ARTICLE

Impact of COVID-19 lockdown on sleep-wake schedule and associated lifestyle related behavior: A national survey

Meenakshi Sinha, Babita Pande, Ramanjan Sinha

Department of Physiology, All India Institute of Medical Sciences, Raipur, India

Abstract

Background: Lockdowns to prevent the community transmission of COVID-19 pandemic has confined the people at home and imposed social restrictions, which is expected to cause alterations in circadian driven sleep-wake schedule and its associated lifestyle behaviors.

Design and Methods: An online questionnaire-based survey was conducted to assess the impact of lockdown on the sleep-wake pattern, meal timings and digital media exposure time on the Indian population during lockdown. Responses of 1511 participants (age ≥18 years) were analyzed to assess the effect of gender and age on these parameters before and during lockdown.

Results: The sleep onset-wakeup times and meals' time was significantly delayed during lockdown, which was more pronounced in younger subjects. However, young individuals reported increased sleep duration at this time. Increased digital media duration was evident in all age groups, mainly in males. However, females reported more delay in sleep onset-waking time and first meal timing with longer sleep duration during lockdown.

Conclusions: Discord with social and natural cues due to complete lockdown during COVID-19 pandemic leads to a state of social jetlag with delayed sleep-wake, meal timings and excessive digital media exposure among Indians, which has differential impact on males and females as well as across different age groups. These findings have applied implications in sleep health and related behavior during longer social isolation conditions such as current COVID-19 or similar situations and may help to prepare better for any such future events.

Introduction

Coronavirus disease (COVID-19) pandemic has affected almost all parts of the world. The lockdown imposed for its containment in many countries, including India, generates a situation similar to extended work free days, with partial social isolation. This situation allows individuals to choose their own preferred timing for sleep and wake just like free days, revealing their masked true inner circadian preference for sleep-wake schedule, meal timing and subjective alertness.

The internal/endogenous circadian system/rhythm adjust the human behavior, *e.g.* sleep-wake timings, physical activity, alertness level to fluctuate from peak to nadir in around 24 hr,[1] and also interact with the external environmental factors *i.e.,* sunlight[2] and social cues *i.e*., working hours, meal timing, exposure to artificial light through digital screen.[3] Earlier studies under complete or partial social isolation have revealed the true circadian nature of human in terms of sleep-wake behaviour.[4,5]

Staying at home during lockdown exposes people to extended artificial light or digital screens due to excessive use of virtual platforms in terms of TV, laptop, mobile etc. However, increased artificial light exposure is known to have adverse effect on sleep health, reducing its quality and increasing the day time sleepiness.[6,7] Alteration in melatonin hormone, the chronobiotic conveying information about night/dark and therefore sleep timing to the brain, is known to be maximally affected by the late-night artificial light exposure.[8] Besides, higher screen time is also correlated to reduced physical activity level that interferes with the sleep quality.[9] In addition, meal timing is known to act as a non-photic cue that entrains the circadian rhythm.[10]

In India, strict lockdown was imposed in three phases from March to June 2020 for the containment of the COVID-19 pandemic. At this juncture, we attempted to assess how derailment of social life due to imposed social isolation, leading to compromised sleep[11] in the present scenario affects circadian driven sleep-wake pattern and other lifestyle related behavior. So, we conducted a brief survey on Indian population in two major Indian languages, English and Hindi, to understand the possible alterations in sleep-wake schedules and the daily routine related activities such as meal timings and exposure time to digital media (*i.e.*, TV, laptop/computer/mobile, *etc.*) as a consequence of lockdown.

Significance for public health

In the background of ongoing COVID-19 pandemic, and increased incidences of domestic violence and unrest, this study reflects a significant influence of prolonged lockdown on some of the basic indicators of lifestyle such as sleep-wakefulness, timing of meals and usage of electronic media. Increased sleep duration in younger age groups with increased screen time and delayed meal time indicate their increased susceptibility to stress and its psychological consequences such as depression, thereby potentially affecting professional productivity and personal relationships. The senior age groups are also adversely affected in relation to these aspects, being increasingly susceptible to associated health risks. On the other hand, across genders, women exhibit greater disruption of their lifestyle behavior in terms of sleep-wake pattern and meal timings which might lead to hormonal imbalance related health conditions over long time. These findings hold vital potential to mitigate any such associated adverse effects.

Design and Methods

The study was purely a cross-sectional questionnaire-based survey conducted for the English and Hindi speaking population of India. The participants were recruited by sharing and circulating the URL links of Google Survey forms in English and Hindi language through social media platforms such as Gmail, WhatsApp and Facebook. Ethical approval was obtained from the institutional ethics committee prior to study. The participants provided informed consent through a statement as a part of survey questionnaire itself before proceeding to complete the survey. CHERRIES (PMID: 15471760; available at https://www.equator-network.org/) guidelines was followed for designing the web survey.

Questionnaire development and validation

We developed 30 relevant questions related to sleep-activity pattern and social wellbeing on the basis of available resources (Munich Chronotype Questionnaire; Morningness-eveningness questionnaire)[12,13] and general lifestyle, in English as well as in Hindi languages. After the validation of the questionnaire in both the languages following standard criteria, they were administered to the Indian population, who had undergone 37 days of lockdown till then. The responses to survey were collated from May 01 to May 07, 2020 (*i.e.* during the second phase of lockdown) for the present study.

It was a single blind study where identities of all the participants were kept completely confidential. It took about 5-10 min to fill the questionnaire online and submit it. A total of 1511 participants (Hindi: n=421 and English: n=1090) responded during this survey period. Subjects with existing sleep disorders, psychiatric diagnoses, subjects on psychotropic drugs or drugs having effect on sleep-wake cycle and pregnant women (as per their self-reporting through the questionnaire) were excluded. Our survey questionnaire also inquired if respondents were found COVID-19 (Corona) positive. As per response, none of them reported to be infected. All the participants included for the study were between 18 to 80 years of age, which were divided into seven study groups (Table 1), out of which 769 were females and 738 were males with 4 unidentified for gender.

Measures

From the 30 items of original questionnaire used, we selected 14 items related to sleep-wake schedule, major meal timings (first meal, lunch and last meal) and the duration of digital media exposure by laptop/desktop/mobile, *etc.* and watching TV before and during lockdown. The sleep duration was derived as a secondary variable from sleep onset-waking times. The internal consistency of the 14 selected items was evaluated using Cronbach's α, which shows moderate degree of reliability (α=0.68) and is acceptable.[14]

Statistical analysis

The data obtained from survey in English and Hindi speaking population of India were maintained in MS Excel and analysis was carried out using SPSS version 16 for windows and XLSTAT (annual version 2019.3.2). As the Kolmogorov-Smirnov test for normality exhibited deviation from normality, analysis for comparison within groups (before and during lockdown) was done using Wilcoxon Signed Rank test (for paired samples), while Mann-Whitney test was employed for between group comparison, *i.e.* between male and female. Also, we conducted *Chi*-square test to assess the association between different factors i.e. lockdown state vs time slots and Kruskal-Wallis test for effect of different age groups on studied parameters before lockdown and during lockdown. Thereafter, Post-hoc Duncan's Multiple Range Test was also carried out to compare the means of studied variables amongst age groups in each lockdown state. All statistical analyses were carried out at the significance level ≤0.05 and all the values were expressed as Mean±SE.

Results

The sleep onset time and wake-up time in the people, irrespective of age and gender, was significantly delayed with average sleep onset by 38±1.2 minutes and wake-up time by 51±1.2 minutes during lockdown as compared to before lockdown. Significantly higher number of people had sleep onset between 22:00 and 00:00 before lockdown but it extended even after 02:00 and 04:00 during lockdown (Figure 1A). Preferred time of wake-up in majority of people was from 06:00-08:00 in the morning before lockdown (Figure 1B) which extended to 06:00-10:00 during lockdown. The average sleep duration was also significantly more (Table 2) during lockdown with higher number of people reporting longer sleep length (Figure 1C). Though the number of people with sleep duration between 7 to 9 hours was more in both groups, the number of people having 10-12 h of sleep duration was also increased during lockdown (Figure 1C).

The average time for the first meal, lunch, and the last meal timings were significantly delayed by 58±0.6 min, 32±0.1 min and 15±0.1 min respectively during lockdown as compared to before lockdown (Table 2). Besides, majority of people took their first meal between 07:00 and 11:00 before lockdown which got extended to 13:00 during lockdown (Figure 1D). Similarly, the extent of lunch and last meal timings became wider (11:00 to 17:00 and 22:00 to 00:00 respectively) during lockdown compared to before lockdown (Figures 1E and 1F).

Also, the average digital media screen time on mobile, laptop *etc.* and television watching was significantly increased (Table 2) during lockdown as compared to before lockdown (from 2-4 h to <10 h and from 1 h to <5 h respectively) (Figures 1G and 1H).

Overall, *Chi*-square test revealed significant ($P<0.001$) association for all the parameters between different time slots and lockdown states, *i.e.* status of lockdown had significant interaction with the time of day (Figures 1A-1H, values shown in each panel of figures) showing alteration in the extent of duration of studied variables.

Table 1. Age and gender wise distribution of participants.

Age	Gender			
	Female	Male	Unidentified gender	Total (n)
18-24 y	457	339	-	796
25-31 y	89	124	-	213
32-38 y	68	90	-	158
39-45 y	50	57	-	107
46-52 y	53	48	-	101
53-59 y	29	41	-	70
≥60 y	17	37	-	54
Unidentified age	06	02	04	12
Total (n)	769	738	04	1511

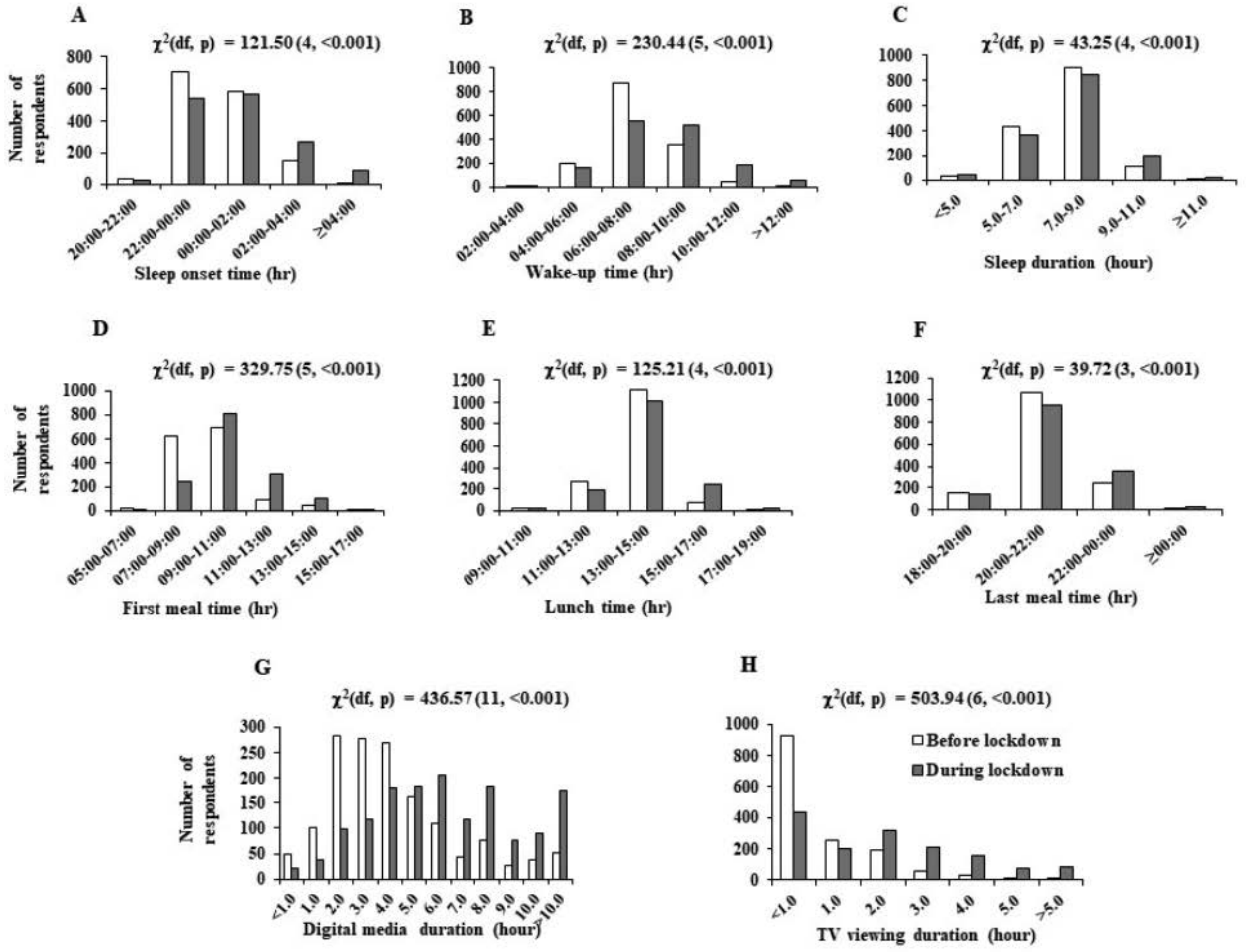

Figure 1. Distribution of number of respondents across different time slots before and during lockdown. Extended sleep onset time beyond 04:00 h (A) and waking time beyond 12:00 h (B) with reduced sleep duration in most of the respondents, though not marked (C), was evident during lockdown. Late first meal time till 15:00 h (D), lunch time till 17:00 h (E) and last meal time till 24:00 h (F) was present during lockdown. Increased duration of digital media even beyond 10 h (G) and TV viewing duration for more than 5 h was seen for majority of subjects (H) during lockdown. Chi-square result shown in each panel depicts significant (p<0.001) association/interaction between different time slots and studied variables in relation to lockdown states.

Table 2. Comparison of different study variables before and during lockdown.

Variables	Mean ± SE		Mean ranks (n)			Wilcoxon Signed Ranks Test
	Before lockdown	During lockdown	Negative*	Positive°	Ties# (n)	Z(p) [Total n]
Sleep onset time (hr)	23:49 ± 0:02	00:28 ± 0:03	488.57 (254)	532.11 (788)	442	-15.27 (<0.001) [1484]
Wake-up time (hr)	06:59 ± 0:02	07:50 ± 0:03	419.07 (216)	570.27 (863)	397	-19.68 (<0.001) [1476]
Sleep duration (hour)	7:11 ± 0:02	7:23 ± 0:02	486.72 (439)	540.21(595)	441	-5.64 (<0.001) [1475]
First meal time (hr)	09:03± 0:02	10:01 ± 0:02	498.18 (200)	595.30 (956)	329	-20.75 (<0.001) [1485]
Lunch time (hr)	13:13 ± 0:02	13:45 ± 0:02	473.07 (268)	557.64 (804)	412	-15.96(<0.001) [1484]
Last meal time (hr)	20:47 ± 0:02	21:02 ± 0:02	440.08 (300)	459.41 (605)	572	-9.37 (<0.001) [1477]
Digital media duration (hour)	4:08 ± 0:04	6:14 ± 0:04	529.47 (133)	656.65 (1153)	202	-25.90 (<0.001) [1488]
TV viewing duration (hour)	1:01 ± 0:01	2:13 ± 0:03	284.41 (41)	479.50 (900)	538	-25.24 (<0.001) [1479]

*During lockdown < before lockdown; °During lockdown > before lockdown; #During lockdown = before lockdown; Z (based on negative ranks). hr, 24-hour format.

Gender difference

As compared to males, females reported significant delay in sleep onset time, wake-up time and sleep duration during lockdown (Table 3). Also, first meal and lunch time was later in females compared to male during lockdown. Last meal time was significantly earlier in females before lockdown but became same as that of males during lockdown (Table 3). Digital media time (on mobile/laptop, *etc*.) was significantly higher in male compared to female both before and during lockdown. However, significantly longer duration of television viewing was reported in males before lockdown, but during lockdown females had more duration of TV watching (Table 3).

Effect of age

Change in age showed significant association with the outcome of all the parameters both before and during lockdown as revealed by Kruskal-Wallis test, except lunch time during lockdown (Table 4). Post hoc analysis showed that before lockdown, only younger people (18-24 years old) were going to sleep significantly later, *i.e.* after midnight, followed by age groups 25-31 and 32-38 years old, while rest of the age groups showed early sleep timings (before or around 11:00). However, during lockdown, significantly delayed sleep onset time was observed in all the age groups (Figure 2A). Wake-up time, before lockdown, was earliest ($p<0.05$) in people above 46-years of age groups (*i.e.* around or before 06:00), followed by later waking time in 39-45 and 32-45 years old age groups. The younger age groups (25-31 and 18-24 years old) had significantly latest wake-up time (after 7:00) before lockdown. But, during lockdown, the wake-up time was seen to be significantly delayed in all the age groups except for ≥60 years old group people. The youngest age group (18-24 years old) reported significantly most delayed wake-up time (after 8:00) compared to other age groups during lockdown (Figure 2B). Before lockdown, significantly longer sleep duration was observed in 25-31 and 32-38 years old age group, followed by 39-45, 46-52, 53-59, ≥60 years old age groups. But, 18-24 years old age group had significantly shortest sleep duration before lockdown (Figure 2C). However, during lockdown, significantly longer sleep duration was observed in 18-24 years old from their pre-lockdown state, whereas, marked reduction in sleep duration was reported in 32-38, 39-45, and ≥60 years old subjects, though statistically not significant (Figure 2C).

The effect of age on meal timings (first and last meals) was significant both before and during lockdown. However, age did not show effect on the lunch time during lockdown (Table 4). The first meal before lockdown was significantly earlier in all age groups (before and around 21:00) except for ≥60 years old group with the youngest age group (18-31 years old) having latest first meal (after 22:00) during lockdown (Figure 2A). Lunch time before lockdown was significantly earlier in age group 18-24 years old (around 13:00) and later in 25-31 years old. A delay in lunch timing was observed during lockdown; however, the difference as function of age was not significant (Figure 2E). The difference in lunch time before and during lockdown differed significantly within all age groups except for 53-59 and ≥60 years old with increased number of people having late lunch timings during lockdown. Age had a significant effect on the last meal timings also both before and during lockdown (Table 4). The last meal time during lockdown was significantly delayed in all the age group people except for 46-52 and ≥60 years old (Figure 2F).

The duration of digital media time in terms of use of mobile, laptop *etc*. and viewing television also significantly differed as function of age both before and during lockdown (Table 4). The screen time was significantly longer in younger age groups (18-38 years old), which showed a decreasing trend with advancing age and ≥60 years old people reported lowest screen time both before and during lockdown as revealed by post-hoc test. In all age groups, the mean digital media time increased significantly during lockdown (Figure 2G). Younger age group (18-24 years old) however, spent least time (average <1 h watching television before lockdown; $p<0.05$) compared to other age groups, while older people (≥60 years old) spent more time. The duration of television viewing increased significantly during lockdown in all age groups (Figure 2H), by about 2 h in young age and 3 h in older people.

Discussion

The present study is an attempt to assess the impact of imposed lockdown on account of COVID-19 pandemic on sleep-wake

Table 3. Gender related comparison of different study variables before and during lockdown.

Variables	Lock-down status	Mean ± SE/Mean rank (n)		Mann-Whitney test	
		Female	Male	Mann-Whitney U	Z(p)
Sleep onset time (hr)	Before	23:47 ± 0:03/731.78 (747)	23:50 ± 0:03/740.35 (724)	267265.0	-0.39 (0.70)
	During	00:32 ± 0:04 /758.52 (747)	00:38 ± 0:04/712.77 (724)	253593.5	-2.08 (0.04)
Wake-up time (hr)	Before	06:58 ± 0:03/730.77 (747)	07:01 ± 0:03/741.40 (724)	266504.0	-0.49 (0.63)
	During	08:00 ± 0:04/773.43 (747)	07:40 ± 0:04/697.38 (724)	242454.0	-3.45 (0.001)
Sleep duration (hour)	Before	7:11 ± 0:02/739.72 (747)	7:10 ± 0:02 /732.16 (724)	267635.0	-0.35 (0.73)
	During	7:29 ± 0:03/764.56 (747)	7:17 ± 0:03/706.54 (724)	249082.0	-2.64 (0.008)
First meal time (hr)	Before	09:01 ± 0:03/731.32 (759)	09:05 ± 0:03/751.17 (722)	266655.5	-0.90 (0.37)
	During	10:09 ± 0:04/779.17 (759)	09:53 ± 0:04 /700.88 (722)	245030.0	-3.55 (<0.001)
Lunch time (hr)	Before	13:13 ± 0:02/732.88 (759)	13:12 ± 0:02/748.52 (721)	267835.0	-0.73 (0.47)
	During	13:49 ± 0:02/759.86 (759)	13:41 ± 0:03/720.12 (721)	258925.0	-1.81 (0.07)
Last meal time (hr)	Before	20:42 ± 0:02/696.47(753)	20:53 ± 0:02 /779.39 (720)	240559.0	-3.80 (<0.001)
	During	21:02 ± 0:02/ 735.29 (753)	21:03 ± 0:02/ 738.78 (720)	269795.5	-0.16 (0.87)
Digital media duration (hour)	Before	3:55 ± 0:05/710.11 (756)	4:23 ± 0:06/776.13 (728)	250700.5	-3.00 (0.003)
	During	5:58 ± 0:06/705.41 (756)	6:31 ± 0:07/781.02 (728)	247145.0	-3.42 (0.001)
TV viewing duration (hour)	Before	0:58 ± 0:02/705.28 (752)	1:03 ± 0:02/772.04 (723)	247239.0	-3.49 (<0.001)
	During	2:10 ± 0:04 /728.45 (752)	2:16 ± 0:04/747.93 (723)	264669.5	-0.90 (0.37)

hr, 24-hour format.

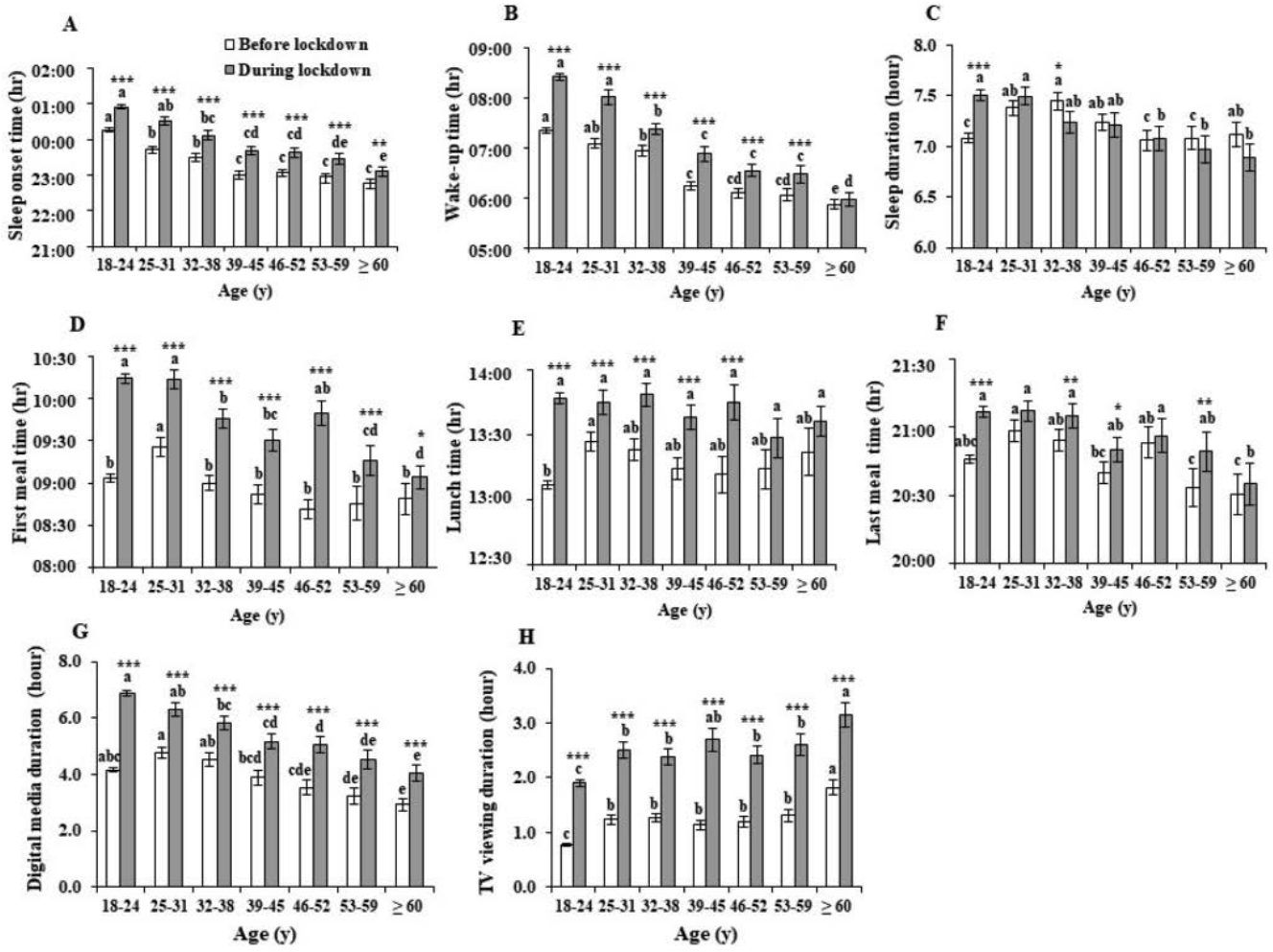

Figure 2. Comparison of effects of before and during lockdown for different age groups. Significantly delayed sleep onset time in all age groups (A), waking time in all age groups except ≥60 y people (B) and increased sleep duration in age groups of 18-24 and 32-38 y (C) was observed during lockdown. Significantly late first meal time in all age groups (D), lunch time in all age groups except 53-59 y and ≥60 y people (E) and last meal time in all age groups except ≥60 y individuals (F) was evident during lockdown. Digital media duration (G) and TV viewing duration (Figure 2H) also was found to be significantly more during lockdown in all age groups. *p<0.05; **p<0.01; ***p<0.001. Values are expressed as Mean±SE.

Post-hoc analysis at the level of p<0.05 denotes the significance of difference in mean change of studied variables across different age groups both before and during lockdown. Highest to lowest mean indicated by 'a' to 'e' alphabets, where, same alphabet denotes non-significant difference among age groups.

Table 4. Summary of Kruskal-Wallis test for the effect of age on different study variables before and during lockdown.

Variables	*Chi*-Square value (df, p, n)	
	Before lockdown	During lockdown
Sleep onset time (hr)	244.00 (6, <0.001, 1473)	154.98 (6, <0.001, 1473)
Wake-up time (hr)	258.55 (6, <0.001, 1466)	282.82 (6, <0.001, 1466)
Sleep duration (hour)	23.61 (6, 0.001, 1465)	40.18 (6, <0.001, 1465)
First meal time (hr)	33.51 (6, <0.001, 1475)	71.76 (6, <0.001, 1475)
Lunch time (hr)	54.41 (6, <0.001, 1474)	8.81 (6, 0.18, 1474)
Last meal time (hr)	22.90 (6, 0.001, 1468)	15.83 (6, 0.02, 1468)
Digital media duration (hour)	48.63 (6, <0.001, 1477)	131.76 (6, <0.001, 1477)
TV viewing duration (hour)	220.21 (6, <0.001, 1469)	69.46 (6, <0.001, 1469)

hr, 24-hour format.

behavior, meal timings and digital media exposure time on Indian population and also to explore the same as function of gender and age. The principal findings clearly point out that social distancing and stay at home restriction due to lockdown has significantly altered all the above-mentioned parameters.

Our survey reveals delayed sleep onset and delayed wake-up time in majority of people during lockdown which was similar to studies comparing work free days/holidays versus work days wherein sleep-wake up times on weekends was seen to be delayed than weekdays.[15] This behavior has been attributed as a mean to compensate the accumulated sleep debt during working days.[15] However, only young age group (18-24 years old) subjects of our study showed longer sleep duration during lockdown as they also reported minimum duration of sleep before lockdown. This confirmed the fact that they compensated their sleep deficit during lockdown. Furthermore, people were away from social entrainment, a potential cue of working society, which forces them to sleep and wake-up on time, resulting in the delayed and self-chosen sleep-wake timings.[3] The present survey was conducted after about 5 weeks of lockdown, which of course was a long duration of deficient exposure of the individuals to the natural sunlight, the most robust body clock (circadian) entrainer/synchronizer which adjust the sleep-wake times to sunrise and sunset timings.[2] Therefore, lack of social and natural light entrainment could be additional reasons for delayed sleep-wake in all age groups.[4,7] However, it should be emphasized here that the sleep duration rather showed reduction (though non-significant) in all other age group subjects except for the younger two groups (*i.e.* 18-31 years old) who are known victims of modern lifestyle related sleep deficits.[16] Late sleep onset and wake-up time of younger age group affirms the evening chronotype of young age group and higher use of light emitting electronic devices.[16] But it may be pointed out here that the sleep duration was not adversely affected during lockdown and people got enough sleep of recommended duration (≥7 h).[17] Latest reports of Blume *et al.*[18] from Europe and Wright *et al.*[19] from USA during the present COVID-19 lockdown has also documented for increased sleep duration due to decrease in work pressure and social jetlag. Average sleep onset and wake-up time in female was later than male in our study during lockdown compared to before lockdown. This result was contrary to the reports suggesting females to be more of morning chronotype and have early melatonin onset compared to males under normal conditions.[20,21] A possible explanation for such finding might be the late night use of light emitting portable electronic devices that suppresses or delays the melatonin onset in females.[16] Significantly more digital time was reported by the females in our survey which was also more in younger age group subjects. However, in contrast to the earlier reports under normal condition that claimed females suffering from sleep disturbances the most,[22,23] we found that during lockdown, sleep duration was more in females. However, all the subjects in our study showed delayed sleep onset and wake-up time during lockdown irrespectively of age and gender which is comparable to a state of *social jetlag*, *i.e.* discrepancy in the sleep timings on the free days in relation to working days[3]. This therefore, was clearly indicative of a state of disturbed sleep-wake rhythm pattern in the subjects. The early sleep and wake-up times and shorter sleep duration in older age groups compared to younger people both before and during lockdown conditions suggest that the age-related alteration in sleep-wake behavior persist during lockdown.[23] The evening chronotype behavior, seen mostly in younger age group people, is also known to shift towards morning preferences with aging[22] which was quite evident in the age-related changes in our study both before and during lockdown.

Our study shows significant delay in the major meal timing *viz*. first meal, lunch and the last meal/dinner during lockdown. An earlier study from north India had reported 06:58 and 22:45 as median of the first and last meal.[24] However, we report later median time for first meal (09:00 to 10:00) and earlier (21:00) for the last meal, irrespective of lockdown status amongst the survey population of India. The current survey encompasses data from many parts of the India including urban as well as rural areas which might be the reason for this difference. The delayed first meal timing in female during lockdown could be reasoned as the delayed awakening that cause late hours distribution of energy and macro nutrients thereby influencing the next meal time.[25,26] Further, this delay in first meal as well as lunch time in females could be accounted to the fact that generally on account of cultural norms, Indian females eat later than other family members. Earlier sleep and wake timing in older age group coincides with earlier first and the last meals during lockdown compared to younger subjects who preferred late hours. But significant delay in all the meal timings during lockdown was quite evident in our study, suggesting thereby a state of altered/disturbed pattern of feeding behavior. Meal timing is also known to act as a non-photic cue that entrains the circadian rhythm,[10] thus in turn the delayed meal timing could also have influenced the sleep-wake schedule. Increased digital/online media, *e.g.* mobile, laptop, television, *etc.,* during lockdown quite obviously points towards the fact that these modes were the only platforms for social connections, working platform and source of entertainment and information/study during lockdown. In fact, increased screen time exposure, specially before bed time, might be the reason for the delayed sleep onset and wake-up time as artificial light exposure is known to hinder the sleep-wake cycle through disruption of melatonin mediated circadian sleep-wake behaviour.[21] Moreover, increased screen time leads to lower physical activity and thus low energy expenditure could be delaying the meal times and altering the sleep-wake rhythm.[9,27,28] In this context, a recent survey in Italian young age group individuals has also reported similar trend of delayed sleep-wake timings, time in bed and increase digital use during lockdown.[29]

Conclusions

With the outbreak of COVID-19 pandemic, there have been various reports from different part of world[18,19,29] assessing impact of lockdown on the social and personal profile of people. However, to the best of our knowledge, present study is the first scientific report for Indian population assessing the impact of COVID-19 lockdown on sleep-wake profile and associated social behavior with insight towards gender difference as well effect of age which has not yet been reported. Other strengths of the study are a) fairly large sample size compared to other reports during the present lockdown and b) collection of data after 37 days of complete lockdown which is a good span of time to quantify the effects of lockdown. Our study concludes that lockdown has reduced the masking effects of societal and natural timing and unveiled individual's circadian preference through altered sleep-wake, meal time and digital media exposure pattern. This opens path for further investigation of association of sleep-wake and lifestyle behavior during longer social isolation, *e.g.* extended COVID-19 lockdown or similar crisis situations.

However, one limitation of the current study is that majority of respondents were from young age group, thus skewing the data while comparing with other age group people. Also, inclusion of potentially susceptible group to behavioral changes, *i.e.* adolescents, could have provided further information.

Correspondence: Dr. Babita Pande, Post Doctoral Fellow, Department of Physiology, All India Institute of Medical Sciences, Raipur 492099, Chhattisgarh, India.
Tel. +91-1793-57829.
E-mail: babitatime14@gmail.com

Key words: COVID-19 lockdown; sleep

Contributions: MS, concept and design, analysis and interpretation of data, drafting and revision of manuscript, final approval; BP, analysis and interpretation of data, drafting and revision of manuscript, final approval; RS, concept and design, critical revision of manuscript, final approval.

Conflicts of interest: None of the authors have any conflicts of interest.

Ethical approval: The study was approved by the Institute Ethics Committee of All India Institute of Medical Sciences, Raipur, Chhattisgarh, India. The participants provided informed consent through a statement as a part of survey questionnaire itself before proceeding to complete the survey.

Acknowledgements: We acknowledge all the volunteers who participated in the online survey to make this study possible.

Funding: None.

Availability of data and material: Data will be available on request.

Received for publication: 22 June 2020.
Accepted for publication: 8 July 2020.

Journal of Public Health Research 2020;9:1826
doi:10.4081/jphr.2020.1826

References

1. Borbély AA, Daan S, Wirz-justice A, Deboer T. The two-process model of sleep regulation: a reappraisal. J Sleep Res 2016;25:131-43.
2. Roenneberg T, Kumar CJ, Merrow M. The human circadian clock entrains to sun time. Curr Biol 2007;17:R44-5.
3. Wittmann M, Dinich J, Merrow M, Roenneberg T. Social jetlag: misalignment of biological and social time. Chronobiol Int 2006;23:497-509.
4. Chandrashekaran MK, Marimuthu G, Subbaraj R, et al. Direct correlation between the circadian sleep-wakefulness rhythm and time estimation in humans under social and temporal isolation. J Biosci 1991;16:97-101.
5. Pande B, Parganiha A, Patra P, Pati AK. Short-duration judgment in young Indian subjects under 30 h constant wakefulness. Indian J Exp Biol 2014;52:559-68.
6. Nag C, Pradhan RK. Impact of television on sleep habits. Biol Rhythm Res 2011;43:423–30.
7. Nuutinen T, Ray C, Roos E. Do computer use, TV viewing, and the presence of the media in the bedroom predict school-aged children's sleep habits in a longitudinal study? BMC Public Health 2013;13:684.
8. Kozaki T, Kubokawa A, Taketomi R. et al. Effects of day-time exposure to different light intensities on light-induced melatonin suppression at night. J Physiol Anthropol 2015;34:27.
9. Štefan L, Horvatin M, Baić M. Are sedentary behaviors associated with sleep duration? a cross-sectional case from Croatia. Int J Environ Res Public Health 2019;16:200.
10. Wehrens SMT, Christou S, Isherwood C, et al. Meal timing regulates the human circadian system. Curr Biol 2017; 27:1768-75.e3.
11. Roenneberg T, Allebrandt KV, Merrow M, Vetter C. Social jetlag and obesity. Curr Biol 2012; 22:939-43.
12. Kantermann T, Juda M, Merrow M, Roenneberg T. The human circadian clock's seasonal adjustment is disrupted by daylight saving time. Curr Biol 2007;17:1996-2000.
13. Horne JA, Östberg O. A self-assessment questionnaire to determine morningness–eveningness in human circadian rhythms. Int J Chronobiol 1976;4:97-110.
14. Hinton PR, Brownlow C, McMurray I, Cozens B. SPSS explained. 1st ed. London: Routledge; 2004.
15. Roenneberg T, Wirz-Justice A, Merrow M. Life between clocks: daily temporal patterns of human chronotypes. J Biol Rhythms 2003;18:80-90.
16. Chang AM, Aeschbach D, Duffy JF, Czeisler CA. Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. Proc Natl Acad Sci USA 2015;112:1232-7.
17. Hirshkowitz M, Whiton K, Albert SM, et al. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. Sleep Health 2015;1:40-3.
18. Blume C, Schmidt MH, Cajochen C. Effects of the COVID-19 lockdown on human sleep and rest-activity rhythms. Curr Biol 2020; doi: https://doi.org/10.1016/j.cub.2020.06.021.
19. Wright Jr KP, Linton SK, Withrow D, et al. Sleep in university students prior to and during COVID-19 stay-at-home orders, Curr Biol 2020; doi: https://doi.org/10.1016/j.cub.2020. 06.022.
20. Adan A, Natale V. Gender differences in morningness–eveningness preference. Chronobiol Int 2002;19:709–20.
21. Cain SW, Dennison CF, Zeitzer JM, et al. Sex differences in phase angle of entrainment and melatonin amplitude in humans. J Biol Rhythms 2010;25: 288-96.
22. Park YM, Matsumoto K, Shinkoda H, et al.Age and gender difference in habitual sleep-wake rhythm. Psychiatry Clin Neurosci 2001;55:201-2.
23. Åkerstedt T, Lekander M, Nilsonne G, et al. Effects of late-night short-sleep on in-home polysomnography: relation to adult age and sex. J Sleep Res. 2018;27:e12626. doi:10.1111/jsr.12626.
24. Gupta NJ, Kumar V, Panda S. A camera-phone based study reveals erratic eating pattern and disrupted daily eating fasting cycle among adults in India. PLoS One 12: e0172852. doi:10.1371/journal.pone.0172852.
25. Almoosawi S, Vingeliene S, Gachon F, et al. Chronotype: implications for epidemiologic studies on chrono-nutrition and cardiometabolic health. Adv Nutr 2019;10:30-42.
26. Meule A, Roeser K, Randler C, Kübler A. Skipping breakfast: morningness-eveningness preference is differentially related to state and trait food cravings. Eat Weight Disord 2012;17:e304–8.
27. Yamanaka Y, Honma K, Hashimoto S, et al. Effects of physical exercise on human circadian rhythms. Sleep Biol rhythms 2006;4:199-206.
28. Chung N, Bin YS, Cistulli PA, Chow CM. Does the proximity of meals to bedtime influence the sleep of young adults? A cross-sectional survey of University students. Int J Environ Res Public Health 2020;17:2677.doi:10.3390/ijerph17082677.
29. Cellini N, Canale N, Mioni G, Costa S. Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. J Sleep Res 2020;00:e13074. doi:10.1111/jsr.13074.