Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Personality and Individual Differences 191 (2022) 111581

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

Morningness-eveningness preference and shift in chronotype during COVID-19 as predictors of mood and well-being in university students

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ARTICLE INFO

Keywords:
Chronotype
COVID-19
Morningness-eveningness
Sleep habits
Circadian rhythm
Mood
Well-being

ABSTRACT

It is suggested that social obligations, such as early work/school starts, have a disadvantageous impact on sleep behavior that can further transfer to mental health problems. Lockdown as a result of the COVID-19 pandemic created a unique opportunity to research human sleep-wake behavior in naturalistic conditions of decreased social obligations. This study aimed to test whether a change in habitual sleep-wake timing (shift in chronotype) during the COVID-19 lockdown impacted mood and well-being, and whether the impact differs according to morningness-eveningness preference. University students ($N = 1011$; $Mean_{age} = 21.95 \pm 1.95$ years) filled out self-report questionnaires containing measures of chronotype (midpoint of sleep) before and during the COVID-19 lockdown, morningness-eveningness preference, mood, and well-being. The impact of morningness-eveningness preference and shift in chronotype was tested via multiple regression analyses. Results showed that participants shifted their chronotype in line with their morningness-eveningness preference, and that shift toward earlier sleep-wake timing was related to better moods and well-being. Moreover, higher levels of positive mood (vigor) and well-being were found in individuals who shifted their sleep-wake timing earlier and were higher on morningness.

1. Introduction

Morningness-eveningness, or chronotype, is an individual trait concerning a preference for functioning at different times of the day. Morningness-eveningness preference reflects individual differences in endogenous circadian rhythms which are demonstrated in several physiological and behavioral functions, such as core body temperature, hormonal secretion, sleep-wakefulness, alertness, and mood (Díaz-Morales & Parra-Robledo, 2021; Merikanto et al., 2021). Being an indicator of underlying biological processes, individuals' morningness-eveningness preference can be used to explain numerous behavioral and psychological outcomes. For this reason, morningness-eveningness is receiving growing attention as a significant aspect of individual differences (Adan et al., 2012; Jankowski & Linke, 2020).

Morningness-eveningness preference and chronotype are often used interchangeably, though the first is determined through the preferred timing for sleep and activity while the second puts emphasis on the actual sleep-wake timing (Roenneberg et al., 2007). In fact, the two operationalizations are closely linked and allow individuals to be classified into morning, intermediate, and evening chronotypes. The morning-type is characterized by earlier sleep-wake timing, and a phase advance in biological and circadian functions compared to the evening-type (Antúneza, Navarroa, & Adan, 2014).

In addition to differences in the phase shift of circadian rhythms, morning- and evening-types differ in several psychological outcomes. A large number of studies have shown a greater incidence of mental health problems and mood disorders among evening-types compared to morning-types and intermediate-types (Taylor & Hasler, 2018). For instance, eveningness is reported to be associated with an inclination toward a higher level of negative moods, such as anger (Jankowski & Linke, 2020), confusion (Gobin, Banks, Fins, & Tartar, 2015), depressiveness (Van den Berg, Kivelä, & Antypa, 2018), fatigue (Merikanto et al., 2021), and tension (Gobin et al., 2015), as well as poor well-being (Jankowski, 2014; Merikanto et al., 2021).

While the evidence consistently indicates eveningness as a correlate and risk factor for mental health problems, the underlying mechanism is still unclear. Consequently, several hypotheses have been proposed to explain the relationship between chronotype and impaired well-being

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https://doi.org/10.1016/j.paid.2022.111581
Received 9 December 2021; Received in revised form 4 February 2022; Accepted 22 February 2022
Available online 28 February 2022

(see more in Bullock, 2019). Particularly, the mismatch between internal circadian rhythm and social/working schedules, also called social jetlag, is considered the primary factor which may cause disadvantageous mood and well-being in evening chronotypes (Taylor & Hasler, 2018; Zaki et al., 2017). However, it is important to examine how behavioral features within the chronotype construct, like changes in habitual sleep-wake timing (shift in chronotype), affect psychological functioning.

Shifts in chronotype affect the moods and well-being of individuals. This can be seen in the developmental shift toward eveningness during adolescence, which has been related to higher negative moods and lower well-being (Díaz-Morales, Escribano, & Jankowski, 2015). Moreover, in laboratory conditions, earlier shift in sleep-timing was found to lead to a decrease in depression and stress and improvement in the well-being of evening-types (Facer-Childs, Middleton, Skene, & Bagshaw, 2019). Similarly, an earlier shift in depressive patients has been reported to improve mood states (Zaki et al., 2017). Nevertheless, it is not clear yet how a shift in chronotype could impact the general population and whether it is related to morningness-eveningness preference.

The COVID-19 stay-at-home condition allowed greater freedom in one's sleep-wake behaviors and thus created a unique environment to explore people's diurnal preferences and self-selected sleep-wake patterns (Rome et al., 2021). During the stay-at-home condition, several changes were observed in sleep habits, such as a delay in sleep onset and offset times, leading to a shift toward eveningness (Rome et al., 2021; Wright et al., 2020); an increase in sleep duration accompanied by poorer sleep quality (Kantermann, 2020; Marelli et al., 2020); and a decrease in social jetlag: the difference in sleep-wake patterns between workdays and free days disappeared (Korman et al., 2020; Wright et al., 2020). At the same time, an increase in mental health problems was reported during the COVID-19 pandemic (Nochaiwong et al., 2021; Odriozola-González, Planchuelo-Gómez, Irurtia, & de Luis-García, 2020). Besides, most profound changes in sleep habits and higher incidence of stress, anxiety, and depressive symptoms are found in younger people (Korman et al., 2020; Varma, Junge, Meaklim, & Jackson, 2020), especially students (Marelli et al., 2020; Odriozola-González et al., 2020). These studies mainly analyzed the changes in sleep habits during COVID-19 pandemic independently of their effects on mental health and their interaction with morningness-eveningness preference.

The individual circadian system is a fundamental biological mechanism that affects both sleep and mental health, and especially mood (Merikanto et al., 2021). Moreover, on free days, people generally align sleep-wake behavior with their internal circadian rhythm (Crowley, Acebo, & Carskadon, 2007), and this was also seen during the COVID-19 stay-at-home situation (Merikanto et al., 2021). Therefore, the relationship between individual circadian rhythm—assessed through morningness-eveningness preference—and changes in sleep habits during COVID-19 would have implications for mood and well-being. In addition, it is necessary to determine how individual chronotype can benefit from changing social schedules during COVID-19—i.e., changing sleep-wake behavior. This will help to develop preventive actions to reduce mental health problems during and after the COVID-19 situation.

In this study, we aimed to test whether shifts in chronotype during lockdown are related to mood and well-being and whether morningness-eveningness preferences affect that relationship. Given that younger people and students appeared particularly vulnerable to both sleep and mental health-related problems during the COVID-19 lockdown, we were interested to study the sleep-wake behavior, mood, and well-being of the university students. We hypothesized that a shift in chronotype will follow one's morningness-eveningness preference, and morningness, as well as earlier shift will be associated positively with better mood and well-being.

2. Materials and methods

2.1. Participants and procedure

From 17 March 2020, the Bangladesh government imposed a suspension of academic activities on all of its educational institutions due to COVID-19 pandemic (Uddin, 2020). Besides, students had little scope for remote learning due to a lack of internet and other technological facilities, and unlike any technologically advanced country, Bangladesh started online classes late, from December 2020 (Khan, Rahman, & Islam, 2021). Moreover, the students could not start a job outside their academic activities as there was countrywide lockdown. Therefore, students stayed in their home without academic or other social activities, except a few personal/family responsibilities.

During the period of suspended academic activities, an online survey was conducted from August 21 to September 9, 2020, where 1011 students (aged 18—27, $M_{age} = 21.95 \pm 1.95$, 383 females) participated from the University of Rajshahi, Bangladesh (23.5° N, 90.0° E). Thus, the participants were totally without academic responsibilities for five months before sampling, and during this study.

Participation in the study was voluntary and anonymous. An informed consent section was displayed at the beginning of the survey questionnaire, stating the free choice to participate or not. The study was carried out in line with Helsinki declaration and the ethical guidelines approved by the Academic/Ethics Committee of the Department of Psychology, University of Rajshahi, Bangladesh.

2.2. Questionnaires

2.2.1. Morningness-Eveningness Preference

The Composite Scale of Morningness (CSM; Smith, Reilly, & Midkiff, 1989) was used to assess morningness-eveningness preference. The CSM comprised 13 self-reported questions regarding individual preference in sleep-wake timing, feeling best time for physical and intellectual activities, subjective alertness after waking, and self-evaluation of morningness and eveningness. A Likert-type response format is used in the CSM items. Total CSM score ranges from 13 (extreme eveningness) to 55 (extreme morningness). The Cronbach's alpha for the Bangla version of CSM was 0.88 (Hasan, Díaz-Morales, & Khan, 2021), and the alpha was 0.87 in the current sample.

2.2.2. Shift in chronotype

The sleep timing questionnaire was designed to assess chronotype based on habitual sleep-wake-related parameters separately during and before the COVID-19 suspension of academic activities. Firstly, questions about sleep-wake timing during COVID-19 were displayed (e.g., "Nowadays, during the COVID-19 suspension of academic activities, when do you go to bed?"), followed by questions about sleep-wake timing separately on workdays and free days during the period before COVID-19 (e.g., "Before the COVID-19 suspension of academic activities, when did you go to bed at the weekend or on free days?"). Chronotype was calculated as midsleep on free days sleep-corrected (MSFsc; Roenneberg, Wirz-Justice, & Merrow, 2003) for the period before the COVID-19 suspension, and using midsleep across the week for the period during the COVID-19 suspension, as there were no work schedule-related changes in sleep across the week (i.e., no social jetlag). Shift in chronotype (Jankowski, 2014) was determined by subtracting the 'during COVID-19 midsleep time' from the 'before COVID-19 MSFsc'. Shift in chronotype shows the amount and direction of change in midsleep time, expressed in hours and minutes. A positive value indicates a shift toward a morning chronotype, while a negative value indicates a shift toward an evening chronotype.

2.2.3. Mood

The Brunel Mood Scale (BRUMS; Terry & Lane, 2010) was used to assess mood. The BRUMS was previously called the Profile of Mood

Table 1
Descriptive statistics and comparisons between morningness-eveningness categories.

Variables	Total (N = 1011)		Morning-type (N = 108)		Intermediate-type (N = 802)		Evening-type (N = 101)		F (2, 1008)	η_p^2
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
Morningness	36.28	7.62	48.13	2.09	36.47	5.26	22.16	2.62	764.39***	0.603
Chronotype Shift[a]	−00:08	01:45	00:21	1:40	−00:05	01:45	−01:03	01:35	18.59***	0.036
Mood										
Anger	4.78	3.91	3.57	3.16	4.70	3.86	6.71	4.39	18.19***	0.035
Confusion	4.23	3.36	2.96	2.67	4.19	3.28	5.86	3.94	20.45***	0.039
Depression	4.43	3.96	3.30	3.61	4.32	3.81	6.49	4.76	18.95***	0.036
Fatigue	4.17	3.02	3.02	2.73	4.12	2.86	5.73	3.87	22.37***	0.042
Tension	4.26	3.30	3.50	3.03	4.2	3.19	5.60	3.99	11.64***	0.023
Vigor	6.90	3.12	8.44	3.04	6.89	3.01	5.36	3.22	26.80***	0.050
Well-being	24.82	5.72	27.28	5.39	24.94	5.57	21.46	5.73	29.16***	0.055

*** $p < .001$.
[a] Expressed in hh:mm; Positive value indicates shift toward morning chronotype (advance in sleep-timing), and negative value indicates shift toward evening chronotype (delay in sleep-timing).

States-Adolescents (POMS-A; Terry, Lane, Lane, & Keohane, 1999) but later validated for adults (Terry, Lane, & Fogarty, 2003). The BRUMS comprises 24 adjectives (e.g., worried, angry, tired, alert), using a response timeframe "How do you feel normally?" To indicate the level of feelings, participants respond on a five-point Likert-type scale ranging from 0 (*not at all*) to 4 (*extremely*). The 24 self-reported items of BRUMS are divided into six mood dimensions: anger, confusion, depression, fatigue, tension, and vigor, each containing four items. The total scores for each dimension are considered separately and range from 0 to 16. The Bangla validation of BRUMS (Hasan & Khan, 2020) showed good internal consistency reliability for each subscale, and the alpha value ranged from 0.77 to 0.86 in the current sample.

2.2.4. Well-being

The Positive Mental Health scale (PMH-scale; Lukat, Margraf, Lutz, van der Veld, & Becker, 2016) was used to assess well-being. The PMH-scale is a brief, unidimensional measure focused on hedonic and eudaimonic approaches to well-being. It contains nine self-reported items (e.g., "I am in good physical and emotional condition"; "All in all, I am satisfied with my life"), responded to on a Likert-type scale ranging from 1 (*not true*) to 4 (*true*). The total score ranges from 9 to 36, a higher score indicating a higher level of well-being. The Bangla validation of the PMH-scale (Hasan & Khan, 2020) showed high internal consistency reliability, and the alpha value in the current sample was 0.84.

2.3. Analyses

Initially, the descriptive statistics (*M* and *SD*) of the studied variables were calculated for chronotype group and total sample, where group differences were determined by the *F*-test. The association between the variables was then computed by Pearson correlation. After that, the interaction effect of morningness-eveningness and shift in chronotype was determined by multiple regression. Multiple regressions were run with age and sex as control variables, with morningness and shift in chronotype entered as moderator and predictor, respectively, in the first block, followed by the interaction term in the second block. Prior to calculating the interaction term, shift in chronotype and morningness were standardized as both were continuous variables. Finally, simple slope analysis (Aiken & West, 1991) was performed to probe the moderating effect of morningness. IBM SPSS statistics 25 was used to perform the analyses.

3. Results

The current sample comprised 10.7% morning-types, 79.3% intermediate-types, and 10.0% evening-types based on the upper and lower 10 percentile criteria (Hasan et al., 2021; Smith et al., 1989). Chronotypes significantly differed in morningness-eveningness, shift in chronotype, and all six dimensions of mood and well-being (see Table 1). Evening- and intermediate-types had a delayed shift in sleep-timing, while morning-types shifted earlier; evening-types scored significantly higher on all negative mood dimensions (anger, confusion, depression, fatigue, and tension), but lower on well-being.

The result of correlational analyses (see Table 2) showed that morningness-eveningness was associated with shift in chronotype—i.e., lower CSM score (eveningness) was related to lower values for shift in chronotype (delayed sleep-timing). Moreover, morningness-eveningness and shift in chronotype were correlated with all dimensions of mood and well-being (r = 0.07 to 0.13). This indicated that higher morningness and advance in sleep-timing were weakly related to lower negative moods and better well-being.

In line with Pearson correlations, when morningness-eveningness and shift in chronotype were considered separately in regression

Table 2
Pearson correlations between the studied variables.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Advance in chronotype	1								
2. Morningness	0.302**	1							
Mood									
3. Anger	−0.109**	−0.249**	1						
4. Confusion	−0.125**	−0.261**	0.704**	1					
5. Depression	−0.111**	−0.249**	0.750**	0.771**	1				
6. Fatigue	−0.074*	−0.266**	0.578**	0.623**	0.638**	1			
7. Tension	−0.090**	−0.210**	0.687**	0.752**	0.810**	0.607**	1		
8. Vigor	0.131**	0.300**	−0.392**	−0.464**	−0.432**	−0.364**	−0.403**	1	
9. Well-being	0.122**	0.330**	−0.542**	−0.574**	−0.601**	−0.461**	−0.552**	0.487**	1

* $p < .05$.
** $p < .01$.

Table 3
Linear regression with mood and well-being: the outcome predicted by variables entered in subsequent blocks.

Block	Anger		Confusion		Depression		Fatigue		Tension		Vigor		Well-being	
	Beta	R^2	Beta	R^2	Beta	R^2	Beta	R^2	Beta	R^2	Beta	R^2	Beta	R^2
Age	−0.024	0.099***	0.035	0.099***	0.000	0.084***	−0.001	0.094***	0.048	0.077***	0.033	0.110***	0.012	0.146***
Sex	0.185***		0.170***		0.142***		0.153***		0.178***		−0.125***		−0.189***	
Morningness (CSM)	−0.240***		−0.248***		−0.240***		−0.276***		−0.226***		0.303***		0.335***	
Advance in chronotype	−0.015		−0.036		−0.025		0.023		−0.013		0.031		0.005	
Morningness*advance in chronotype	0.000	0.000	−0.021	0.000	−0.012	0.000	-0.045	0.002	−0.014	0.000	0.089**	0.008**	0.070*	0.005*

Note: sex coded: male = 0, female = 1.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

analysis, both became significant predictors of mood and well-being. This means that both morningness-eveningness and shift in chronotype independently contributed to mood and well-being. While morningness-eveningness and shift in chronotype were considered together, it was found that only morningness-eveningness had a significant effect on mood and well-being (see Table 3). Additionally, the interaction of morningness-eveningness and shift in chronotype was significant for positive mood (vigor) and well-being, but not for negative moods. To probe the significant interaction, the pick-a-point approach was used. The simple slopes were computed by the cut-off values for morningness-eveningness (Hasan et al., 2021) rather than conventional ±1 *SD* as suggested by Hayes (2018). Here, 46 and 26 were values for high morningness and low morningness (eveningness), respectively. The slopes were significantly different for both vigor ($p < .001$) and well-being ($p < .001$). Therefore, morningness was a statistically significant moderator in the relationship between shift in chronotype, vigor, and well-being. This result indicates that a shift toward earlier sleep-wake-timing was associated with higher level of vigor and well-being in individuals with higher morningness (see Fig. 1a and b).

4. Discussion

This study investigated whether a shift in chronotype during COVID-19 affected mood and well-being and whether such an effect was dependent on morningness-eveningness preferences. The results showed that during COVID-19 lockdown evening-types had a delayed shift while morning-types shifted earlier, indicating that a shift in sleep timing was in line with one's chronotype. Similarly, the correlational analysis showed that advance in sleep-timing was associated with morningness. Though some studies conducted during COVID-19 reported a delayed sleep pattern among majority of the participants regardless of their chronotypes (Merikanto et al., 2021; Rome et al., 2021), the current study found that morning-types advanced their sleep timing – an unusual observation compared to the results of other studies. In fact, during normal conditions morning-types have to be involved in some evening activities (e.g., shopping, homework) and some of these activities (socializing) may play a special role in shifting morning-type students toward later hours. Reduced social opportunities at night during COVID-19 lockdown may allow morning types to advance their sleep timing to be more in line with their preferences. Nevertheless, further investigations are required to clarify this finding. Generally, there is a view that people tend to follow their internal rhythm when there are fewer social constraints (Crowley et al., 2007; Jankowski, 2015), and this study provides an empirical argument supporting the notion that such a mechanism works also in real life conditions—i.e., during the COVID-19 lockdown.

The findings support a well-known observation that eveningness is associated with higher negative mood and lower positive mood, and well-being. Several other studies have reported similar findings on the association between morningness-eveningness, mood (Jankowski & Linke, 2020; Partonen, 2015), and well-being (Merikanto et al., 2021; Papaconstantinou et al., 2019). The mismatch between internal circadian rhythms and social schedules is considered the primary cause underlying the relationship between eveningness and disadvantageous moods as well as poor well-being (Díaz-Morales et al., 2015; Zaki et al., 2017). In contrast, during the COVID-19 stay-at-home condition, there was less requirement to maintain the normal social and working schedules, which could have lowered the mismatch (Korman et al., 2020; Wright et al., 2020). Despite this, we found that eveningness is related with adverse mood and poor well-being, which supports an alternative mechanism that besides the circadian misalignment, eveningness may be intrinsically—i.e., genetically (Maukonen et al., 2020; Partonen, 2015)—related to, and more susceptible to, disadvantageous mood and mental health problems (Merikanto et al., 2021). Although the role of genetics in explaining evening-types' adverse condition in health and well-being is still unclear, recent genome-wide association

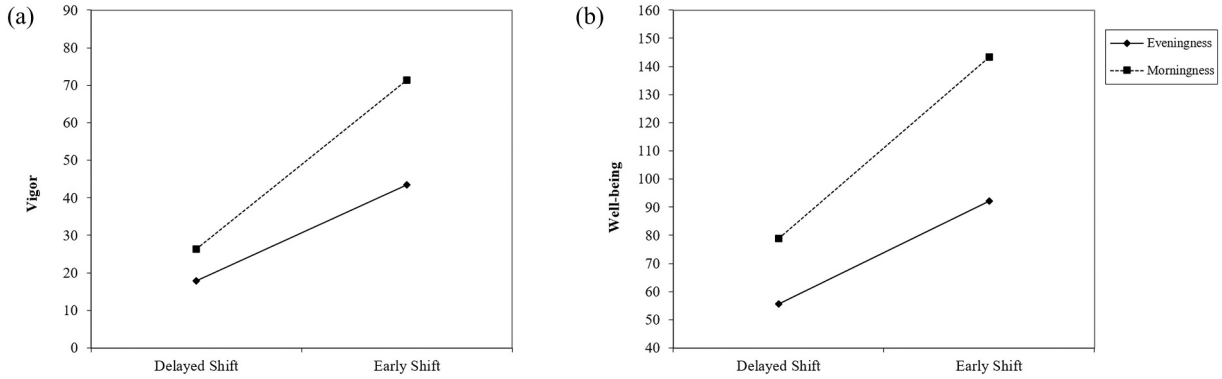

Fig. 1. Shift in chronotype affects (a) positive mood (vigor) and (b) well-being depending on morningness-eveningness preference.

study (GWAS) of chronotype showed that greater genetic risk score (GRS) was related with eveningness (Maukonen et al., 2020).

To the best of our knowledge, this is the first study to report how a shift in chronotype induced by the COVID-19 lockdown is related to mood and well-being. The results showed that earlier shift in sleep-timing was related to better mood and well-being. This has been shown earlier in the general population (Facer-Childs et al., 2019; Hasler, Buysse, & Germain, 2015) and in depressive patients (Zaki et al., 2017). Contrastingly, a shift toward eveningness during adolescence has been related to higher negative moods and lower well-being (Díaz-Morales et al., 2015). There was not much research on shifts in sleep timing in naturalistic conditions. One such study, conducted in a setting different from the COVID-19 stay-at-home condition, did not find changes in mood and well-being despite apparent shifts in chronotype evoked by seasonal changes in the photoperiod (Jankowski, 2014).

The unique finding of this study is that morningness-eveningness preference could moderate the relationship between shift in chronotype, positive mood, and well-being. This finding implies that morningness could enhance the effect of earlier sleep-timing on vigor and well-being. The simple slope analyses demonstrated that higher levels of vigor and well-being were found in individuals who reported earlier shift and higher morningness. In contrast, evening-types who had delayed shift reported lower vigor and well-being. The interactive effect of morningness-eveningness preference was not related to negative moods. This can be explained by previous observation that it is the positive mood, not the negative, that depends on the circadian system (Díaz-Morales & Parra-Robledo, 2021; Hasler et al., 2015), which can be explained by the more reactive nature of negative moods (Jankowski & Ciarkowska, 2008). Therefore, the findings support our hypothesis only partially, because morningness and earlier shift in chronotype were related to higher positive mood, but not to the negative one.

The main limitation of the current study is that it was a cross-sectional study and thus causality cannot be determined. Secondly, there might remain recall bias, as the participants were asked to recall sleep habits from approximately six months earlier. Thirdly, outside of academic and social activities, personal responsibilities were not controlled. Fourthly, we did not randomize the order of questionnaires; self-reports of morningness-eveningness preference and chronotype could possibly influence each other. Finally, this study used only university students and that they were selected through an online sampling technique, so the question remains whether or not the results can be generalized to other populations. In order to generalize the findings of this study to other populations, further research applying biological markers of circadian phase will help to understand better how shift in sleep timing contributes to mood and well-being.

5. Conclusions

The current study is the first to show that a shift in chronotype during the COVID-19 pandemic was a significant predictor of mood and well-being, such that an earlier shift is related to higher positive mood (vigor) and well-being, and this effect is higher in people with higher morningness. Though this study did not find any effect of shift in chronotype on the negative moods, the findings can help to understand how changes in sleep habits contribute to the development of mental health problems during the COVID-19 pandemic. While COVID-19 itself is a threat to human well-being, eveningness accompanied by delayed shift is exacerbating people's mood and mental health-related problems. This study contributes to public health by indicating that one can enhance positive mood and well-being by shifting sleep-wake time earlier.

CRediT authorship contribution statement

M. Mahmudul Hasan: Conceptualization, Methodology, Investigation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Konrad S. Jankowski:** Methodology, Funding acquisition, Writing – original draft, Writing – review & editing. **Mozibul H.A. Khan:** Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

None.

Acknowledgement

Preparation of the manuscript was supported by the Polish Ministry of Science and Higher Education (IP2015026774). We acknowledge the participants of this study for their voluntary participation.

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