleep duration is longer as a compensation for lower sleep quality. Indeed it was found that on average, sleep quality of women is lower compared to men [33] and this gender difference was reported even during lockdown [32]. It is however important to note that the current findings regarding gender should be addressed carefully because our sample was not balanced for gender with significantly more female subjects (74) than male subjects (17).

Interestingly, work status and living conditions did not influence any of the measures of the study. Some studies present possible interactions between chronotype and work in college students [34] but it is possible that even for working students, many have switched to home base work or had significantly less work hours during the time of lockdown. We did not identify any studies that examined relationship between sleep, chronotypes, and different living conditions in students but regardless, it is possible that our data were not precise enough on this matter to explore specific effects of housing conditions, including students' dormitories, roommates, living with partners, and with parents. We plan to collect more detailed data in future cohorts.

The study has some clear limitations. First, it is important to note that the study population (college students from one institution in Israel) is highly specific and is not intended to represent the general population. Additionally, whereas daily sleep logs are considered a good way to evaluate measures of sleep, the study would have been stronger if objective measures obtained from wearable devices were obtained as already done in some studies [17]. As these technologies are becoming more available we hope that we would be able to use them in future work. Last, it would have been an advantage if we could have included some biological markers in the study and explore changes of circadian hormones or gene expression parallel to the behavioral change. These tools were unfortunately not available to us.

Conclusion

Overall, our results using detailed and relatively long-term daily sleep logs analysis confirm previous work using more limited measures, such as one-time surveys. Results clearly demonstrate that lockdown period affected sleep–wake behavior: during lockdown sleep duration is increased and sleep onset is delayed. Nevertheless, the circadian preference is maintained. Considering the general replication crisis of scientific findings [35] we suggest that the present study, using a more precise method compared with most previous work, is clearly of importance as it significantly strengthens our understanding of the effects of reducing social constrains on sleep.

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Declarations

Ethical approval statement The study was approved by the ethics committee at Tel-Aviv-Yaffo Academic College (protocol 2020058). Participants signed an informed consent form at the beginning of the study.

Conflict of interest statement The authors declare no conflict of interest.

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