RESEARCH LETTER

Evaluation of the chronotype and its predictive factors in patients with obstructive sleep apnea

Agata Gabryelska[1], Piotr Białasiewicz[1], Mikołaj Malicki[1], Dominik Strzelecki[2], Marcin Sochal[1]

1 Department of Sleep Medicine and Metabolic Disorders, Medical University of Lodz, Łódź, Poland
2 Department of Affective and Psychotic Disorders, Medical University of Lodz, Łódź, Poland

Introduction Obstructive sleep apnea (OSA) is a chronic condition characterized by recurrent pauses in breathing during sleep caused by complete or partial collapse of the upper respiratory airways, resulting in arousals, sleep fragmentation, and oxygen desaturation during the night.[1] The number of patients with OSA has been continuously rising in recent decades. It is estimated to reach close to 1 billion adults worldwide, with a prevalence exceeding 50% in some populations,[1] which highlights the significant burden of the disorder. Outside of its impact on sleep quality, OSA is associated with multiple comorbidities. The most deeply explored ones include cardiovascular and metabolic complications, since OSA is an independent risk factor for arterial hypertension, type 2 diabetes mellitus, and metabolic syndrome, among many others.[1,2] Recently, however, more attention has been paid to neurocognitive and psychiatric comorbidities, and recognizing factors that might help identify OSA subgroups at the highest risk of these complications. Many studies reported a high frequency of anxiety and depressive symptoms among patients with OSA.[3]

Chronotype is defined as an individual circadian preference of functioning, including a schedule of sleep and activity. It is most commonly assessed on the morningness-eveningness (ME) scale, and is usually divided into a morning (early, so-called larks), evening (late, so-called owls), and intermediate chronotype. Recently, other chronotype orientations have been investigated—Oginska et al[4] reported distinctness of rhythm (DI) as an additional chronotype dimension that is associated with the individual's ability to adjust their activity to different times of the day. In the general population, eveningness has been associated not only with an increased risk of depressive symptoms but also with greater severity of such symptoms, as well as with limited response to treatment.[5,6] Similarly, it has been observed that insomnia symptoms and usage of sleep medication are more frequent among individuals with an evening, as compared with those with a morning chronotype.[7]

Data regarding the chronotype among patients with OSA are limited and inconsistent. Kim et al[8] suggested an intermediate chronotype to be a protective factor against OSA, as they found the disorder was more severe in individuals with morning and evening chronotypes. On the other hand, a study by Lucassen et al[9] reported that the prevalence of OSA was twice as high in patients with an evening chronotype, as compared with those with a morning chronotype. Sansom et al[10] did not find any differences between the frequency of individual chronotypes in either mild, moderate, or severe OSA, nor did they observe a difference in OSA severity across all chronotypes. Even less data are available regarding sleepiness, insomnia, and depressive symptoms in the context of OSA.[11] To date, no studies have evaluated the DI of the chronotype in OSA patients. In light of the above, the aim of this study was to assess the association between various chronotype dimensions, subjective and objective sleep parameters, and depressive symptoms among patients with OSA.

Patients and methods **Sample** The study group consisted of 332 individuals referred to the Sleep and Respiratory Disorders Center in Łódź, Poland with a presumptive diagnosis of OSA. All participants underwent a standard nocturnal polysomnography (PSG) examination. Based on the apnea-hypopnea index (AHI), they were divided into a healthy control group (n = 86; AHI <5) and an OSA group (n = 246; AHI ≥5). The latter was further stratified into a mild OSA (AHI ≥5 and <15), moderate OSA (AHI ≥15 and <30), and severe OSA group (AHI ≥30). The exclusion criteria comprised inflammatory diseases (eg, connective tissue diseases or inflammatory bowel diseases), chronic respiratory diseases

Correspondence to:
Agata Gabryelska, MD, PhD,
Department of Sleep Medicine
and Metabolic Disorders,
Medical University of Lodz,
ul. Mazowiecka 6/8, 92-215 Łódź,
Poland, phone: +48 42 272 56 60,
email: agata.gabryelska@gmail.com
Received: May 28, 2023.
Revision accepted: July 31, 2023.
Published online: August 7, 2023.
Pol Arch Intern Med. 2023;
133 (7-8): 16541
doi:10.20452/pamw.16541

(eg, bronchial asthma or chronic obstructive pulmonary disease), any infection within 1 month of blood collection, diagnosis of cancer (active or in medical history), major neurologic conditions, psychiatric disorders, including insomnia, and taking medications affecting sleep (eg, benzodiazepines or melatonin). The study was approved by the Ethics Committee of the Medical University of Lodz (RNN/432/18/KE). All patients provided their written informed consent to participate.

Polysomnography The participants were admitted to the sleep laboratory at approximately 9 PM (or up to 30 minutes before / after that time), and underwent physical examination (measurement of body mass, height, heart rate, and blood pressure). The following channels were recorded during PSG: electroencephalography (C4\A1, C3\A2), chin muscle and anterior tibialis electromyography, electrooculography, measurements of the oronasal airflow (a thermistor gauge), snoring, body position, respiratory movements of the chest and abdomen (piezoelectric gauges), unipolar electrocardiogram, and oxygen saturation (SpO_2). The examination was performed using an Alice 6 device (Phillips-Respironics, Murrysville, Pennsylania, United States). The criteria based on the 30-second epoch standard were used to score sleep stages in the recorded PSG. Apnea was defined as a reduction of airflow to less than 10% of the baseline for at least 10 seconds. Hypopnea was described as a reduction of airflow by at least 30% for at least 10 seconds, accompanied by an over 3% decrease in SpO_2 or arousal. The American Academy of Sleep Medicine guidelines were used to score the arousals.

Questionnaires The questionnaires used in the study included 5 research instruments: the Caen Chronotype Questionnaire (CCQ), Pittsburgh Sleep Quality Index (PSQI), Beck Depression Inventory (BDI), Athens Insomnia Scale (AIS), and Epworth Sleepiness Scale (ESS). All of them were filled out by each participant in the morning following the PSG examination with the assistance of a physician.

Caen Chronotype Questionnaire The CCQ scale consists of 16 questions pertaining to 2 scales: the ME scale, where a higher score indicates a greater preference for evening activity, and the DI scale, which reflects the ability of a person to sense or adjust his or her levels of energy depending on the time of day, where a higher score indicates greater DI.[4]

Pittsburgh Sleep Quality Index PSQI is a self-evaluation questionnaire assessing 7 various sleep-related aspects in adults. It evaluates sleep quality parameters, such as difficulties with falling asleep, problems with maintaining the continuity of sleep, and functioning during the day. It also includes questions regarding the most frequent causes of sleep disorders over the past 4 weeks. The score range is 0 to 21 points. A result higher than 5 points indicates low sleep quality and is a threshold differentiating patients with poor sleep quality from those with good sleep quality, with higher scores corresponding to poorer quality of sleep.

Beck Depression Inventory The BDI self-evaluation questionnaire consists of 21 questions, each assessing the intensity of a depression symptom on a 4-grade scale (0–3 points). All answers are summed, giving a maximum score of 63 points. BDI is a quick and simple screening test. Based on the results, patients are divided into 4 groups: minimal depression (0–13 points), mild depression (14–19 points), moderate depression (20–28 points), and severe depression (29–63 points). The questionnaire does not define a lack of depression.

Athens Insomnia Scale AIS is a questionnaire consisting of 8 questions designed to quantify the severity of insomnia. The first 5 questions are based on the criteria for insomnia diagnosis listed in the *International Classification of Diseases, Tenth Revision*. They include the assessment of difficulty with sleep induction, awakening, total sleep time, and overall quality of sleep. The last 3 items evaluate consequences of insomnia during the day, such as subsequent well-being, functioning, and daytime sleepiness. Each question is scored from 0 to 3 points, corresponding to "no problem at all" to "a very serious problem", respectively. The maximum score is 24 points.

Epworth Sleepiness Scale The ESS questionnaire consists of 8 questions, in which a patient assesses their likeliness to fall asleep in a given situation on a scale of 0 to 3. It is used to assess excessive daytime sleepiness.

Statistical analysis The level of statistical significance was set at P below 0.05. Statistical analysis was performed using SPSS 28.0 software (IBM, Chicago, Illinois, United States). The normality of distribution of the variables was evaluated with the Shapiro–Wilk test. The parameters with normally distributed data were presented as mean (SD) and were compared using the independent-sample t test and 1-way ANOVA with the post hoc Tukey test. Comparisons of the variables that did not follow the normal distribution were performed using the Mann–Whitney test and the Kurskal–Wallis test with the post hoc Dunn tests, and the variables were presented as median and interquartile range (IQR). The χ^2 test was used to compare the categorical variables. The Spearman rank correlation coefficient was used to assess correlations. Multivariable linear regression with a stepwise procedure was performed to identify the factors predicting eveningness and a greater DI of the chronotype.

Results Baseline characteristics of the study participants, including demographic data, PSG

parameters, questionnaire results, and comparisons between the control group and the OSA group, as well as between the control group and the OSA subgroups are shown in TABLE 1. Among all the analyzed questionnaire results, only the ME scale of CCQ differed between the control and OSA groups (P = 0.001), with OSA participants achieving higher scores. Furthermore, in the subgroup assessment, higher scores on the ME scale were achieved in the mild OSA group (P = 0.046) and in the severe OSA group (P = 0.01), as compared with the control group. No differences were observed between the groups in terms of the DI scale of CCQ (P = 0.18).

In the OSA group, the factors that were associated with higher scores on the ME scale were older age (r = 0.251; P <0.001; Supplementary material, *Figure S1A*), longer REM latency (r = 0.13; P = 0.04; Supplementary material, *Figure S1B*), greater arousal index (r = 0.152; P = 0.02; Supplementary material, *Figure S1C*), and higher minimum SpO_2 (r = 0.145; P = 0.03; Supplementary material, *Figure S1D*). No significant correlations were observed between the DI score and the demographic or PSG parameters. Both ME and DI scores correlated with the results of the following questionnaires: ESS (r = –0.287; P = 0.001; Supplementary material, *Figure S2A* and r = –0.276; P = 0.002; Supplementary material, *Figure S2B*, respectively), AIS (r = –0.342; P <0.001; Supplementary material, *Figure S2C* and r = –0.459; P = 0.002; Supplementary material, *Figure S2D*, respectively), PSQI (r = –0.228; P <0.001; Supplementary material, *Figure S2E* and r = –0.215; P <0.001; Supplementary material, *Figure S2F*, respectively), and BDI (r = –0.268; P <0.001; Supplementary material, *Figure S2G* and r = –0.535; P <0.001; Supplementary material, *Figure S2H*, respectively). Lastly, an association between ME and DI scores was observed (r = 0.165; P = 0.01; Supplementary material, *Figure S2I*).

Among the participants with OSA, a multivariable linear regression was constructed for both chronotype dimensions (ME and DI) by stepwise elimination. For eveningness, the model explained 23.7% of the variance (P <0.001), and the only significant parameter included was the ESS score (β = –0.206; P = 0.03). For the greater DI of the chronotype, the obtained model accounted for 36.8% of the variance (P <0.001), and the significant parameters were the ESS score (β = 0.153; P = 0.04), AIS score (β = –0391; P <0.001), PSQI score (β = 0.320; P = 0.01), and BDI score (β = –0.264; P <0.001). The full list of parameters included in the regression models is shown in Supplementary material, *Table S1*.

Discussion In the present study, we showed that, in comparison with healthy controls, patients with OSA had a higher ME score, suggesting a tendency toward an evening chronotype in this group. The outcomes of the few prior studies on the topic were inconsistent. Our results are in line with those obtained by Lucassen et al,[9] who reported higher OSA prevalence among individuals with an evening chronotype.[9] However, in a recent study from Australia,[10] the distribution of all chronotypes was found to be similar regardless of OSA severity. Most of the available studies did not report a direct association between OSA severity and eveningness. Similarly, we did not observe a correlation between the AHI and ME scores; however, a weak dependence was noted between OSA severity and the arousal index. While the available studies exploring the topic of chronotype in OSA did not report such association, Mongrain et al[12] did not notice any differences in reaction to sleep fragmentation among individuals with various chronotypes,[12] which implies a lack of relevance of this observation.

To the best of our knowledge, this is the first study evaluating not only the ME dimension of the chronotype among patients with OSA but also the DI dimension. However, no significant association was found between OSA severity or other PSG parameters and the distinctiveness of the chronotype, neither did the DI dimension differ between the healthy participants and the individuals with disordered breathing.

In the present study we found a weak association between objective sleep parameters and the chronotype. However, both dimensions of the chronotype correlated with subjective sleep quality, daytime sleepiness, and in particular, insomnia severity and the presence of depressive symptoms in the OSA group. Of note, along with an increase in the ME and DI scores (suggesting a tendency toward eveningness and greater DI of the chronotype) among the OSA patients, insomnia severity and pronouncement of depression symptoms decreased. This is in contrast to most of the available data suggesting that an evening chronotype is associated with the presence of depressive symptoms, depressive episodes, as well as subclinical presentation of depression.[5,13] The results of some studies are in line with our observations, for example, Lemoine et al,[14] found individuals with a morning chronotype to be more likely to suffer from depression. Similarly, eveningness was previously recognized to be connected with insomnia severity and excessive daytime sleepiness.[7,15] Only a single study[11] investigated subjective sleep-related complaints in patients with OSA, and found that a morning chronotype was protective against increased daytime sleepiness only in combination with longer sleep duration. It is worth pointing out that these results are in line with our findings in the OSA group and in contrast to the results obtained in healthy controls. It could be hypothesized that longer sleep duration, if ineffective (thus presenting as excessive daytime sleepiness), might be a cause for persons with a tendency for hypersomnia to have an evening chronotype.[16] Moreover, in the regression model for eveningness among the OSA participants, a decrease in excessive daytime sleepiness was the only predictor, which is in line with the results obtained by Verent et al.[16] The interplay

TABLE 1 Baseline characteristics of the study population (continued on the next page)

Parameter		Control group (n = 86)	OSA (n = 246)	*P* value	Mild OSA (n = 81)	Moderate OSA (n = 58)	Severe OSA (n = 107)	*P* value (control, mild OSA, moderate OSA, and severe OSA groups)
Age, y		47 (36–58.5)	54 (45–64)	<0.001	52 (42.5–62.5)	54.5 (48–64)	54 (45–65)	<0.001; 0.04[a]; 0.002[b]; <0.001[c]
Sex	Men, n (%)	54 (62.79)	178 (71.95)	0.1	51 (62.94)	43 (74.14)	84 (78.5)	0.1
	Women, n (%)	32 (37.21)	68 (27.64)		30 (37.04)	15 (25.86)	23 (21.5)	
BMI, kg/m^2		27.58 (24.34–32.77)	31.1 (27.78–36.11)	<0.001	28.63 (25.8–31.59)	30.99 (27.44–36.59)	33.45 (30.25–38.99)	<0.001; 0.007[b]; <0.001[c]; 0.01[d]; <0.001[e]
Sleep efficiency, %		82.75 (68.23–89.4)	83.8 (74.3–89.9)	0.26	79 (70–89.6)	87.6 (80.3–91.9)	84.5 (74.35–89.3)	0.26
Sleep onset latency, min		23.75 (10.63–35.88)	18.5 (10.5–34)	0.26	19.5 (11–40.5)	18.25 (12.5–34.13)	17.5 (8.5–31)	0.26
Sleep maintenance efficiency, %		89.6 (79.7–96.1)	90.5 (82.4–94.6)	0.76	87.9 (78.7–95)	92.7 (88–95.4)	89.9 (83–93.85)	0.76
REM sleep latency, min		98.5 (77.5–143.5)	94 (63.5–139.55)	0.27	98.75 (69.75–141.65)	81 (59.13–116)	105 (58–166)	0.27
TST, h		6.05 (5.38–6.7)	6.2 (5.2–6.89)	0.93	5.95 (5.15–6.66)	6.2 (5.52–6.98)	6.4 (5.2–6.99)	0.93
REM duration, h		1.27 (0.76–1.68)	1.15 (0.8–1.57)	0.4	1.14 (0.83–1.58)	1.35 (0.92–1.79)	11.03 (0.7–1.46)	0.4
nREM duration, h		4.71 (4.13–5.45)	4.91 (4.23–5.48)	0.56	4.76 (4.08–5.29)	4.86 (4.4–5.37)	5.03 (4.2–5.69)	0.56
Arousal index, events/h		9.9 (6.7–17.6)	17.4 (10.95–26.05)	<0.001	11.9 (8–18)	14.6 (10.1–18.42)	25.9 (18.6–36.4)	<0.001; <0.001[c]; <0.001[e]; <0.001[f]
AHI in REM, events/h		2.17 (0–4.78)	26.34 (9.18–49.59)	<0.001	8.75 (4.79–16.38)	24.35 (12.4–32.9)	50.45 (32.17–66.31)	<0.001; 0.02[a]; <0.001[b]; <0.001[c]; <0.001[d]; <0.001[e]; <0.001[f]
AHI in nREM, events/h		1.28 (0.66–2.79)	20.84 (9.3–44.49)	<0.001	6.98 (4.33–9.77)	18.60 (14.32–21.86)	47.58 (35.58–67.18)	<0.001; <0.001[a]; <0.001[b]; <0.001[c]; <0.001[d]; <0.001[e]; <0.001[f]
Total AHI, events/h		1.6 (0.9–3.3)	25.1 (11.05–47.85)	<0.001	8.3 (7–11)	20.3 (17.35–25.35)	51.3 (39–70.6)	<0.001; <0.001[a]; <0.001[b]; <0.001[c]; <0.001[d]; <0.001[e]; <0.001[f]
Desaturations, n		12 (5–22.5)	146 (68–290)	<0.001	51 (35–68)	129 (105–169)	304 (228.5–406.5)	<0.001; <0.001[a]; <0.001[b]; <0.001[c]; 0.02[d]; <0.001[e]; 0.002[f]
Desaturation index, events/h		2 (1–3.38)	25.5 (11.08–51.15)	<0.001	8.9 (6–11.4)	20.55 (18–26.25)	54 (40–70.4)	<0.001; <0.001[a]; <0.001[b]; <0.001[c]; <0.001[d]; <0.001[e]; <0.001[f]
Basal SpO_2, %		94.05 (92.28–95)	92.4 (91–93.7)	<0.001	93.3 (92–94)	92.55 (91.98–93.93)	91.3 (88.7–92.9)	<0.001; 0.005[b]; <0.001[c]; <0.001[e]; <0.001[f]
Mean SpO_2 during desaturations, %		90.45 (88.75–92.4)	88 (85.48–90)	<0.001	89.8 (88–91.4)	88.75 (87.55–89.7)	85.4 (81.5–88)	<0.001; 0.001[b]; <0.001[c]; 0.03[d]; <0.001[e]; <0.001[f]
Minimum SpO_2, %		88.15 (84.68–90.9)	79.9 (71–83.98)	<0.001	84.45 (81.9–86.93)	80 (75.98–82.03)	71 (62.93–79)	<0.001; 0.02[a]; <0.001[b]; <0.001[c]; <0.001[d]; <0.001[e]; 0.001[f]
ME score of CCQ		18.5 (15–23)	21 (18–24.25)	0.001	20 (18.5–24.5)	20 (17–25)	22 (18–24)	0.01; 0.046[a]; 0.01[c]
DI score of CCQ		18 (15–21)	19 (16–22)	0.15	18 (16–21)	20 (15.75–24)	20 (16–22)	0.46

TABLE 1 Baseline characteristics of the study population (continued from the previous page)

Parameter	Control group (n = 86)	OSA (n = 246)	*P* value	Mild OSA (n = 81)	Moderate OSA (n = 58)	Severe OSA (n = 107)	*P* value (control, mild OSA, moderate OSA, and severe OSA groups)
AIS score	10 (7–13)	9 (7–13)	0.18	9 (6.5–12)	9 (6–11)	9 (7–13)	0.17
PSQI score	6 (5–10)	6 (4–9)	0.29	6 (4–9)	6 (4–8)	6 (5–9)	0.41
BDI score	10.5 (8–17)	10 (5–15)	0.05	10 (5–15)	10 (4–14)	10 (5–15)	0.19

Data are presented as median (interquartile range) unless indicated otherwise.

P value for following comparisons:

a Control vs Mild OSA

b Control vs Moderate OSA

c Control vs Severe OSA

d Mild OSA vs Moderate OSA

e Mild OSA vs Sever OSA

f Moderate OSA vs Severe OSA

Abbreviations: AIS, Athens Insomnia Scale; AHI, apnea-hypopnea index; BDI, Beck Depression Inventory; CCQ, Caen Chronotype Questionnaire; DI, Distinctiveness; ESS, Epworth Sleepiness Scale; ME, Morningness-eveningness; nREM, non-REM phase; OSA, obstructive sleep apnea; PSQI, Pittsburgh Sleep Quality Index; REM, rapid eye movement; TST, total sleep time

between insomnia, depression, and chronotype is complicated, and many mechanisms of action have been proposed. Hasler et al[17] suggested that changes in neural structures might be involved in the aforementioned relationship. This is particularly relevant in the context of OSA, since it has been documented that due to recurrent hypoxia irreversible changes in brain structures are present in this group of patients.[18] Nevertheless, further research is needed to better understand these complicated underlying mechanisms. Additionally, Knauert et al[19] recognized the morning chronotype as a predictor of better adherence to OSA treatment. However, this singular observation needs to be investigated in the context of comorbidities, such as insomnia and depression, which were previously shown to be connected with all chronotype orientations among OSA patients.

The strength of our study is a relatively large study group. On the other hand, its main limitation is the usage of CCQ to evaluate the chronotype, and not the Munich Chronotype Questionnaire (MCQ).[20] However, it should be noted that CCQ allows for the assessment of both the ME and DI dimensions of the chronotype, while MCQ only accounts for the EM dimension. The variety of questionnaires used in the present study reduced the possibility of direct comparisons with other analyses, and might be the reason for the disparities in the obtained results. Nevertheless, the inclusion of several tools to evaluate the quality of sleep and symptoms of insomnia and depression made the results more reliable.

To conclude, patients with OSA presented with higher ME scores, which suggests a tendency toward eveningness in this group, as compared with healthy individuals. However, no direct associations between the OSA severity and chronotype characteristics were observed. Both dimensions of the chronotype, eveningness and greater distinctiveness, were associated with a decreased severity of insomnia and depression as well as with parameters reflecting subjective sleep quality, rather than with objective sleep evaluation parameters assessed through PSG.

SUPPLEMENTARY MATERIAL

Supplementary material is available at www.mp.pl/pain.

ARTICLE INFORMATION

ACKNOWLEDGMENTS None.

FUNDING This research was funded by National Science Centre, Poland (2018/31/N/NZ5/03931; to AG).

CONFLICT OF INTEREST None declared.

HOW TO CITE Gabryelska A, Białasiewicz P, Malicki M, et al. Evaluation of the chronotype and its predictive factors among patients with obstructive sleep apnea. Pol Arch Intern Med. 2023; 133: 16541. doi:10.20452/pamw.16541

REFERENCES

1 Gleeson M, McNicholas WT. Bidirectional relationships of comorbidity with obstructive sleep apnoea. Eur Respir Rev. 2022; 31: 210256.

2 McNicholas WT. Cardiac rhythm disorders and obstructive sleep apnea: a multifaceted relationship. Pol Arch Intern Med. 2022; 132: 16269.

3 Edwards C, Almeida OP, Ford AH. Obstructive sleep apnea and depression: a systematic review and meta-analysis. Maturitas. 2020; 142: 45-54.

4 Oginska H, Mojsa-Kaja J, Mairesse O. Chronotype description: in search of a solid subjective amplitude scale. Chronobiol Int. 2017; 34: 1388-1400.

5 Merikanto I, Kronholm E, Peltonen M, et al. Circadian preference links to depression in general adult population. J Affect Disord. 2015; 188: 143-148.

6 Müller MJ, Kundermann B, Cabanel N. Eveningness and poor sleep quality independently contribute to self-reported depression severity in psychiatric inpatients with affective disorder. Nord J Psychiatry. 2016; 70: 329-334.

7 Merikanto I, Kronholm E, Peltonen M, et al. Relation of chronotype to sleep complaints in the general Finnish population. Chronobiol Int. 2012; 29: 311-317.

8 Kim LJ, Coelho FM, Hirotsu C, et al. Is the chronotype associated with obstructive sleep apnea? Sleep Breath. 2015; 19: 645-651.

9 Lucassen EA, Zhao X, Rother KI, et al. Evening chronotype is associated with changes in eating behavior, more sleep apnea, and increased stress hormones in short sleeping obese individuals. PLoS One. 2013; 8: e56519.

10 Sansom K, Reynolds A, Dhaliwal SS, et al. Cross-sectional interrelationships between chronotype, obstructive sleep apnea and blood pressure in a middle-aged community cohort. J Sleep Res. 2022; 32: e13778.

11 Prasad B, Steffen AD, Van Dongen HPA, et al. Determinants of sleepiness in obstructive sleep apnea. Sleep. 2018; 41: zsx199.

12 Mongrain V, Noujaim J, Blais H, Dumont M. Daytime vigilance in chronotypes: diurnal variations and effects of behavioral sleep fragmentation. Behav Brain Res. 2008; 190: 105-111.

13 Antypa N, Vogelzangs N, Meesters Y, et al. Circadian preference links to depression in general adult population. Depress Anxiety. 2016; 33: 75-83.

14 Lemoine P, Zawieja P, Ohayon MM. Associations between morningness/eveningness and psychopathology: an epidemiological survey in three in-patient psychiatric clinics. J Psychiatr Res. 2013; 47: 1095-1098.

15 Chan JWY, Lam SP, Li SX, et al. Eveningness and insomnia: independent risk factors of nonremission in major depressive disorder. Sleep. 2014; 37: 911-917.

16 Vernet C, Arnulf I. Idiopathic hypersomnia with and without long sleep time: a controlled series of 75 patients. Sleep. 2009; 32: 753-759.

17 Hasler BP, Germain A, Nofzinger EA, et al. Chronotype and diurnal patterns of positive affect and affective neural circuitry in primary insomnia. J Sleep Res. 2012; 21: 515-526.

18 Celle S, Delon-Martin C, Roche F, et al. Desperately seeking grey matter volume changes in sleep apnea: a methodological review of magnetic resonance brain voxel-based morphometry studies. Sleep Med Rev. 2016; 25: 112-120.

19 Knauert MP, Adekolu O, Xu Z, et al. Morning chronotype is associated with improved adherence to continuous positive airway pressure among individuals with obstructive sleep apnea. Ann Am Thorac Soc. 2023 Mar 14. [Epub ahead of print]

20 Zavada A, Gordijn MCM, Beersma DGM, et al. Comparison of the Munich chronotype questionnaire with the Horne-Östberg's morningness-eveningness score. Chronobiol Int. 2005; 22: 267-278.