

Late Sleepers Are More Prone to Anxiety and Depression: A Weibo-Based Study

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Abstract

[Objective] This study aimed to explore the relationship between night-owl behavior and anxiety and depression using large-scale Weibo data. [Methods] Based on nocturnal activity status, this study divided 1 million active Weibo users into a night-owl group and a non-night-owl group, and compared the word frequencies of anxiety- and depression-related terms in their posted messages. [Results] Independent samples t-tests revealed that the night-owl group exhibited significantly higher frequencies of anxiety-related words than the non-night-owl group, $t=36.86$, $p<0.001$; the night-owl group also showed significantly higher frequencies of depression-related words than the non-night-owl group, $t=49.71$, $p<0.001$. [Limitations] Word frequency analysis is not entirely equivalent to assessing anxiety and depression via standardized psychological scales. While big data-based word frequency analysis offers an efficient methodological approach, it cannot fully substitute for rigorous psychological measurement. [Conclusion] Delayed sleep timing adversely affects sleep quality; night-owl individuals are more vulnerable to anxiety and depression.

Full Text

Delayed Sleepers Experience More Anxiety and Depression: A Study Based on Weibo Data

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Abstract:

[Objective] To examine the relationship between delayed sleep and emotions

of anxiety and depression by analyzing big data from Weibo.

[Methods] The current study divided 1 million active Weibo users into a delayed sleep group and a non-delayed sleep group based on their nighttime activity patterns, and compared the frequency of anxiety- and depression-related words in the two groups' Weibo content.

[Results] Independent t-tests revealed that the frequency of anxiety and depression expressions were significantly higher in the delayed sleep group, $t = 36.86$, $p < 0.001$, and $t = 49.71$, $p < 0.001$, respectively.

[Limitations] While word frequency analysis based on big data provides an efficient research approach, it is not equivalent to measuring anxiety and depression emotions obtained from psychological scales and cannot replace rigorous psychological measurement.

[Conclusions] Delayed sleep impairs sleep quality; delayed sleepers are more susceptible to anxiety and depression.

Keywords: sleep problems, delayed sleep, Weibo, anxiety, depression

1 Introduction

For most people, mental alertness peaks in the morning, followed by a fatigue period in the afternoon, and by nighttime the body requires sleep. "Rising at sunrise and resting at sunset" summarizes millennia of human activity patterns. The Industrial Revolution disrupted this pattern to some extent, as electric lighting enabled nighttime work and entertainment, while modern smartphones and computers have further delayed bedtimes. Nevertheless, most people still generally follow a pattern of daytime work and nighttime rest. In the late nineteenth century, German physician Wilhelm Fließ and others proposed the concept of biological rhythms, suggesting that humans developed adaptive cycles to better survive in accordance with nature's periodic patterns. For instance, to adapt to the sun's daily cycle, the hypothalamus secretes adenosine and melatonin to promote sleep. Sleep is crucial for humans, playing an essential role not only in the growth and development of brain nerve cells but also in daily life by relieving fatigue and restoring bodily functions. Research has found that the human brain can efficiently clear metabolic waste during sleep, demonstrating the importance of sleep at the molecular level [?].

Sleep disorders represent a significant problem, affecting at least 10% of the population. With the proliferation of mobile electronic devices, internet access, and accelerated life pace, factors such as mobile entertainment, chatting, and overtime work have progressively delayed sleep onset, making delayed sleep increasingly common. Anxiety refers to an unhealthy psychological state of tension arising from internal stress, conflict, and contradiction, preventing relaxation and emotional balance, typically manifesting as suppression, irritability, dissatisfaction, anger, impulsivity, and irrational emotions or behaviors [?]. Depression is an affective disorder characterized primarily by low mood, disap-

pointment, and helplessness. Depressed individuals often feel sad, experience low mood, lose interest in external activities or previously enjoyable matters, cannot derive pleasure from life, and suffer from decreased self-confidence, fatigue, self-blame, and slowed mental activity [?].

Sleep disturbances are very common in depression. Research indicates that over 90% of patients with major depressive disorder experience insomnia or daytime sleepiness, leading sleep disorders to be included as a diagnostic criterion for depression. Yang et al. investigated the relationship between sleep quality and anxiety-depression emotions among medical students using the Pittsburgh Sleep Quality Index, Self-Rating Anxiety Scale, and Self-Rating Depression Scale, finding significant positive correlations between sleep quality and both anxiety and depression [?]. Meng et al. similarly found significant positive correlations between sleep quality and anxiety-depression emotions, with analysis of factors affecting sleep quality revealing the following order of influence: sleep efficiency, sleep disorders, sleep onset time, daytime dysfunction, hypnotic medication, and insomnia duration [?]. Huang et al. studied 93 patients presenting with insomnia complaints who had undergone psychological evaluation, using the Minnesota Multiphasic Personality Inventory (MMPI) for assessment. Patients were divided into sleep disorder and non-sleep disorder groups based on sleep disorder factor scores, with comparisons made across age, anxiety factors, repression factors, manifest anxiety, ego strength, subjective depression, manifest depression, and latent depression. Results showed that the sleep disorder group scored significantly higher on four factors: anxiety, manifest anxiety, subjective depression, and manifest depression [?]. The study also examined relationships between sleep disorders and these psychological factors, finding positive correlations between sleep disorders and anxiety factors, manifest anxiety, subjective depression, and manifest depression. Thus, sleep disorders likely represent one manifestation of somatization in patients with depression or anxiety, and individuals with sleep disorders often experience accompanying anxiety and depression. As sleep onset time is an important factor affecting sleep quality, does it also influence anxiety and depression emotions?

McIver et al. (2015) collected and analyzed comprehensive Twitter data from users, finding that although users with sleep disorders showed significantly lower overall Twitter activity, mutual follows, and follower counts than those without sleep disorders, they were more active during traditional sleep hours and expressed more negative emotions in their content [?]. Big data technology provides new methods and channels for understanding Chinese citizens' psychological and sleep conditions.

Weibo is a microblogging service launched by Sina.com that allows users to post messages or upload images via web, WAP, or mobile client. Users can share text, images, or videos with friends anytime and anywhere through computers or mobile phones for discussion and sharing; they can also repost and comment on others' posts and follow friends to see their updates instantly. Additionally, hot search lists provide access to the latest news events. According to Sina

Weibo's Q2 2017 financial report, monthly active users reached 361 million, a 28% year-over-year increase, with 92% being mobile users; daily active users reached 159 million, a 26% year-over-year increase. Weibo has surpassed Twitter to become the world's largest social media platform.

Previous research on sleep quality and depression/anxiety has primarily relied on questionnaires, which are highly subjective and susceptible to social desirability bias and other factors that may prevent accurate representation of true conditions. Our study aims to validate previous findings that poor sleep quality leads to increased anxiety and depression using big data methods based on Weibo, seeking a more timely and objective approach to understanding and monitoring negative emotions such as anxiety and depression, and providing new insights for big data-based psychological research. Based on this, we hypothesized that the frequency of depression- and anxiety-related vocabulary in posts by the delayed sleep group would be significantly higher than that in the non-delayed sleep group, indicating that delayed sleep leads to higher levels of depression and anxiety.

2 Methods

This study utilized big data from Sina Weibo, crawling all original posts from 1 million active Weibo users across China during eight weeks in 2017 (two weeks per quarter). We classified users into delayed sleep and non-delayed sleep groups based on their Weibo posting times and conducted text analysis on the content to assess users' emotional states according to the frequency of depression- and anxiety-related words. Specifically, we defined posts published between 0:00 and 4:00 AM as being posted while users were staying up late, indicating delayed sleep onset. We classified users into delayed sleep and non-delayed sleep groups by counting all posts published during these late-night hours across the eight weeks. To validate this grouping, we introduced the concept of sleep quality by analyzing whether the frequency of sleep quality-related words ("can't sleep" and "insomnia") in posts differed significantly between groups, thereby confirming whether actual sleep quality differences existed. We then analyzed whether significant differences existed in the frequency of depression- and anxiety-related words between the two groups to determine whether delayed sleep affects the development of such negative emotions.

2.1 Weibo User Data

Our sample comprised all original Weibo posts from 1 million active users nationwide during the following eight weeks: March 6-19, 2016; June 12-25, 2016; September 11-24, 2016; and December 11-24, 2016.

2.2 Emotion Word Selection

We selected emotional vocabulary reflecting depression and anxiety based on the Chinese Emotion Word Ontology compiled by the Information Retrieval Laboratory at Dalian University of Technology (Xu Linhong et al., 2008). This emotional classification system was constructed based on Ekman's influential six-category emotional classification framework. In this study, depression and anxiety corresponded to the "sadness" and "annoyance" categories in the ontology. The sadness category included 1,665 words such as "distressed" and "miserable," while the annoyance category included 1,279 words such as "irritable" and "upset."

2.3 Data Analysis

We counted the number of Weibo posts published by users between 0:00 and 4:00 AM. Users who posted more than once during this period were defined as the delayed sleep group, while those who posted once or not at all were defined as the non-delayed sleep group. To further verify the validity of this classification, we first used sleep quality as the dependent variable, selecting "insomnia" and "can't sleep" as keywords. We extracted the frequency of these two keywords from users' original Weibo content using Python 3.6 and conducted independent samples t-tests. Next, based on the Chinese Emotion Word Ontology compiled by the Dalian University of Technology, we identified 1,665 words expressing depression and 1,279 words expressing anxiety. Using Python 3.6, we extracted all original posts containing these category words posted between 0:00 and 4:00 AM by both groups and conducted independent samples t-tests on the word frequencies.

3 Results

3.1 Sleep Quality Differences Between Groups

Results showed significant differences in sleep quality between the delayed sleep and non-delayed sleep groups. The frequency of "can't sleep" and "insomnia" words was significantly higher in the delayed sleep group ($M = 0.09$, $SD = 0.65$) than in the non-delayed sleep group ($M = 0.05$, $SD = 0.41$), $t = -38.23$, $p < 0.001$. This validated the grouping rationale, indicating that delayed sleepers indeed experienced poorer sleep quality than non-delayed sleepers, confirming the validity of our classification.

3.2 Anxiety Differences Between Delayed Sleep and Non-Delayed Sleep Groups

Independent samples t-test analysis of anxiety-related word frequencies revealed that the delayed sleep group showed significantly higher anxiety word frequency than the non-delayed sleep group, $t = 36.86$, $p < 0.001$, indicating that delayed

sleepers are more prone to anxiety emotions (as shown in Figure 1 [Figure 1: see original paper]).

3.3 Depression Differences Between Delayed Sleep and Non-Delayed Sleep Groups

Independent samples t-test analysis of depression-related word frequencies revealed that the delayed sleep group showed significantly higher depression word frequency than the non-delayed sleep group, $t = 49.71$, $p < 0.001$, indicating that delayed sleepers are more prone to depression emotions (as shown in Figure 1 [Figure 1: see original paper]).

Figure 1 Emotional word frequency differences between delayed sleep and non-delayed sleep groups

4 Discussion

This study examined the impact of delayed sleep behavior on anxiety and depression emotions among Weibo users, finding that emotional expressions of anxiety and depression were significantly higher in the delayed sleep group than in the non-delayed sleep group. These results validate previous findings and confirm their credibility. Previous studies on sleep and anxiety-depression relationships among college students, medical students, and insomnia patients have all found significant correlations between sleep disorders and anxiety/depression. Our study demonstrates that delayed sleepers exhibit more anxiety and depression than non-delayed sleepers, and that non-delayed sleepers enjoy better sleep quality.

Sleep is a crucial factor in maintaining physical and mental health. In today's rapidly developing era, individuals must not only quickly adapt to changes but also respond rapidly to remain competitive and avoid social elimination, making overtime work commonplace. Long-term competitive states mean sustained high psychological pressure, which not only triggers anxiety but also significantly affects sleep quality, leaving individuals physically and mentally exhausted. Meanwhile, the proliferation of smartphones, tablets, and other electronic devices has led many to develop pre-sleep usage habits, which can cause physiological or emotional arousal and affect sleep onset. Additionally, various life and interpersonal issues can also affect emotions, leading to difficulties falling asleep, frequent dreams, easy awakening, and poor sleep quality.

Independent samples t-tests on anxiety-related keywords in posts by delayed sleep and non-delayed sleep groups revealed that delayed sleepers exhibited higher levels of anxiety. This may be because substantial life pressures create anxiety that continuously compresses sleep duration and quality, while decreased sleep quality leads to mental fatigue, daytime attention deficits, and

reduced learning and work efficiency. Over time, this inevitably affects individuals' learning, work, and life, further worsening their anxiety.

Independent samples t-tests on depression-related keywords revealed that delayed sleepers exhibited higher levels of depression. Clinical practice shows that patients with anxiety and depression often present with poor sleep quality, and those with poor sleep quality often experience anxiety and depression, indicating a complex bidirectional relationship between sleep quality and anxiety/depression [?].

5 Conclusion

This study used big data methods to analyze the impact of delayed sleep behavior on anxiety and depression expression among Weibo users. Results showed that individuals who stay up late are more likely to experience negative emotions such as anxiety and depression, consistent with previous research findings. That is, delayed sleep onset affects sleep quality, thereby generating more anxiety and depression.

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Bi Yajie: Methods writing

Zhang Hong: Results writing

Zhu Tingshao: Data provision, research supervision

Note: Figure translations are in progress. See original paper for figures.

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