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ORIGINAL RESEARCH

Association of Delayed Sleep/Wake Rhythm with Depression During the First COVID-19 Lockdown in France

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Purpose: The containment of the population during the COVID-19 pandemic led to the emergence or recurrence of psychiatric conditions and sleep disorders. The influence of sleep/wake rhythm on mental health is well known. The objective of our study was to evaluate the link between the shift in sleep/wake rhythm and the presence of depressive symptoms during the March to May 2020 lockdown in the French population.

Participants and Methods: Participants (n = 2513) were recruited via newspapers and social networks in March 2020. We evaluated i) the chronotype before and during the lockdown, assessed by the change in mid-sleep time on work-free days corrected for sleep debt on workdays (delta MSFsc); ii) morningness-eveningness circadian preference (Horne & Ostberg questionnaire); iii) depressive symptoms (Patient Health Questionnaire-9, PHQ-9). The delta MSFsc and the PHQ-9 score were compared between circadian preference types. A multivariate model adjusted for age, sex, circadian preference, housing type, and marital status was used to assess the influence of delta MSFsc on the PHQ-9 score in the whole population.

Results: The population consisted of 77% women, of median (IQR) age 39 (30–48) years. Compared with the pre-lockdown period, the median (IQR) MSFsc was shifted by 30 (0–66) min during the lockdown, with a significant difference between evening [60 (15–120) min], morning [15 (0–46) min] and neutral [30 (0–70) min] circadian type individuals, $p < 0.001$. One-third of all participants had moderate to severe depressive symptoms (PHQ-9 ≥ 10). A 1-hour shift in MSFsc was associated with a 0.50-point increase [95% CI (0.28; 0.72), $p < 0.001$] in the PHQ-9.

Conclusion: A phase delay in the chronotype was observed in the general population during lockdown. Such disruption was associated with depressive symptoms but the direction of the relationship remains hypothetical. The impact on mental health of preventive measures targeting the sleep/wake rhythm in this context needs further evaluation.

Keywords: phase delay, pandemic, containment, mental health, chronotype, circadian preference

Introduction

The COVID-19 pandemic emerged in late 2019 and spread fast across the world. The first cases were reported in China and subsequently in many other countries. A general population lockdown was declared on March 2020, 17th in France for a period of 2 months, aiming to reduce the number of cases and fatalities.[1] However, containment was identified as an anxiety-provoking period[2,3] due to various factors: isolation, boredom, lack of or overexposure to information, financial loss and fear of contamination.[4] Such anxiety was worsened by limited autonomy, professional difficulties, stigma, loss of reference points and changes in physical activity.[5]

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The first major national survey on psychological distress associated with lockdown in the general population was conducted in China.[6] It showed that the containment measures were responsible for depressive and anxious symptoms likely to promote the development or recurrence of psychological disorders.[6] In this study, nearly 35% of respondents reported experiencing psychological distress.[6] Subsequently, several studies and systematic reviews have confirmed these findings, with a prevalence of depression in the general population during the COVID-19 pandemic ranging from 28% (95% CI [0.17–0.38])[7] to 33.7% (95% CI [27.5–40.6]).[8]

In parallel, sleep disturbances associated with home confinement were reported in many countries.[9,10] In France, the prevalence of insomnia increased by almost 50% compared to 2017.[11] In the general population, rates of sleep disturbances reached 41% and proved to be more pronounced under lockdown conditions.[10] Although the determinism of sleep disturbances appears to be multifactorial, insomnia was particularly associated with anxiety and mood disorders including suicidal ideation, presumably with a bidirectional relationship.[9,12–15] Interestingly, changes in sleep-wake rhythm during confinement were one of the most prominent findings.[16] Several patterns were consistently reported, including delayed bedtime with or without delayed wake-up time, as well as a decrease in "social jetlag" defined by the difference between weekday and weekend sleep times (ie, the mismatch between social and biological time),[17] with an increase in sleep duration mitigated by a lower sleep quality.[18–21] These changes in sleep-wake rhythms observed in a large part of the population during the lockdown were attributed to the reduced exposure of individuals to environmental cues such as outdoor daylight and daily social and occupational constraints, which are the main drivers of biological rhythms, but also to high levels of stress and anxiety linked to the pandemic.[16,22–25]

Circadian rhythms, including their phase, amplitude and period, play a key role not only in the regulation of sleep but also in mental health and cognitive functions.[26,27] Some authors have shown that even a slight misalignment between the circadian phase and the timing of sleep period can disturb mood in healthy subjects.[28] An association between an evening chronotype and the risk of depression, anxiety, and problematic substance use was also reported.[29,30] The experimental advance shift of evening-type late timing with light exposure, behavioral measures and exercise leads to significant improvement in self-reported depression.[31] Such modulation of brain physiology by circadian rhythms was recently shown to be underpinned by changes in cortical excitability, which is enhanced and associated with improved cognitive performance at the preferred time of the day.[32] Interestingly, impaired cortical excitability and brain plasticity have also been reported in depression.[33]

Thus, the impact of lockdown on mood could be partly explained by sleep and circadian rhythm disturbances. However, it is not clear whether the changes in lifestyle and the decrease in schedule constraints, allowing individuals to bring their sleep-wake rhythm closer to their circadian preference, has a favorable or deleterious effect on mood. Whereas increased sleep problems and poorer mental health have been reported in evening-types during the pandemic, few studies have assessed the link between changes in sleep behavior (circadian rhythm shift, ie, change in chronotype) and depressive symptoms or negative emotions.[34–36] Only one recent survey study performed on 1011 students in Bangladesh showed that participants shifted their chronotype according to their circadian preference, and that a shift toward earlier sleep-wake timing was related to better moods and well-being.[35] We therefore aimed to extend these findings in the general population by exploring if delays in chronotype would be associated with lower mood and if this relationship would be modulated by circadian preference.

In this cross-sectional study based on questionnaires administered online in the general French population between April 2020 and June 2020 among 2609 participants, we investigated (i) the effect of changes in sleep-wake rhythms on depression symptoms during the containment and (ii) the factors modulating this relationship, including the demographic characteristics and the chronotype. We hypothesized that a greater shift in sleep-wake rhythm would be associated with an increased risk of depression, with a particular vulnerability of individuals with extreme circadian preference.

Materials and Methods

Study Procedure and Participants

We conducted a web-based self-reported cross-sectional questionnaire survey to collect data about sleep schedules and depressive symptoms. The questionnaire was built by psychiatrists and sleep physicians. The web-platform Framaforms was used to distribute the online-survey which was delivered in French language from April 2020, 9th to June 2020, 11th.

At the time of the survey's distribution, a strict lockdown had been imposed in France. The population was required to stay at home, and all non-essential activities were prohibited since March 2020, 17th.

To recruit a large number of participants, the survey was promoted via the Vinatier Hospital communication systems, social networking (Facebook, Twitter) as well as traditional media (local newspapers and radio programs). It took about 15 min to fill the questionnaire online and submit it. No monetary compensation was provided for participating in the study. Data were exported in xls format.

The study was approved by the Centre Hospitalier Le Vinatier Institutional Review Board and was conducted in accordance with the Declaration of Helsinki (protocol number: #2021.09.E01). All participants completed the survey anonymously and gave informed consent electronically before participating. General data protection regulations were applied to ensure privacy and confidentiality.

Questionnaires

Several dimensions were assessed in the questionnaires:

- Socio-demographic information: gender, age, cohabitation/marital status, employment status, children and their ages, housing (number of people in the dwelling, type and size of the dwelling, presence of an outdoor space).
- Medical data: psychiatric and non-psychiatric medical history and current treatments.
- Sleep patterns: work schedule before and during the containment, bedtime and wake-up time on weekdays and weekends before and during the containment, sleep duration, presence and duration of naps.
- Circadian preference: the Horne and Ostberg self-questionnaire[37] was used to determine the circadian preference of the participants. A total score above 70 indicates a "very morning" circadian type, a score between 59 and 69 a "rather morning" circadian type, a score between 42 and 58 a "neutral" circadian type, a score between 31 and 41 a "rather evening" circadian type and a total score below 30 a "very evening" circadian type.
- Symptoms of depression: the Patient Health Questionnaire (PHQ-9)[38] which is also a self-administered questionnaire was used to screen for the presence and severity of depression during the 2 last weeks. Its questions rate each of the 9 DSM-IV criteria for Major Depressive Disorder (MDD) (the core criteria for MDD have not changed in the DSM-V) from "0" (not at all) to "3" (almost every day). A total score of 5 to 9, 10 to 14, 15 to 19 and 20 to 27 indicates ? mild, moderate, moderately severe, and severe levels of depression, respectively. It has been shown that a score ≥10 has good sensitivity (0.88) and specificity (0.88) for screening for an MDD.[39] A contact link was also provided to the participants (emergency call number and hotline of the Centre Hospitalier Le Vinatier) that could be reached in case of psychological distress.

This was a one-off questionnaire performed during the lockdown, meaning that the sleep/wake schedule before the lockdown was assessed retrospectively and that the symptoms of depression were assessed once.

Midsleep Point

In order to assess the chronotype, we used the mid-sleep point, which is one of the most accurate behavioral markers of the circadian phase.[40,41] As sleep-wake schedules are constrained during workdays, the midsleep point is calculated on work-free days (MSF, MidSleep point on Free days), when the circadian system is under less pressure to adapt. However, most people accumulate a sleep debt during work days, which is compensated for on free days by waking-up later: this is the "social jetlag". This sleep debt during workdays inducing sleep compensation on free days leads to a later MSF.[42] In order to account for this confounding homeostatic factor, MSF corrected for sleep debt has been proposed (midsleep point on work-free days sleep debt corrected, MSFsc).[43] The MSFsc is calculated by subtracting from the MSF half of the difference between the average duration of sleep on work-free days (SDf) and the average duration of sleep over the whole week (SDw). This correction was only applied to participants who slept longer on rest days than on work days (SDf > SDw).[43]

Statistical Analysis

Continuous variables were presented as mean ± standard deviation (SD) or median (Q1-Q3) depending on their distribution and categorical variables as N and %. Circadian preference types were merged in 3 groups: morning (rather and quite morning time), neutral, and evening (rather and quite evening) types. The variation of MSFsc between pre- and per-lockdown periods and the PHQ-9 score were compared between the 3 circadian types with the Kruskal–Wallis test. A linear model with PHQ-9 score as dependent variable, and delta MSFsc, age, sex, housing type, cohabitation/marital status and circadian rhythm type as independent variables was used to assess the influence of delta MSFsc on the PHQ-9 score in the whole population. As our analysis was exploratory, we did not control for alpha risk inflation, so caution should be exercised in interpreting the significance level of the p-value, which was set at 0.05%.

Results

Among the 2609 participants who responded to the survey, 96 individuals were excluded. Reasons for exclusions were 1) age below 18 (n = 18 participants); 2) shift in MSFsc >4 hours (n = 78 participants) as expected changes in MSFsc were estimated to be around 30 minutes with a SD between 1:15 and 1:45.[44,45] This 4h value (>30 min + 2 SD) allowed to exclude outliers mainly due to misunderstandings (eg, we noticed that some participants had recorded bedtimes and wake-up times in 12-hour instead of 24-hour format), a table is provided with characteristics of these outliers (Supplementary Table 1); The final sample consisted of 2513 participants, among which 285 were excluded from the multivariate analysis because of missing data for the main outcome or at least one of the adjustment variables.

Characteristics of the Population

The population consisted of 77% women, of median (IQR) age 39 (30–48) years. Two-thirds of participants were employees with daytime working hours before the confinement and worked from home during the lockdown. The demographic characteristics of the population are presented Table 1. Most individuals had never been treated for a psychiatric condition (N = 1965, 78%). In participants with a current or past psychiatric medical condition, the most common disorder was depression (N = 391) (Table 2). The most common reported treatments were antidepressants (N = 202) and anxiolytics (N = 147). Data regarding medical past apart from psychiatric history are presented in Supplementary Table 2.

The circadian preference evaluation with the Horne & Ostberg questionnaire showed a neutral type in 1325 (53%), a morning type in 892 (35%) and an evening type in 296 (12%) participants. The distribution of PHQ-9 severity scores is shown in Table 3. One-third of the population had a PHQ-9 score ≥10 (N = 730, 33%). The median PHQ-9 score was 7 (4, 11) in the whole population, but significant differences were observed between circadian preference groups ($p < 0.001$). Evening type individuals rated higher on PHQ-9 scale (9.0 [6.0, 15.0]) than neutral (7.0 [4.0, 11.0], $p < 0.001$) and morning (6.0 [2.0, 9.0], $p < 0.001$) types.

Sleep Schedule During Lockdown

The average (SD) reported total sleep time in the whole population before confinement was 7h29 (1h17) on weekdays and 8h43 (1h33) on weekends or days off. During the lockdown, the total sleep time was 7h36 (1h55) on weekdays and 8h26 (1h55) on weekends. A reduction in the difference in sleep habits between weekdays and weekends was also observed for napping. Before the lockdown, 42% of the participants took naps (33% on weekends or days off and 9% every day or almost every day) compared to 36% during the lockdown (18% on weekends and days off and 18% every day or almost every day).

The median (Q1, Q3) MSFsc increased from 3:30:00 (3:00:00, 04:19:00) before the lockdown to 4:00:00 (3:17:00, 5:00:00) during the lockdown (Figure 1 and Supplementary Table 3). The median change in MSFsc was 30 minutes (0, 66), with a significant difference between participants according to the circadian preference ($p < 0.001$). Evening type individuals shifted the MSFsc more (60.0 [15.0, 120.0]) than neutral (30.0 [0.0, 70.0], $p < 0.001$) and morning (15.0 [0.0, 46.0], $p < 0.001$) types.

Table 1 Demographic Characteristics of the Participants

Variables	Participants (n = 2513)
Gender, n (%)	
Women	1937 (77%)
Age, median (Q1, Q3)	39 (30, 48) (N=2286)*
Familial situation	
Marital status, n (%)	
Single	664 (26%)
Unmarried cohabitation	481 (19%)
Civil union	326 (13%)
Married	815 (32%)
Divorced	201 (9%)
Widowed	26 (1%)
Children, n (%)	
No	1102 (44%)
Yes	1411 (56%)
Number of children, mean (SD)	1.13 (1.18)
Children < 18 years)	664 (26%)
Housing, n (%)	(N=2510)*
Flat	1477 (59%)
House	1027 (41%)
Other	6 (0.2%)
Median (Q1, Q3) size of dwelling in m^2	85 (62, 115) (N=2471)
Space outside the dwelling n (%)	(N=2510)*
No	624 (25%)
Yes	1886 (75%)
Profession, n (%)	
Student	206 (8%)
Employee	1679 (67%)
Retired	184 (7%)
No profession	37 (2%)
Looking for a job	108 (4%)
Invalid/disabled	35 (1%)
Self-employed	200 (8%)
Other	64 (3%)
Working hours before lockdown, n (%)	(N=1936)*
Daytime schedule	1671 (86%)
Night shift	27 (1%)
Irregular, alternating or shift work	238 (12%)
Working pattern during lockdown, n (%)	(N=2009)*
Time off	507 (26%)
Work on site	304 (16%)
Work on site + from home	182 (9%)
Exclusive work from home	943 (49%)

Notes: *Missing data, the number of participants is indicated. Note that percentages may not total 100 due to rounding.

Association Between Sleep Schedule and Depression During the Lockdown

The PHQ-9 score was significantly associated with sex, age, housing type, marital status, circadian preference and MSFsc shift; being a female, younger, living in an apartment (vs a house), being single, having a vesperal preference and showing a delay in MSFsc were associated with higher level of depression (Table 4). A multivariate analysis adjusted for

Table 2 Psychiatric Medical Past of the Participant

Follow-Up for a Psychiatric Condition or Addiction n (%)	(N=2511)*
No	1965 (78%)
Past	348 (14%)
Yes	198 (8%)
Depression n (%)	391 (16%)
Bipolar disorder n (%)	24 (1%)
Anxiety disorder n (%)	143 (6%)
Sleep disorder n (%)	104 (4%)
Psychotic disorder n (%)	8 (0.3%)
Post-Traumatic Stress Disorder n (%)	77 (3%)
Addiction n (%)	52 (2%)
Neurodevelopmental disorder n (%)	13 (0.5%)
Eating disorder n (%)	84 (3%)
Other n (%)	35 (1%)

Notes: Note that some participants had more than one present or past psychiatric condition *Missing data, the number of participants is indicated. Note that percentages may not total 100 due to rounding.

Table 3 Distribution of Phq-9 Scores Among Participants

Severity of Depression	
No depression	789 (31%)
Mild depression	894 (36%)
Moderate depression	495 (20%)
Moderately severe depression	222 (9%)
Severe depression	113 (5%)

Note: Note that percentages may not total 100 due to rounding.

sex, age, housing type, marital status and circadian preference showed that the shift in the MSFsc was associated with the PHQ-9 score (Table 5 and Figure 2). Including the presence of children aged up to 17 in the analysis did not improve the model (Supplementary Table 4). A one-hour increase in the MSFsc between pre- and per-lockdown was associated with a 0.50 [95% CI 0.28–0.72] increase in the PHQ-9 score ($p < 0.001$).

Discussion

In this cross-sectional study performed during the first lockdown in France in 2158 participants we found i) a delay in the chronotype of about 30 min as estimated by the MSFsc as well as a reduction in the difference in total sleep time between weekdays and weekends; ii) a high rate of moderate to severe depressive symptoms, reported in over a third of the population; iii) an association between the amplitude of the sleep-wake rhythm shift and depressive symptoms.

The 30-minute delay in MSFsc during the lockdown can be explained by a shift in bedtime and wake-up time along with a decrease in sleep debt during the week. These findings of a later and longer sleep during weekdays, thus reducing social jetlag, corroborate previous studies performed during the lockdown: Leone et al found a 36-minute delay in MSFsc in the Argentina's population[44] and Smit et al reported a 30-minute delay in sleep schedule in Canadian students.[45] Such change in sleep-wake rhythm during the week may be related to the fact that most participants of our study worked from

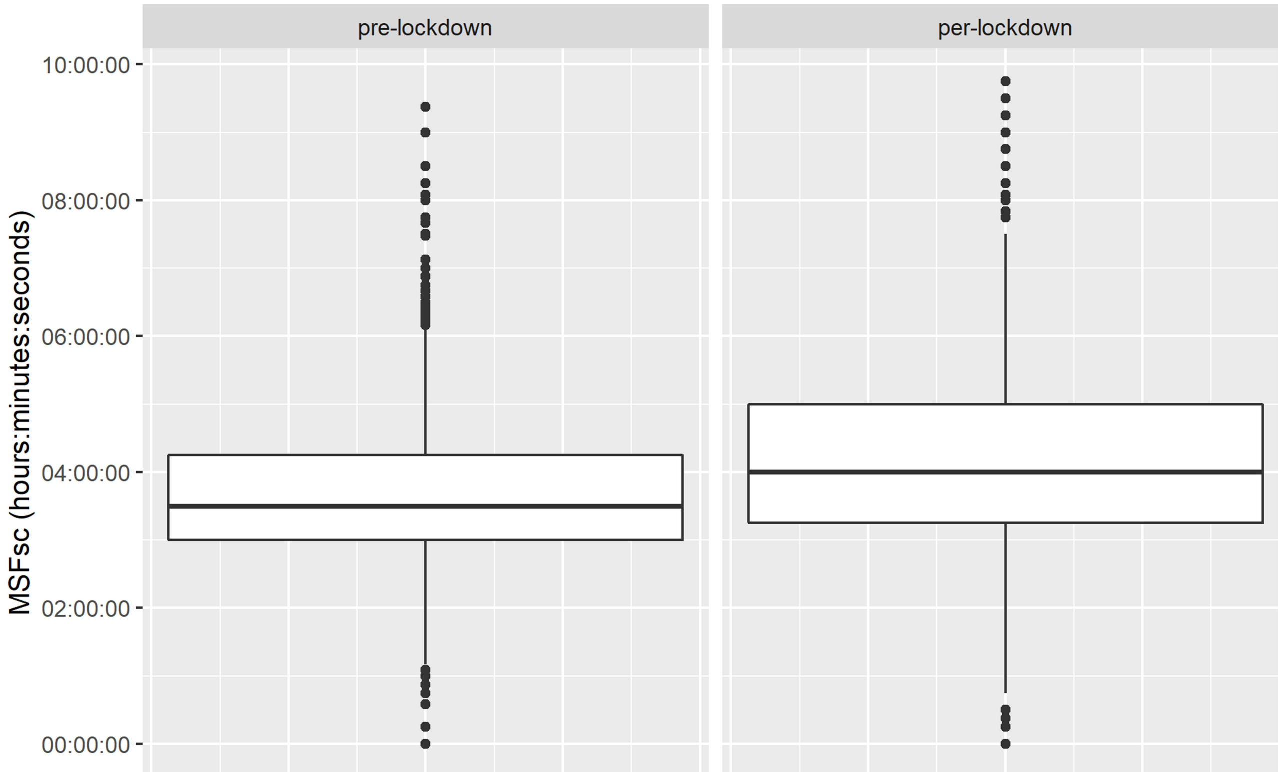

Figure 1 MSFsc change between pre- and per-lockdown. The median (Q1, Q3) MSFsc increased from 3:30:00 (3:00:00, 04:19:00) before the lockdown to 4:00:00 (03:17:00, 05:00:00) during the lockdown.

home during the lockdown, with more flexible schedules and a decrease in exposure to external synchronizers such as outdoor daylight and social constraints.[22] It may also result from the psychological distress linked to the pandemic.[24] In our study, although most participants had a neutral circadian preference according to the Horne & Ostberg questionnaire,

Table 4 Univariate Analysis of the PHQ-9 Score

Variable	Beta	95% CI[a]	p-value
Age	−0.09	−0.11, −0.07	<0.001
Gender			
Female	—	—	
Male	−1.3	−1.9, −0.81	<0.001
Change in MSF_(h)	0.81	0.60, 1.0	<0.001
Circadian preference			
Neutral	—	—	
Morning	−1.5	−2.0, −1.1	<0.001
Evening	2.6	1.9, 3.3	<0.001
Housing			
Apartment	—	—	
House	−1.0	−1.4, −0.55	<0.001
Marital status			
Single	—	—	
Cohabiting	−2.1	−2.7, −1.4	<0.001
Civil union	−2.6	−3.3, −1.8	<0.001
Married	−2.9	−3.5, −2.4	<0.001
Divorced	−1.2	−2.1, −0.32	0.007
Widowed	−2.9	−5.1, −0.75	0.008

Abbreviation: [a]CI, confidence interval.

Table 5 Multivariate Analysis of PHQ-9 Score

Variable	Beta	95% CI[a]	p-value
Age	−0.06	−0.08, −0.04	<0.001
Gender			
Female	—	—	
Male	−1.2	−1.7, −0.65	<0.001
Change in MSF_(h)	0.50	0.28, 0.72	<0.001
Circadian preference			
Neutral	—	—	
Morning	−1.0	−1.5, −0.48	<0.001
Evening	2.0	1.3, 2.7	<0.001
Housing			
Apartment	—	—	
House	−0.41	−0.88, 0.06	0.068
Marital status			
Single	—	—	
Cohabiting	−2.0	−2.6, −1.3	<0.001
Civil union	−1.9	−2.7, −1.2	<0.001
Married	−1.5	−2.1, −0.85	<0.001
Divorced	0.05	−0.88, 1.0	0.915
Widowed	0.03	−2.3, 2.4	>0.982

Abbreviation: [a]CI, confidence interval.

morning types (37%) were over-represented as compared to evening types (12%). This finding differs from the distribution of circadian preference in the general population, showing a slight overrepresentation of later types.[46] This can be explained by the characteristics of our population, which was mostly composed of females, with a median age of 39 years. Indeed, the circadian preference is related to age and gender, morning type being more frequent in older and female individuals.[46,47] It may also have resulted from the fact that almost one-fourth of the participants had a child younger than 18 years, given the association between childcare and earlier chronotype in women and men younger than 40 years.[48] Interestingly, "evening" subjects shifted their sleep more, presumably because they had the opportunity to align with their physiological rhythm in the absence of constraints, in line with previous studies on the topic.[34] It should be noted that the increase in sleep duration on workdays during confinement was modest, compared with previous studies in the field.[21,44] This may be related to country-specific habits or to the characteristics of our population, which included more women and few participants working exclusively at home.

A high rate of depressive symptoms was observed in our study. The proportion of moderate to severe depression, according to the PHQ-9, reached one-third of patients which is within the range of values reported in other studies.[7,8] The high level of psychological distress during the pandemic, and specifically the impact on mental well-being and mood of public health measures restraining daily life, was highlighted as early as 2020.[49] Several factors have been identified as contributing to mental health issues related to confinement, including demographic characteristics such as female gender and young age, as confirmed by our study.[50] We also showed that being single and living in an apartment (as opposed to a house, which is usually larger and more exposed to light) were associated with higher PHQ-9 scores. Bereavement, social isolation, uncertainty and socioeconomic distress, poor diet and low physical activity, as well as individual factors such as low resilience, were also reported to be involved in adverse mental health issues.[51–55] Interestingly, we found that individuals with late circadian preference seemed to be more vulnerable and scored higher on depression scale. This finding echoes the literature about eveningness impact on general health including mental diseases.[56,57] Recently, a multinational cross-sectional study conducted on 19,267 adults examined the potential role of circadian preference in explaining sleep and mental health outcomes during the first wave of the COVID-19 pandemic.[34] The investigators explored the circadian preference (assessed by a single question), as well as sleep-wake schedule and sleep quality before and during the pandemic, insomnia symptoms, anxiety (GAD-2), depression (PHQ-2), post-traumatic stress disorder

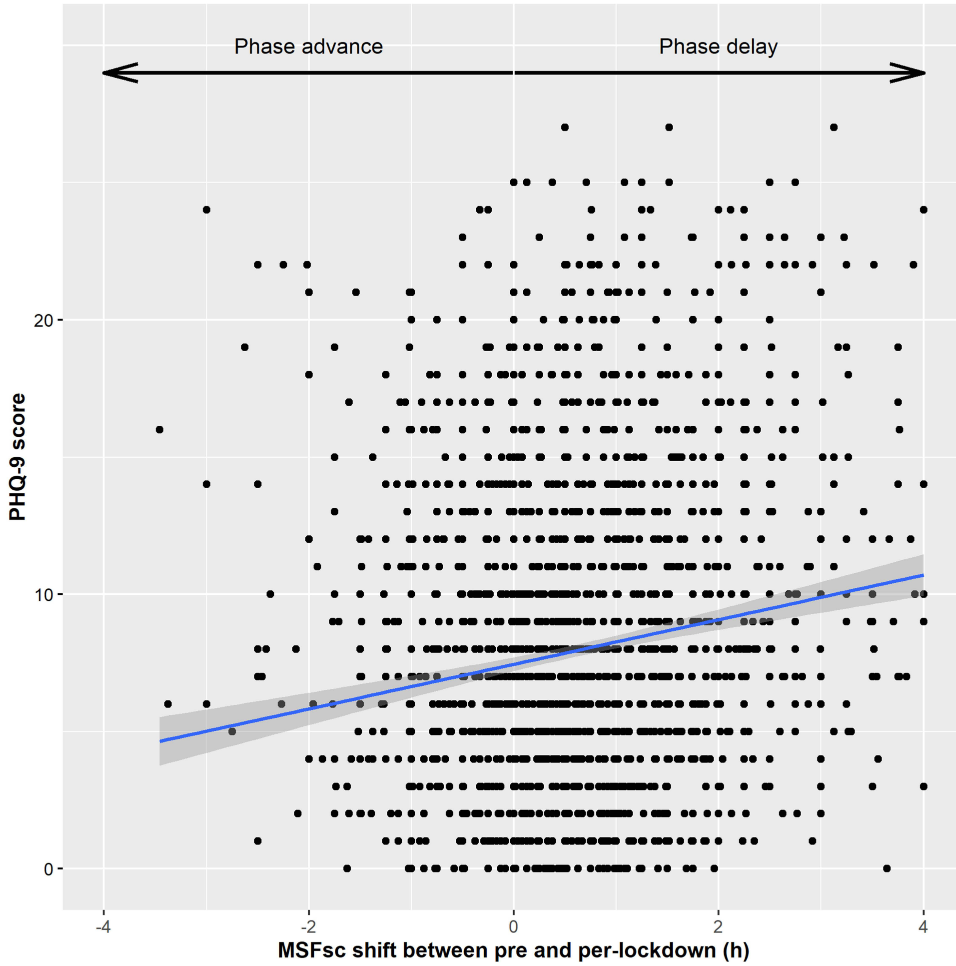

Figure 2 Correlation between change in MSFsc and depression symptoms. The depression severity score as assessed by the PHQ-9 scale is positively correlated with the change in MSFsc between pre- and per-lockdown period (expressed in hours, h). Note that a negative MSFsc shift indicates a phase advance and a positive MSFsc shift indicates a phase delay.

symptoms, stress and quality of life. They found poorer outcomes among evening types regarding employment, financial status, mental health status and quality of life. They also observed increased sleep duration, later midpoint of sleep and decreased sleep quality in these participants. These findings were moderated by socio-economic status and confinement. However, in this study, the relationship between circadian rhythm shift and mental health was not assessed.[34]

The main result of our study is that the shift in sleep schedule was associated with more severe depressive symptoms as assessed by the PHQ-9 score. Although this effect was quantitatively limited (0.5 points on the PHQ-9 scale for 1-hour MSFsc shift) and the risk of depression appeared to be multifactorial (age, gender, circadian preference, social environment), this relationship suggests that chronotype and mood are closely linked. To our knowledge, only one recent study performed on university students reported the association between change in sleep patterns and risk of depression according to the circadian preference in the context of population containment.[35] Our study is therefore an important step towards a better understanding of the impact of sleep-wake rhythms on the risk of depression when individuals are no longer exposed to the usual social environmental constraints. Our results may seem somewhat counter-intuitive. Indeed, social jetlag and sleep restriction during the week have been associated with negative health-related outcomes including metabolic and cardiovascular conditions, performances, and are also suspected to increase the risk of depression.[58] Thus, one may have expected that the decrease in social jetlag during the pandemic, linked to increased flexibility in sleep-wake schedules, might have alleviated sleep disturbances and mental health disorders especially in evening-type individuals. Our results can be interpreted in several ways. One can

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hypothesize that the depressive symptoms may have led to sleep-wake rhythm disruption as circadian misalignment has been reported for several biological rhythms in MDD.[27,59,60] Another explanation is that common underlying factors may explain both the depression and the shift in chronotype in the pandemic context (eg, unemployment or financial loss, which were reported to be more frequent during the pandemic in evening circadian types).[34] However, the change in chronotype itself may exert an impact on depression.[27] Such a relationship has been reported for shift work and social jetlag even if data in the latter case are less consistent.[61,62] Experimental data obtained in animal models by manipulation of the suprachiasmatic nucleus activity strongly support the negative effect of circadian rhythm disruption on depressive symptoms.[63,64] Mechanisms underlying the relationship between change in chronotype and depression may involve disturbances in cortical excitability and impaired synaptic plasticity.[32,33] Only longitudinal and interventional studies will allow to disentangle the respective influence of these different factors. Interestingly, preliminary studies suggest that keeping stable routine including physical exercise and regular sleep hours during home confinement may have a positive impact on mood, suggesting a causal link between sleep-wake schedule and mental health.[65]

One of the strengths of this study was its rapid implementation and its large sample size. Indeed, although the lockdown containment was a sudden decision, we managed to set up the study and disseminate the questionnaire quickly using the virtual snowball sampling technique.[66] We used Facebook because it is an effective approach for engaging the so-called "hard-to-reach" populations.[66] In addition, we combined the social network dissemination with the use of traditional media, in order to reach other populations, especially those who do not have access to the internet. This may have balanced the results as we know that social media can be particularly attractive to people in distress, looking for answers or support, which can create bias.[67]

We acknowledge several limitations to our work. First, its cross-sectional design allowed us to highlight possible links but prevented us from drawing conclusion about causality. Additionally, as in most studies performed in this context, it is not possible to rule out a memory bias in the retrospective estimation of the sleep-wake rhythm before confinement. Second, depressive symptoms were assessed only once at the time of confinement, and several other factors may have contributed to the depressed mood; some were included in our model, such as age, gender, and marital status, but others may also have modulated well-being and sleep-wake rhythms, such as screen exposure and time spent outdoors.[23,68] Third, it should be noted that our sample included a high proportion of middle-aged, employed women with a morning chronotype. As some of these characteristics may be related to better resources for coping with the pandemic, this may limit the generalizability of our results. Fourth, the use of self-report screening questionnaires without additional clinical assessment may have led us to overestimate the prevalence of the conditions explored.[69] Finally, previous work focusing on the evolution of psychological distress during infectious disease outbreak has shown that, although initial reactions were characterized by high levels of anxiety, these symptoms tended to decrease over the course of the pandemic.[70,71] Some studies suggest that the same findings may be observed for the COVID-19 pandemic.[72] The change in chronotype might also prove to be temporary and recoverable, reflecting the variability of restrictions imposed to the population as the pandemic develops. Further studies will be needed to assess the long-term effect of the population containments as well as the COVID-19 pandemic on mental health and sleep.

Conclusion

In a containment situation, a phase delay in the chronotype was observed in the general population. Such disruption is associated with depressive symptoms, with a greater vulnerability in people with an evening circadian preference. The mechanisms underlying this association are still hypothetical because depression can also influence the sleep/wake rhythm. The impact on mental health of preventive measures targeting the sleep/wake rhythm in this context should be further evaluated.

Disclosure

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