

SCIENTIFIC INVESTIGATIONS

## COVID-19 pandemic impact on sleep habits, chronotype, and health-related quality of life among high school students: a longitudinal study

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**Study Objectives:** The COVID-19 pandemic has challenged the population of affected areas in multiple dimensions. Adolescents have been especially affected with school closure and home confinement. The impact of the pandemic on sleep habits and quality of sleep and quality of life among adolescents has not been adequately characterized. We hypothesized that the COVID-19 pandemic has induced an evening shift of the daily rhythm among adolescents and adversely affected sleep quality and quality of life of high school students.

**Methods:** Students were questioned about their usual bed and wake-up times and answered the Pittsburgh Sleep Quality Index Questionnaire, the Epworth Sleepiness Scale, the Horne-Osteberg Morningness-Eveningness Questionnaire, and the World Health Organization Quality of Life Questionnaire-abbreviated version before and during the pandemic.

**Results:** Ninety-four students (64% females, aged  $15 \pm 1$  years) participated in both phases of the study. Students delayed bed and wake-up times by 1.5 (0.5–2.0) and 2.0 (1.5–2.5) hours, respectively. Chronotype (per the Morningness-Eveningness Questionnaire) shifted toward eveningness during the pandemic. Sleep duration increased and quality of sleep (per the Pittsburgh Sleep Quality Index) improved only among those students with shorter sleep duration before the pandemic. During the pandemic, the physical and psychological domains of the World Health Organization Quality of Life Questionnaire worsened but the environmental domain improved as compared with the study before the pandemic.

**Conclusions:** High school students have delayed bed and wake-up times and shifted chronotype toward eveningness during the COVID-19 pandemic. The worsening of the physical and psychological World Health Organization Quality of Life Questionnaire domains and improvement in the environmental domain highlight the conflicting experiences that high school students are facing during the COVID-19 pandemic.

**Keywords:** COVID-19, social jet lag, chronotype, quality of life, adolescents

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### BRIEF SUMMARY

**Current Knowledge/Study Rationale:** School closure and home confinement during the COVID-19 pandemic has imposed behavioral changes among adolescents. The purpose of this study was to assess the impact of the COVID-19 pandemic on sleep habits, chronotype, and quality of life among high school students.

**Study Impact:** High school students shifted their bed and wake-up times as well as their chronotype towards eveningness during the COVID-19 pandemic. The impact of the COVID-19 pandemic on the quality of life of adolescents showed mixed results, reflecting the conflicting experiences adolescents are facing.

### INTRODUCTION

The COVID-19 pandemic has adversely affected the physical and mental health of the world population. Although COVID-19 offers more health risks for middle-aged and older adults, younger people have been impacted as well. Fear of infection, social distancing, and negative economic impact have significantly affected adolescents. Despite the return of commercial activity in places where lockdown was adopted, in many cities schools remain closed. The COVID-19 pandemic has impacted the health-related quality of life of adults<sup>1</sup> and adolescents.<sup>2</sup>

Recent evidence has shown that the COVID-19 pandemic induced changes in sleep habits among adults, especially in

places where lockdown was adopted. Despite an increase in time in bed, poorer sleep quality was reported among adults.<sup>3</sup> Adolescents typically have a preference to sleep late. A delayed sleep phase,<sup>4</sup> use of electronic devices, and social life are associated with adolescents' sleep behavior. A common consequence is sleep restriction and poor school performance.<sup>5,6</sup> Delayed school start time has been advocated to improve sleep quality and duration in adolescents.<sup>7</sup> During the pandemic, adolescents have had more flexibility with their schedule, which should help align with their sleep preferences. Online classes begin later than the usual in-person classes and there is no time spent commuting to school. The impact of the pandemic on sleep habits and quality of sleep and quality of life among

adolescents has not been adequately characterized and compared with the period previous to the pandemic in the same group of students. We hypothesized that the COVID-19 pandemic induced an evening shift of the daily rhythm among adolescents. In addition, we hypothesized that the pandemic adversely affected sleep quality and quality of life in high school students. To address these hypotheses, high school students who were participating in an ongoing study on sleep quality and quality of life before the pandemic were invited to participate in a new data collection during the pandemic. Thus, the present study assessed the same students before and during the pandemic.

## METHODS

Students from the Rudolf Steiner Waldorf High School in São Paulo (Brazil) who were participating in an ongoing study aiming to address sleep quality and quality of life before the pandemic were invited to participate. The Waldorf High School is a private commuter school serving approximately 200 students from the city of São Paulo and surroundings. The Waldorf school serves a diverse community, mostly from the middle class, offering scholarships for low-income students. The study was approved by the University of São Paulo School of Medicine Institutional Review Board. Students were asked to answer a set of questionnaires on March 15, 2019 (1 year before social isolation was implemented and schools were closed in São Paulo) regarding sleep quality, chronotype, sleepiness, and quality of life. The same questionnaires were answered from June 19–June 27, 2020. In São Paulo, only essential businesses such as supermarkets, pharmacies, and health-related services could remain open as of March 23, 2020. Schools and all other businesses remained closed from that date on, which included the period during which the questionnaires were answered. Social isolation was reinforced during this period. Students who left the school after the initial evaluation in 2019 because they graduated or moved to another school were excluded. School started at 7:15 AM before the pandemic. Online classes during the pandemic started at 8:00 AM.

Data collected in 2019 were paper-based and later stored in REDCap electronic data capture tools hosted at the Hospital das Clínicas in São Paulo.<sup>8</sup> During the pandemic, the REDCap online survey tool was used to distribute the same questionnaires used initially.

### Questionnaires

All participants answered the Brazilian Portuguese versions of the Pittsburgh Sleep Quality Index (PSQI),<sup>9</sup> the Epworth Sleepiness Scale,<sup>10</sup> the Horne-Osteberg Morningness-Eveningness Questionnaire (MEQ),<sup>11</sup> and the World Health Organization Quality of Life Questionnaire-abbreviated version (WHOQOL-BREF).<sup>12</sup> In addition, students were asked to state their usual bed and wake-up times during each day of the week and weekend. Social jet lag was calculated using the following formula:  $\text{midsleep}_{\text{freedays}} - \text{midsleep}_{\text{workdays}}$ .<sup>13</sup> Sleep quality was assessed using the PSQI, a self-administered questionnaire that evaluates sleep quality with questions regarding the last

month. Scores range from 0 to 21. Scores above 5 indicate poor sleep quality. Information about sleep latency and sleep duration was taken from the PSQI.

Daytime sleepiness was assessed using the Epworth Sleepiness Scale, which is also a self-administered questionnaire that evaluates daytime sleepiness with questions regarding the chance of dozing in 8 different situations. Each situation has 4 different scores, ranging from 0 to 3. Higher scores indicate a higher chance of dozing. Global scores are obtained by the sum of the scores of the situations. Global scores range from 0 to 24. Scores above 11 represent excessive daytime sleepiness.

The MEQ was used to classify participants into 3 different groups. Participants with scores lower than 42 were classified as evening types, participants with scores between 42 and 58 were classified as intermediate types, and participants with scores above 58 were classified as morning types.

The WHOQOL-BREF is a shorter version of the WHOQOL-100 quality-of-life questionnaire. The WHOQOL-BREF assesses the quality of life regarding the last month. The questionnaire is divided into 4 different domains (physical, psychological, environmental, and social) and scores are calculated in each of the domains. Higher scores indicate a better quality of life in a given domain.

Statistical analyses were performed using Stata (StataCorp, College Station, TX). The Shapiro-Wilk test was used to test for normal distribution. A paired Student *t* test or Wilcoxon matched-pairs signed-rank test was used to compare continuous data before and during the pandemic. In order to test if shorter or longer reported sleep duration at the initial assessment influenced the study variables, the study group was split in 2 according to reported sleep duration. An unpaired Student *t* test or Wilcoxon rank-sum test was used to compare variables according to the average sleep duration. In order to test if the pandemic influenced the study variables of each chronotype differently at initial assessment, the study group was classified according to morning, intermediate, and evening chronotypes. A one-way analysis of variance or Kruskal-Wallis test was used to compare groups. A Bonferroni or Dunn test was used for posthoc between-group comparisons. The distribution of chronotypes during the initial assessment and during the pandemic was compared using a chi-square test. Pearson and Spearman correlation coefficients were used to test for the association between the change (before and during the pandemic) among variables. Linear regression was used to test independent predictors of the change in quality of life. Data are presented as mean  $\pm$  standard deviation or median (25th–75th percentiles), according to data distribution.

## RESULTS

A total of 193 students participated in the initial 2019 assessment. Ninety-nine students were excluded for various reasons, as follows: 58 students graduated before the pandemic, 18 left the school before the pandemic, and 23 refused to participate in the second phase of the study. A total of 94 students (40% of the high school student body) participated in both phases of the study. Included students were similar to those who refused to

**Table 1**—Students' characteristics during the initial evaluation and during the pandemic.

	Before the Pandemic	During the Pandemic	Mean Difference	P
Age, y	15.0 ± 1.0	16.4 ± 1.1		
Sex, % female	64	64	0	> .99
High school grade, %				
9th	40.4	0	—	
10th	30.9	40.4	—	
11th	28.7	30.9	—	
12th	0	28.7	—	
Sleeping preferences				
Bedtime, h	22:00 (21:45–22:40)	23:30 (22:30–24:12)	1:30 (0:30–2:00)	<.001
Sleep latency, min	15 (10–30)	20 (10–30)	0 (–7 to +10)	.412
Sleep duration, h	7.4 ± 1.1	7.4 ± 1.1	0.0 ± 1.1	.920
Wake-up time, h	6:00 (5:48–6:18)	8:00 (7:42–8:30)	2:00 (1:30–2:30)	<.001
Social jet lag, h	1.0 (0.4–1.5)	0.5 (0.0–0.8)	–0.4 (–1.1 to +0.1)	<.001
Questionnaires, score				
ESS	11 (8–14.5)	10 (6–15)	0 (–3 to 3)	.882
PSQI	6.4 ± 2.8	6.8 ± 3.6	0.4 ± 3.0	.166
WHOQOL-BREF				
Physical	68.9 ± 14.2	63.5 ± 18.2	–5.4 ± 13.9	<.001
Psychological	64.0 ± 15.3	57.0 ± 17.1	–7.0 ± 12.7	<.001
Social	67.8 ± 20.4	65.7 ± 19.5	–2.0 ± 23.4	.425
Environmental	73.0 ± 11.6	76.0 ± 13.3	3.0 ± 11.6	.016
MEQ	50.5 ± 8.1	47.8 ± 8.8	–2.8 ± 7.1	<.001
MEQ chronotypes, %				
Morning	13.8	10.6	—	.398
Intermediate	70.2	66.0	—	
Evening	16.0	23.4	—	

Data are presented as means ± SDs or medians (25th–75th percentile) unless otherwise indicated. N = 94. ESS = Epworth Sleepiness Scale, MEQ = Morningness-Eveningness Questionnaire, PSQI = Pittsburgh Sleep Quality Index, SDs = standard deviations, WHOQOL-BREF = World Health Organization Quality of Life Questionnaire-abbreviated version.

participate regarding age, sex, and baseline questionnaires (Epworth Sleepiness Scale, PSQI, WHOQOL-BREF; data not shown). Although some students did not answer 1 or more of the questionnaires, each questionnaire was answered by at least 80% of the participants.

Students were aged  $16.4 \pm 1.1$  years and most were females (64%). All students were in high school (40% in the 9th grade, 31% in the 10th grade, and 29% in the 11th grade) (**Table 1**). Before the pandemic, students reported poor sleep quality, short sleep duration, daytime sleepiness, and a median social jet lag of 1 hour. Most students reported an intermediate chronotype.

Students delayed bedtime by 1.5 (0.5–2.5) hours and wake-up time by 2.0 (1.5–2.50) hours during the pandemic as compared with the initial evaluation in 2019. Social jet lag was reduced by  $-0.4 [-1.1 \text{ to } +0.1]$  hours during the pandemic. Sleep latency, sleep duration, daytime sleepiness, and sleep quality as assessed by the PSQI remained unchanged. During the initial evaluation (before the pandemic), 13 students were classified as morning, 66 as intermediate, and 15 as evening chronotype. The MEQ shifted toward eveningness during the pandemic. Change

in sleepiness before and during the pandemic was associated with changes in the physical and psychological domains of quality of life (**Table 2**). Change in quality of sleep was associated with changes in chronotype, quality of life (physical domain), sleep latency, and sleep duration (**Table 2**). A linear regression model to predict the change in the physical domain of the WHOQOL-BREF showed that the changes in sleepiness and quality of sleep were independent predictors, controlled for sex and school grade (**Table 3**). Only the change in sleepiness was a predictor of the change in the psychological domain of the WHOQOL-BREF. Changes in sleepiness and quality of sleep were not predictors of the change in the social and environmental domains of the WHOQOL-BREF.

**Table 4** shows differences in sleeping preferences, daytime sleepiness, quality of sleep, quality of life, and chronotype between the evaluation before and during the pandemic according to the reported average sleep duration (7.4 hours) as a cutoff. Students who slept less than the average woke up later during the pandemic and increased sleep duration as compared with those who slept more than the average sleep duration. In

**Table 2**—Correlations between the differences (before and during COVID-19 pandemic) of daytime sleepiness, sleep quality, chronotype, quality of life, sleep duration, and social jet lag.

	PSQI	MEQ	WHOQOL-BREF-Physical	WHOQOL-BREF-Psychological	WHOQOL-BREF-Social	WHOQOL-BREF-Environmental	Sleep Duration	Social Jet Lag
ESS	0.266* (n = 90)	-0.052 (n = 92)	-0.394*** (n = 92)	-0.356*** (n = 90)	-0.021 (n = 84)	0.080 (n = 89)	-0.185 (n = 92)	0.011 (n = 86)
PSQI	—	-0.327** (n = 92)	-0.323** (n = 92)	-0.209 (n = 88)	-0.158 (n = 84)	0.089 (n = 88)	-0.698*** (n = 92)	0.197 (n = 85)
MEQ		—	0.286** (n = 93)	0.053 (n = 90)	0.063 (n = 85)	0.072 (n = 90)	0.289** (n = 94)	-0.176 (n = 87)
WHOQOL-BREF-Physical			—	0.514*** (n = 90)	0.189 (n = 85)	0.260* (n = 90)	0.172 (n = 93)	-0.054 (n = 87)
WHOQOL-BREF-Psychological				—	0.342** (n = 82)	0.142 (n = 87)	0.041 (n = 90)	-0.068 (n = 84)
WHOQOL-BREF-Social					—	0.007 (n = 82)	0.096 (n = 85)	-0.098 (n = 80)
WHOQOL-BREF-Environmental						—	-0.196 (n = 90)	0.206 (n = 84)
Sleep duration							—	-0.300** (n = 87)

\*\*\* $P < .001$ , \*\* $P < .01$ , \* $P < .05$ . ESS = Epworth Sleepiness Scale, MEQ = Morningness-Eveningness Questionnaire, PSQI = Pittsburgh Sleep Quality Index, WHOQOL-BREF = World Health Organization Quality of Life Questionnaire-abbreviated version.

**Table 3**—Linear regression models considering the change in the 4 WHOQOL-BREF domains (physical, psychological, social, and environmental) before and during the pandemic as dependent variables.

	Physical			Psychological			Social			Environmental		
	Coeff	Std. Error	P	Coeff	Std. Error	P	Coeff	Std. Error	P	Coeff	Std. Error	P
$\Delta$ PSQI	-1.40	0.66	.036	-0.62	0.49	.210	-0.94	0.99	.343	0.32	0.47	.492
$\Delta$ ESS	-0.84	0.27	.003	-0.57	0.27	.036	0.06	0.55	.913	-0.0	0.26	.987
Model			<.001			.064			.821			.403

Coeff = coefficient,  $\Delta$ ESS = change in the Epworth Sleepiness Scale before and during the pandemic,  $\Delta$ PSQI = change in the Pittsburgh Sleep Quality Index before and during the pandemic, Std. Error = standard error, WHOQOL-BREF = World Health Organization Quality of Life Questionnaire-abbreviated version.

addition, sleep quality improved significantly more among students who slept less than the average as compared with those who slept more than the average. Sleep duration before the pandemic was inversely associated with the change in sleep duration before and during the pandemic ( $r = -.534$ ,  $P < .001$ ).

**Table 5** shows differences in sleeping preferences, daytime sleepiness, quality of sleep, quality of life, and chronotype according to the chronotype classification estimated before the pandemic. Wake-up time was delayed more among evening chronotypes as compared with morning chronotypes. The MEQ decreased more among morning chronotypes as compared with evening chronotypes.

## DISCUSSION

In the present study we showed that school closure and home confinement during the COVID-19 pandemic significantly

impacted sleep behavior and quality of life in high school students. The major findings were as follows: (1) students delayed bedtime and wake-up time by 1.5 and 2.0 hours, respectively, during the pandemic; however, sleep duration increased and sleep quality improved only among students who were more sleep deprived before the pandemic; (2) social jet lag was reduced during the pandemic; (3) chronotype shifted toward eveningness; and (4) while the physical and psychological quality-of-life domains (WHOQOL-BREF) worsened during the pandemic, the environmental domain improved.

In the present study, students delayed bedtime by 1.5 hours during the pandemic as compared with 1 year previously. The natural tendency of later bedtime among adolescents as they get older is a potential explanation for this shift. The 2006 National Sleep Foundation poll showed that adolescents aged 16 years went to bed during weekdays only 19 minutes later than those aged 15 years.<sup>14</sup> Therefore, the abrupt delay of bedtime in a short time frame was most likely the result of a combination between the behavioral changes induced by the pandemic and

**Table 4**—Difference of study variables between the initial evaluation and during the pandemic according to the mean sleep duration (7.4 hours).

Difference	Sleep Duration < 7.4 Hours (n = 43)	Sleep Duration ≥ 7.4 Hours (n = 51)	P
Bedtime, h	1.0 (0.5–2.5)	1.5 (0.5–2.3)	.279
Sleep latency, min	0 (–5 to +10)	0 (–10 to +10)	.527
Wake-up time, h	2.2 (1.7–2.5)	2.0 (1.5–2.3)	.042
Sleep duration, h	0.5 ± 0.2	–0.4 ± 0.2	<.001
Social jet lag, h	–0.3 (–1.2 to +0.3)	–0.4 (–0.9 to +0.1)	.415
ESS	0 (–5 to +2)	1 (–2 to +3)	.257
PSQI	–0.3 ± 0.50	1.1 ± 0.4	.021
WHOQOL-BREF			
Physical	–3.0 ± 12.9	–7.5 ± 14.9	.123
Psychological	–5.4 ± 11.4	–8.4 ± 13.7	.263
Social	–2.4 ± 24.1	–1.7 ± 23.1	.892
Environmental	4.2 ± 12.2	1.9 ± 11.0	.351
MEQ	–2.3 ± 6.0	–3.3 ± 7.9	.507

Data are presented as means ± SDs or medians (25th–75th percentile). ESS = Epworth Sleepiness Scale, MEQ = Morningness-Eveningness Questionnaire, PSQI = Pittsburgh Sleep Quality Index, SDs = standard deviations, WHOQOL-BREF = World Health Organization Quality of Life Questionnaire-abbreviated version.

**Table 5**—Difference in study variables between the initial evaluation and during the pandemic according to baseline chronotype.

Difference	Morning (n = 13)	Intermediate (n = 66)	Evening (n = 15)	P
Bedtime, h	1.5 (0.5–2.5)	1.1 (0.5–2.0)	2.0 (0.5–3.0)	.165
Sleep latency, min	0 (–5.0 to +5.0)	–0.0 (–7.0 to +10.0)	0 (–10.0 to +10.0)	.998
Wake-up time, h	1.5 (1.5–2.0)	2.0 (1.5–2.5)	2.5 (2.0–3.0)*	.008
Sleep duration, h	–0.3 ± 1.1	–0.0 ± 1.2	0.4 ± 1.4	.284
Social jet lag, h	–0.1 (–0.4 to +0.2)	–0.5 (–1.1 to +0.1)	–0.9 (–1.1 to –0.3)	.253
ESS	–1.0 (–7.0 to +3.0)	0.0 (–2.0 to +3.5)	0.0 (–7.0 to +2.0)	.453
PSQI	–0.3 ± 2.4	0.6 ± 3.0	0.1 ± 3.2	.521
WHOQOL-BREF				
Physical	–0.3 ± 13.8	–6.2 ± 13.6	–6.4 ± 15.6	.370
Psychological	–0.9 ± 7.0	–8.5 ± 13.1	–5.7 ± 13.9	.134
Social	5.2 ± 20.1	–1.6 ± 24.3	–11.1 ± 20.8	.203
Environmental	6.6 ± 9.1	2.9 ± 12.1	0.4 ± 11.3	.368
MEQ	–6.0 ± 7.2	–3.1 ± 6.5	1.0 ± 7.9*	.027

Data are presented as means ± SDs or medians (25th–75th percentile). \* $P < .05$ , compared with the morning chronotype. ESS = Epworth Sleepiness Scale, MEQ = Morningness-Eveningness Questionnaire, PSQI = Pittsburgh Sleep Quality Index, SDs = standard deviations, WHOQOL-BREF = World Health Organization Quality of Life Questionnaire-abbreviated version.

lockdown and the natural tendency of adolescents to sleep late. Students reported an average sleep duration of 7.4 hours during the initial evaluation before the pandemic, which is lower than the 8 to 10 hours recommended for this age group.<sup>15</sup> During the initial evaluation, students also showed poor sleep quality, a social jet lag of 1 hour, and excessive daytime sleepiness. These findings suggest that the majority of students were sleep deprived and reflect adolescents' poor sleep habits resulting from a preference to sleep late, excessive electronic media use, and social activities.<sup>5</sup> Early school start time has been shown to restrict adolescents' sleep duration and increase the risk of

behavioral and emotional disturbances.<sup>16</sup> Delaying school time, as occurred during the pandemic, has been shown to increase sleep duration, daytime alertness, school attendance, academic performance, mental health, and well-being.<sup>17,18</sup> The COVID-19 pandemic put the world into a naturalistic experiment of multiple dimensions. School closure eliminated commuting and imposed online classes that started later than regular onsite classes. Added to home confinement, changes in school schedule allowed adolescents to modify their sleep schedule. We showed that high school students delayed their sleep habits during the pandemic compared with baseline. This finding is



consistent with previous observations among preschoolers,<sup>19</sup> university students,<sup>20</sup> and adults.<sup>21,22</sup> Previous studies assessing sleep behavior among participants other than teenagers reported longer sleep duration during the pandemic as compared with a previous period.<sup>19–22</sup> In the present study, sleep duration was unchanged during the pandemic as compared with the initial assessment before the pandemic. However, sleep duration during the initial assessment was inversely associated with the change in sleep duration. Students who slept less than the average at the initial assessment woke up later during the pandemic and reported increased sleep duration as compared with students who slept more than the average sleep duration. In addition, a reduction in the PSQI (improvement in sleep quality) was associated with an increased sleep duration. Sleep quality improved significantly more among students who slept less than the average at baseline as compared with those who slept more than the average. Taken together, home confinement and school closure delayed bed and wake-up time in concert with adolescent preferences. However, sleepiness and quality of sleep only improved among the more sleep-restricted students who were able to sleep longer during the pandemic.

Previous reports have shown worsening of quality of life among adults<sup>1</sup> and adolescents<sup>2</sup> during the COVID-19 pandemic. We add to these previous observations by showing that the change in quality of life has differed according to different domains. While we observed that the physical and psychological domains worsened, the environmental domain improved during the pandemic. The COVID-19 pandemic has brought conflicting experiences. The number of fatalities, fear of getting sick, changes in daily routine, lack of in-person contact with teachers and friends, lack of predictability of the consequences of the pandemic, family income reduction, and restriction of physical activity may have influenced the observed worsening in quality of life. In contrast, some aspects may have positively impacted quality of life during the pandemic, such as improved sleep time and quality of sleep, additional spare time spent at home, more time preparing meals and potential improvement in the quality of diet, more interaction with family members, and fewer academic duties. We showed that changes in sleepiness and quality of sleep before and during the pandemic were independent predictors of the change in the WHOQOL-BREF physical dimension, highlighting the impact of sleep quality and sleepiness on quality of life.

Most students were classified as intermediate chronotypes before the pandemic in the present study, which is in accordance with a previous observation.<sup>23</sup> Students classified as evening chronotypes before the pandemic delayed wake-up times more than morning chronotypes during the pandemic, as expected. Interestingly, the average MEQ score was reduced during the pandemic as compared with the baseline observation, suggesting a shift toward an evening chronotype. The reduction in the MEQ was significantly larger among morning as compared with evening chronotypes. These results corroborate the proposal that chronotype is a status, not a trait inherent to the individual. Although adolescents often delay their chronotype during ontogenesis, there are other factors that may influence chronotype.<sup>24</sup> The change in MEQ scores observed

during the pandemic as compared with before the pandemic was inversely associated with the PSQI and directly associated with the WHOQOL-BREF physical dimension, suggesting that a reduction in the MEQ (shift toward eveningness) was associated with poorer sleep quality and poorer quality of life.

The major limitation of the present study is that sleep behavior was not objectively determined but based on self-report. Our findings were consistent with previous observations among other age groups. In addition, some students did not answer all questionnaires. Each questionnaire was answered by at least 80% of the students. The inclusion of students from a single school limits the generalizability of the findings. However, the school serves families with a diverse background, which represents well the adolescent population of São Paulo. The major strength of the study is the opportunity to compare data obtained in 2019 and during the pandemic in the same group of students. Most previous studies assessing the impact of the COVID-19 pandemic reported data during the pandemic only.

In conclusion, the COVID-19 pandemic was associated with changes in sleep behavior among high school students, resulting in later bed and wake-up times, reduction in social jet lag, and a shift of chronotype toward eveningness. Sleep duration and quality of sleep changed only among those students with a shorter sleep duration at baseline. While the physical and psychological quality of life domains worsened, the environmental domain improved, highlighting the conflicting experiences that high school students are facing during the pandemic.

## ABBREVIATIONS

MEQ, Morningness-Eveningness Questionnaire

PSQI, Pittsburgh Sleep Quality Index

WHOQOL-BREF, World Health Organization Quality of Life Questionnaire-abbreviated version

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