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ORIGINAL ARTICLE

Sleep disturbances partly mediate the association between chronotype and depressive symptoms in adult video game players

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BACKGROUND
Playing video games is a popular leisure activity, but if prolonged it can increase the risk of sleep and mood disturbances. Individuals with an evening chronotype show a greater tendency to be engrossed in video games.

PARTICIPANTS AND PROCEDURE
This study tested whether sleep disturbances would mediate the association between chronotype and depressive symptoms in adult video game players. Participants were 1208 adults (86.7% men, mean age 27.4 ± 8.07 years) who regularly play video games. Chronotype was assessed with the Morningness-Eveningness Questionnaire, the Centre for Epidemiological Studies Depression Scale was used to measure depressive symptoms, and sleep disturbance was evaluated with the Athens Insomnia Scale.

RESULTS
We found that adults who play video games and show an evening chronotype preference spent more time playing than those with a more intermediate or morning preference. An evening chronotype was linked to a higher level of depressive symptoms, and our bootstrap mediation analysis revealed that sleep disturbances partly mediated this association (β = −.15, *SE* = .02, 95% CI [−.19; −.11]).

CONCLUSIONS
Our study suggests that an evening chronotype should be considered when exploring psychological risk factors contributing to the development of problematic gaming. In adults who play video games and display a tendency towards eveningness, higher rates of depressive symptoms may be partly explained by inadequate sleep.

KEY WORDS
chronotype; sleep disturbance; depressive symptoms; video games; mediation analysis

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BACKGROUND

Approximately one billion people play video games every day, and in addition to being a recreation and an e-sport, playing video games may be associated with cognitive benefits (Entertainment Software Association, 2023; Pallavicini et al., 2018). Nonetheless, some gamers develop pathological patterns of play. The inclusion of internet gaming disorder (IGD) in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), and of gaming disorder (GD) in the 11th edition of the International Classification of Diseases (ICD-11; WHO, 2019) has led to increased research on this problem. However, lack of standardized definitions and measuring tools has resulted in varying prevalence of gaming addiction in the population (0.2% to 34%) (Kristensen et al., 2021).

There is a growing recognition that gaming, in particular when prolonged and near bedtime or at night, can displace sleep, cause arousal, and lead to muscular discomfort and headaches (Kristensen et al., 2021). The blue-spectrum light emitted by gaming screens can also directly increase alertness and arousal, suppress melatonin secretion, which is important for regulating the sleep-wake cycle, and contribute to difficulties with falling asleep. Relatedly, excessive gaming behavior can also be a risk factor for depressive symptoms (Colder Carras et al., 2020).

Interestingly, there are data suggesting that sleep disturbances may mediate the relationship between gaming and depression since several studies have found that excessive gaming can lead to delayed bedtimes, shorter sleep duration, and disrupted sleep patterns, which can subsequently increase the risk of depressive symptoms (Vollmer et al., 2014; Weaver et al., 2010). However, it is important to note that the relationship between gaming and depression is complex and can be influenced by various factors such as the content of the games played and individual characteristics of gamers (Allen & Anderson, 2018; Rehbein et al., 2015).

Considering the large number of individuals who play video games, studying predictors of inappropriate play patterns is essential to better understand this phenomenon, and to prevent negative consequences such as sleep problems and depression. At the same time, it is important to stress that long hours spent playing games should not be automatically assumed as problematic, as they could be a matter of intentional choice, a coping mechanism, or a way of making a living (Kardefelt-Winther et al., 2017). In addition, as sleep disturbances and depression are a major health and social issue, understanding the relationship between gaming, poor sleep and depression is critical for both scientific and practical purposes. In this way, we can not only contribute to the growth of scientific knowledge, but also propose specific actions to improve subjective well-being and overall health. According to the evidence presented earlier, it can be concluded that gaming becomes problematic not only when players spend extended time playing that is having a negative impact on their life, but also when they continue playing at a time when they should be sleeping (Kemp et al., 2021; Kristensen et al., 2021). Therefore, the time of using computer games is important. The chronotype, a natural tendency to be awake or asleep at a certain time, influences the preference of the time in which an individual plays games. Evening types appear to be more likely to suffer from the negative effects of both late-night video gaming and not getting enough sleep (Merikanto et al., 2012). Additionally, an evening chronotype is associated with a higher risk of depressive symptoms (Norbury, 2021). We therefore assume that an evening chronotype is an important factor potentially contributing to the development of a harmful gaming pattern, which is associated with a higher risk of disturbed sleep and depression.

CHRONOTYPE, SLEEP DISTURBANCES, DEPRESSION AND PROBLEMATIC GAME PLAY

Chronotype, an individual variation in circadian rhythms, determines whether individuals are inclined towards morning or evening hours for work, intellectual activity and leisure pursuits, as reflected by objective effectiveness of activities and by mood oscillations (Jankowski & Zajenkowski, 2016). Chronotype is also linked to individual preferences for bedtimes and rise times (Vollmer et al., 2012), which are influenced by genetic, social and environmental factors (Adan et al., 2012).

Evening-oriented individuals are more likely to experience sleep problems such as difficulty with falling asleep, delayed sleep onset, and a shorter sleep duration (Merikanto et al., 2012; Van den Berg et al., 2018). Their internal biological rhythms are often misaligned with societal demands, leading to difficulties in adjusting sleep-wake schedules (Adan et al., 2012). Chronotype differences can also influence the risk of developing sleep disorders such as delayed sleep phase disorder (Roenneberg & Merrow, 2007).

Additionally, individuals with an evening chronotype have a greater vulnerability towards developing depression (Norbury, 2021). The misalignment between their internal biological rhythms and societal demands can lead to increased stress and mood disturbances. For this reason, these individuals also have a higher propensity for addictive behaviors such as craving cigarettes and alcohol use (Prat & Adan, 2011). Additionally, evening types spend more time engaged with screens (Vollmer et al., 2012), including problematic smartphone use (Randjelovic et al., 2021). Importantly, compared to individuals with other chrono-

types, those with an evening preference dedicate more time to computer gaming (Urbán et al., 2011), and both prolonged and problematic gaming behaviors are also more prevalent in these individuals (Vollmer et al., 2014). Relatedly, evening-oriented individuals tend to have a higher risk of game addiction (Charlton & Danforth, 2007). This may be explained by a finding that an evening chronotype is associated with a higher level of engagement in gaming activities, resulting in a difficulty in disengaging from gameplay (Vollmer et al., 2014), which subsequently leads to signs of problematic or addictive gaming behaviors. The tendency to stay awake and engage in late-night gaming sessions can lead to disrupted sleep patterns and further contribute to the development of addictive gaming behaviors (Charlton & Danforth, 2007; Lemola et al., 2011).

SLEEP, DEPRESSION AND PROBLEMATIC GAME PLAY

Epidemiological studies suggest that sleep disturbances are present in over 80% of those with depression (Stewart et al., 2006). However, systematic reviews and meta-analyses of prospective data have reported that insomnia disorder increases the risk of future depression more than twofold while too short and too long sleep also significantly increase the probability of future depression (Hertenstein et al., 2019). It is thus now recognized that the associations between aberrant sleep patterns and depression are not unidirectional; for some individuals insomnia disorder or symptoms precede depression onset, while for others both conditions occur at the same time. Is it also plausible that sleep disturbances and depression share common etiological factors (Staner, 2010).

Furthermore, a meta-analysis by Kristensen et al. (2021) based on problematic gamers found that this population had reduced sleep duration, lower sleep quality, and greater daytime sleepiness. While these data cannot be extrapolated to individuals whose gaming behavior does not meet the DSM-5 or ICD-11 diagnostic criteria, a recent review based on habitual gamers (defined as "individuals who self-identified as gamers or individuals who played games regularly or consistently") corroborated Kristensen et al.'s (2021) findings. Specifically, in comparison with those who did not play video games, playing for > 1 hour a day was associated with poor sleep quality, longer sleep latency, and lower sleep efficiency. Gaming was also linked to later bedtimes and rise times (Kemp et al., 2021).

SUMMARY AND HYPOTHESIS

Herein we present evidence showing that playing video games, particularly if prolonged or considered as problematic, has negative consequences for sleep and emotional well-being, in particular depressive symptoms. We further discuss data indicating that problematic gaming behavior is correlated with an evening chronotype, which is also linked to a greater risk of sleep and mood disturbances. Therefore, in an attempt to integrate these lines of empirical evidence, we decided to test whether sleep disturbances mediate the association between chronotype and depressive symptoms in a sample of adults playing video games.

PARTICIPANTS AND PROCEDURE

PARTICIPANTS

Participants (age ≥ 18 years; $N = 1208$) were recruited through social media channels that included Reddit, Discord, and Facebook. Potential participants who indicated that they did not play video games were not invited to this study, and there were no other exclusion criteria. Participation in this study was voluntary, responses were fully anonymous, and those who took part were not paid for their time. Recruitment took place from June until October 2022. The study was approved by the Ethics Committee at the Faculty of Psychology of the SWPS University.

PROCEDURE

After giving online consent, all participants provided information on demographic, social and economic variables. Next, participants were asked to complete questions about their gaming behavior, following by sleep, depressive symptoms and chronotype questionnaires. All data collection was in English since the aim was to recruit participants from Europe (and beyond), but no particular country was targeted in this study.

MEASURES

Background measures. Participants were asked about their age, sex, country of residence and a range of socio-economic data including education, type of work, relationship status, and number of children.

Gaming. Participants indicated whether they played online or as a single player, and gave information about the daily time they spent playing video games. We also enquired about the genre of games and present these data in Table S1 in Supplementary materials.

Chronotype. Chronotype was assessed with the 19-item Morningness-Eveningness Questionnaire (Horne & Östberg, 1976). Scores were summed, with higher ones suggesting a more morning preference. Based on the cut-offs described by Horne and Östberg (1976), scores can also be divided to reflect dis-

crete diurnal preferences: scores of 16-41 indicate an evening preference, scores of 42-58 reflect an intermediate chronotype, while scores over 58 indicate a morning preference. The Cronbach α was .85.

Depressive symptoms. Depressive symptoms were measured with the 20-item Center for Epidemiologic Studies Depression Scale (CES-D) by Radloff (1977). In this scale, answers can range from 0 (*rarely or none of the time*) to 3 (*all of the time*), with higher scores indicating greater mood disturbances. Additionally, based on the well-established cut-off point of 16, we divided participants into those without or with mild depressive symptoms (< 16), and those with elevated depressive symptoms (≥ 16). The Cronbach α was .91.

Sleep. Sleep disturbances were assessed with the Athens Insomnia Scale (Soldatos et al., 2000), an 8-item questionnaire asking about the most frequent insomnia symptoms in the past month. On this scale answers are scored from 0 (*no problem*) to 3 indicating a severe difficulty with a given symptom. Scores were summed, with greater scores reflecting higher disturbances. Additionally, based on the cut-offs described by Okajima et al. (2020), we divided participants into those without sleep issues (≤ 5) and those with sleep disturbances (≥ 6). The Cronbach α was .81.

STATISTICAL ANALYSIS

All analyses were performed using IBM SPSS Statistics (version 28). Chi-squared tests were performed to test associations between chronotype expressed in subtypes (evening, intermediate, morning) and daily time spent playing video games as well as depressive and sleep symptoms. Mediation analysis was carried out using PROCESS package version 4.2. The total effect (c) represents the sum of the direct and indirect effect of chronotype on depressive symptoms. The direct effect (c′) is the effect of chronotype on depressive symptoms after adjustment for sleep disturbance. Finally, the indirect effect (ab) is the effect of chronotype on depressive symptoms through sleep disturbances. See Supplementary materials for Figure 1 depicting the conceptual model tested in our study. The results are presented as unstandardized coefficients, standard errors (*SE*) and 95% confidence intervals (95% CI). For indirect effects, 95% CI were calculated using bootstrapping, with 5000 bias-correcting (Bc) bootstrap samples (5000 is a default option in the PROCESS package version 4.2). We used 95% CI (for direct and total effects) and Bc 95% CI (for indirect effects), rather than *p*-values, to infer whether the observed effects were statistically significant. Since chronotype ($r = .17$, $p < .001$) and depressive symptoms ($r = -.10$, $p < .001$) were associated with age, we used age as a covariate. Sleep problems were not associated with age ($p = .420$). Chronotype was not associated with sex ($p = .579$), but sex differences were evident with regards to sleep disturbances ($p < .001$) and depressive symptoms ($p < .001$), with women and participants who were non-binary reporting greater sleep and depression complaints. We thus decided to use sex as a covariate as well.

RESULTS

SAMPLE CHARACTERISTICS

As shown in Table 1, participants were on average 27 years old and the majority were male and single. Almost 46% of participants had a university degree, about 46% were in full time work, and 25% were students. To save space we do not to show data on participants' country of residence in Table 1, since we had participants from over 30 countries, but the five countries with the highest number of participants were Germany ($n = 331$), the United States ($n = 178$), Italy ($n = 177$), the United Kingdom ($n = 80$), and Spain ($n = 65$). In terms of playing video games, the majority of participants classified themselves as "an online player", and the "3-4 hours" duration was the most often endorsed daily duration spent playing games (38.3%), followed by "1-2 hours" (26.7%) and "5-6 hours" (21.4%) categories. The average score on the Morningness-Eveningness Questionnaire was 45.9 ($SD = 10.7$) corresponding to an intermediate chronotype. On the CES-D scale, the mean score was 16.6 ($SD = 11.2$), which means that on average our participants had elevated depressive symptoms. Indeed, 45% of the sample was over the ≥ 16 cut-off point on the CES-D. Finally, the average sleep score was 5.3 ($SD = 3.9$), and nearly 41% of the sample had elevated sleep disturbances.

There was a significant association between time spent playing video games and one's chronotype ($p < .001$); namely the shortest duration ("1-2 hours") was more often selected by a morning and an intermediate chronotype than by an evening chronotype, while "5-6 hours", "7-8 hours" and "≥ 8 hours" durations were nearly twice as frequent among those who were in the evening chronotype category than among those who were morning chronotypes (see Table 2). Exploration of distribution of elevated depressive symptoms and elevated sleep disturbances also showed significant associations with chronotype category ($p < .001$ for both variables); 57.0% of those with an evening chronotype had raised scores on the CES-D and 52.5% of them had elevated sleep problems, while this was the case for 35.9% and 27.5%, respectively, of participants who were in the morning chronotype category (see Table 3).

In bivariate correlations (see Table 4), chronotype was negatively associated with sleep and depressive symptoms, indicating that participants with an evening preference were more likely to have sleep and

Table 1

Descriptive statistics of study variables

	Frequency (%) or mean (*SD*)
Age	27.4 (8.07)
Sex	
Male	1047 (86.7)
Female	121 (10.0)
Non-binary	25 (2.1)
Rather not say	14 (1.2)
Relationship status	
Single	704 (58.3)
In a relationship	216 (17.9)
Married/cohabiting	275 (22.8)
Divorced/separated	13 (1.1)
No. of children[a]	
0	1086 (89.9)
1	51 (4.2)
2	48 (4.0)
Education	
High school	423 (35.0)
College	220 (18.2)
Degree (up to master's)	539 (44.6)
Doctorate	26 (2.2)
Type of employment	
Full-time	555 (45.9)
Part-time	102 (8.4)
Self-employed/own business	60 (5.0)
Unemployed	153 (12.7)
Student	319 (26.4)
Retired	19 (1.6)
Type of player	
Online	893 (73.9)
Single player	315 (26.1)
Daily time spent playing video games	
1-2 hours	323 (26.7)
3-4 hours	463 (38.3)
5-6 hours	259 (21.4)
7-8 hours	71 (5.9)
≥ 8 hours	92 (7.6)
Chronotype (range 20-80)	45.9 (10.7)
Chronotype (divided into subtypes)	
Evening	421 (34.9)
Intermediate	634 (52.5)
Morning	153 (12.7)
Depressive symptoms (range 0-56)	16.6 (11.2)
Depressive symptoms (binary division)	
< 16	663 (54.9)
≥ 16	545 (45.1)
Sleep disturbance (range 0-24)	5.3 (3.9)
Sleep disturbance (binary division)	
≤ 5	714 (59.1)
≥ 6	494 (40.9)

Note. [a]There were no participants in our study who reported having 3 or more children, and $n = 23$ (1.9%) did not provide data on this variable.

mood complaints. The association between sleep and depressive symptoms was quite strong in our data, and a higher level of sleep disturbances correlated with greater depressive symptoms.

MEDIATION ANALYSIS

In line with our bivariate correlations, our mediation analysis revealed that chronotype was a significant predictor of sleep disturbances (path a: $\beta = -.09$, $SE = .01$, 95% CI [−.11; −.07]), indicating that participants with an evening chronotype reported poorer sleep. Poor sleep was also predictive of greater depressive symptoms (path b: $\beta = 1.66$, $SE = .07$, 95% CI [1.53; 1.80]). The total effect of chronotype on depressive symptoms was significant (path c: $\beta = -.23$, $SE = .03$, 95% CI [−.28; −.17]), again indicating that those with a more evening chronotype reported greater mood disturbances. In the direct effect (path c′: $\beta = -.08$, $SE = .02$, 95% CI [−.13; −.03]) chronotype remained a significant albeit a smaller predictor of depressive symptoms, which means that the relationship between chronotype and depressive symptoms was not fully mediated through sleep disturbances. However, the result of the indirect effect reflecting an effect of chro-

Table 2

Distribution of daily time spent playing video games by chronotype

	Frequency (%)				
Chronotype	1-2 h	3-4 h	5-6 h	7-8 h	≥ 8 h
Evening	62 (14.7)	156 (37.1)	118 (28.0)	38 (9.3)	46 (10.9)
Intermediate	192 (30.3)	262 (41.3)	117 (18.5)	25 (3.9)	38 (6.0)
Morning	69 (45.1)	45 (29.4)	24 (15.7)	7 (4.6)	8 (5.2)

Table 3

Distribution of elevated depressive symptoms and sleep disturbances by chronotype

	Frequency (%)			
Chronotype	CES-D < 16	CES-D ≥ 16	Sleep disturbance ≤ 5	Sleep disturbance ≥ 6
Evening	181 (43.0)	240 (57.0)	200 (47.5)	221 (52.5)
Intermediate	384 (60.6)	250 (39.4)	403 (63.6)	231 (36.4)
Morning	98 (64.1)	55 (35.9)	111 (72.5)	42 (27.5)

Note. CES-D – Center for Epidemiologic Studies Depression Scale.

Table 4

Bivariate correlations between chronotype, depressive symptoms and sleep disturbances

	Chronotype	Depressive symptoms	Sleep disturbance
Chronotype	1	−.23*	−.25*
Depressive symptoms		1	.61*
Sleep disturbance			1

Note. *$p < .001$.

notype on depressive symptoms through sleep disturbances was significant (path ab: $\beta = -.15$, $SE = .02$, 95% CI [−.19; −.11]), suggesting that in our data, sleep disturbances partially mediated the relationship between chronotype and depressive symptoms.

It needs to be acknowledged that the conducted mediational analyses do not determine the causal relationship between the analyzed variables. In fact, one may also consider the reverse relationship in the way that depression mediates the relationship between chronotype and sleep. Thus, the decision was made to test such a model, which was adjusted for age and sex as was the case in the main mediation analysis. The indirect effect was significant, though weaker in comparison to the one reported above (path ab: $\beta = -.05$, $SE = .01$, 95% CI [−.06; −.03]).

DISCUSSION

This study set out to test whether sleep disturbances would mediate the association between chronotype and depressive symptoms in adult video game players. Our results revealed that indeed in adults who play video games those with an evening chronotype had higher levels of depressive symptoms, which was partly explained by disturbed sleep.

In order to test our hypothesis, we integrated a few lines of evidence that have been rarely explored in one study alone. First, in support of the extant literature, we found that an evening chronotype was associated with more disturbed sleep and greater depressive symptoms (Merikanto et al., 2012; Norbury, 2021). Second, also in line with past studies (Urbán et al., 2011; Vollmer et al., 2014), we discovered that adults who play video games and show a tendency towards eveningness spent more time playing than their counterparts with a more intermediate or morning preference. Third, although there is evidence that having an evening chronotype increases one's risk of depressive symptoms and depression disorder, the precise mechanisms linking these phenomena are not well understood (Norbury, 2021). The possibility that individuals with an evening chronotype may

have greater risk of experiencing depressive symptoms through disturbed sleep was suggested a number of years ago, but to date only a few studies, which were predominantly based on university students (Horne et al., 2019; Van den Berg et al., 2018), have researched this hypothesis, and indeed found support for this notion. Importantly, we now extend these data to a large sample of adult video game players.

In our data, the association between an evening chronotype and greater depressive symptoms was only partially mediated by disturbed sleep. This supports findings by Horne et al. (2019), where sleep problems were also a partial mediator of the association between chronotype and depressive symptoms. In contrast, another study conducted among university students found that the relationship between morningness–eveningness and depressed mood was entirely explained by poor sleep quality (Bakotic et al., 2017). However, in a sample of adults with a major depressive disorder, sleep disturbance did not mediate an association between eveningness and depression severity (Müller et al., 2016). These findings suggest that sleep disturbance may be an (important) contributor to the development of depressive symptoms in those with an evening chronotype, but certainly other factors are also likely to be implicated, such as problematic cognitive emotion regulation strategies including self-blame (Van den Berg et al., 2018), cognitive reactivity (e.g. rumination) (Antypa et al., 2017), or personality characteristics including neuroticism or low consciousness (Gorgol et al., 2022). It is also plausible that in certain populations (e.g. university students) sleep may be a more important mediator than in other groups, such as those diagnosed with a major depressive disorder (Müller et al., 2016).

Our study has a number of limitations. Our data are cross-sectional, and hence caution is needed when making interpretations about the temporal precedence of the studied relationships. Although we found that an evening chronotype preference was associated with greater depressive symptoms partly through sleep disturbances, these relationships could also exist through reverse causality or via another unmeasured variable (Norbury, 2021). Sleep was measured with self-report, which is affected by biases, and objective and subjective sleep data are only moderately correlated. We did not ask participants which or how many different gaming platforms (e.g. computer, console, smartphone) they used. This is important as different platforms can impact sleep differentially, for example, through light exposure or different levels of arousal (Kemp et al., 2021). We also did not ask participants if they had a (past or present) diagnosis of computer game addiction, major depressive disorder or insomnia, so it is possible that some of our participants had one or more than one of these disorders, which could have biased our results. We did not have a control group, which is another shortcoming of this study. Finally, there exist sex differences in game experience and preferences (Terlecki et al., 2011), but because only 10% of our participants were female (n = 121), running our analyses separately in men and women would have provided unreliable results due to low statistical power.

CONCLUSIONS

Playing video games is a popular pastime activity among children, adolescents and adults alike. In addition to being a recreation and an e-sport that can have some cognitive benefits, there is evidence that gaming behavior can become an addiction. Our study suggests that an evening chronotype should be considered when exploring psychological risk factors contributing to the development of problematic gaming. In adults who play video games and display a tendency towards eveningness, higher rates of depressive symptoms may be partly explained by inadequate sleep.

Supplementary materials are available on the journal's website.

Disclosures

This research received no external funding.
The study was approved by the Ethics Committee at the Faculty of Psychology of the SWPS University (Approval No. WKE/S 2020/9/XI/94).
The authors declare no conflict of interest.

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