Effects of Irregular Bedtime on Sleep Quality, Daytime Sleepiness, and Fatigue among University Students in Taiwan

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Abstract

Background

Irregular bedtime schedule is a prevalent problem in young adults and could be a factor detrimentally affecting sleep quality. The goal of the present study was to explore the association between irregular bedtime schedule and sleep quality, daytime sleepiness, and fatigue in undergraduate students in Taiwan.

Methods

A total of 160 students underwent a semi-structured interview and completed a survey comprising four parts: Pittsburg Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS), Fatigue Severity Scale (FSS), and a rating of irregular bedtime frequency. Participants underwent a semi-structured interview to assess their bedtime schedule and grouped in terms of irregular bedtime frequency into 3 groups: low, intermediate, or high. To screen for psychological disorders or distress that may have affected responses on the sleep assessment measures, the CHQ-12 (Chinese health questionnaire-12) was also administered.

Results

We found that an increase in bedtime schedule irregularity significantly decreased the
average sleep time per day (Spearman $r = -0.22$, $p = 0.05$). Multivariable regression revealed that irregular bedtime frequency and average sleep time per day were correlated with PSQI scores, but not with ESS or FSS scores. A significantly positive correlation between irregular bedtime frequency and PSQI scores was evident in the intermediate and high frequency groups compared to low frequency group (partial $r = 0.18$, $p = 0.02$, and partial $r = 0.15$, $p = 0.05$, respectively).

**Conclusions**

The results of our study suggest a high prevalence of both an irregular bedtime schedule and insufficient sleep in university students in Taiwan. Students with an irregular bedtime schedule may experience poor sleep quality. Further research exploring the mechanisms involved in an irregular bedtime schedule, and the effectiveness of interventions for improving this condition is encouraged.
Background

Some behaviours or activities are detrimental to normal sleep have been suggested. These “inadequate sleep hygiene” behaviours include irregular sleep schedules, frequent or prolonged daytime naps, excessive alcohol consumption before bedtime, and staying on one’s bed for non-sleep-related activities [1-3]. Accordingly, adequate sleep hygiene is considered to be an important adjuvant for treating patients with insomnia or other sleep disturbances [1,3,4]. However, in normal subjects, who have not been affected by these pathological conditions, the associations between sleep hygiene and sleep itself is surprising inconsistent [5-8].

In humans, sleep is regulated by two main processes: the sleep homeostatic drive, influenced by experienced durations of sleep and wakefulness, and the circadian system, an intrinsic pacemaker involving a pathway from the suprachiasmatic nucleus to the hypothalamus [9]. The circadian system has complex interactions with daily behaviours, known as entraining factors. It is thought that having a regular bedtime schedule can strengthen the circadian rhythm, and is beneficial for achieving a good quality of sleep [10]. In addition, people with an irregular bedtime schedule could be prone to chronic sleep insufficiency and associated problems. Many studies have identified that accumulated sleep deprivation results in impairments in cognition, vigilance, and memory, and disturbances of mood [11-14].
Even one-night alteration to a sleep schedule can be sufficient to induce difficulties with sleep initiation and maintenance. A series of early studies conducted by Taub et al. on young adults showed that an acute shift of 2 hours in sleep schedules without altering the duration of sleep also resulted in decreased cognitive and psychological functioning in a laboratory setting [15-18]. However, it is unclear if this finding can be generalised to real life conditions over long durations. Studies have shown that a shift in the sleep-wake schedule of shift workers adversely affects sleep and general health, and results in decreased sleep quality, altered sympathetic activity, increased cardiovascular risks, and reduced cognitive performance [19-21]. Nevertheless, the shifting sleep/wake pattern of shift workers differs greatly from that of young adults; the phase shifts of the latter are shorter but more irregular than the former. This suggests that the data obtained regarding shift workers may not adequately represent that for young adults having an irregular sleep schedule.

Although the prevalence varies, it has been observed that many adolescents and young adults have an irregular sleep schedule and a tendency to sleep late (phase-delayed sleep) [22-26]. A remarkable degree of sleep problems and poor sleep quality in university students has also been observed in many Western countries.
[22-26]. However, to our knowledge, the data regarding sleep patterns and habits in China is limited. It is necessary to directly investigate this issue in the Chinese population, because ethnicity, social factors, and cultural effects affect sleep habits [24,26]. The purpose of the present study was to investigate sleep quality and associated daytime effects in Chinese undergraduate students. We were particularly interested in determining how bedtime schedule relates to sleep quality and daytime functioning.
Methods

Sampling and study population

The Taipei Medical University Hospital Review Board approved the study. All participants gave their informed consents. A semi-structured survey was given to a random sample of first-year undergraduate students from a medical university in Taipei, Taiwan. We excluded subjects with a history of either chronic medical or psychotic disorders, as well as those currently on medication. Of 197 students interviewed, 160 (81.2%) completed the survey; 81 males and 79 females, with a mean age of 20.3 ± 1.9 years were included in the study.

Measures and data management

The survey included three questionnaires evaluating sleep quality, daytime sleepiness, fatigue, and irregular bedtime frequency. Sleep quality was assessed using the Pittsburg Sleep Quality Index (PSQI), which is widely accepted as a valid and reliable index [27,28]. The PSQI includes 19 items, and yields a score from 0 (good quality) to 21 (poor quality). Sleep onset latency and sleep efficiency, defined as the actual sleep time divided by the time in bed, can also be obtained with the PSQI. Daytime sleepiness was assessed using the Epworth Sleepiness Scale (ESS), a widely used and reliable predictor of daytime sleepiness [29]. The ESS uses a four-point scale to rank a
subject’s chances of falling asleep in different scenarios. Fatigue was evaluated using the Fatigue Severity Scale (FSS); this scale includes nine questions, yields a total score from 9 (no fatigue) to 63 (severe fatigue), and has been previously applied in clinical evaluations of fatigue [30,31].

A semi-structured interview to each subject was conducted to clarify the sleep schedule and estimate the average daily sleep time according the self-reported sleep log in prior 2 weeks. In order to decrease recall bias and uncertainty, irregular bedtime frequency was defined as the number of times a greater than 1 hour shift in bedtime from the usual bedtime had occurred in the past two weeks. The subjects were grouped into three categories: low, ≤1 night per week; intermediate, 1–3 nights per week; and high, ≥3 nights per week or not having a regular bedtime.

Subjects were also administered the CHQ-12 (Chinese health questionnaire-12) in order to screen for psychological disorders or distresses that may have affected responses on the sleep assessment measures. The CHQ-12 includes 12 items, and has been termed valid for use with the Chinese population [32]. Eleven students were excluded for having a CHQ-12 score greater than 2 points.
**Statistical analysis**

There were five major dependent variables: sleep onset latency, sleep efficiency, and scores for each of the PSQI, ESS, and FSS. The Student’s $t$-test was used to compare males and females with respect to each variable. The Chi-square test and Spearman’s correlation were used to analyse relationships between irregular bedtime frequency and average sleep time per day.

To control for the potential confounding effects of sleep insufficiency, multivariable linear regression adjusted for average daily sleep time per used to analyse how irregular bedtime frequency related to scores for each of the PSQI, ESS and FSS. Each level of irregular bedtime frequency was treated as a dummy variable for analysis. The significance level was set as $p < 0.05$. 
Results

There was no statistical difference for any variable between males and females; hence, the data for both genders was combined in all subsequent analyses. Across all subjects, the sleep onset latency was $14.2 \pm 10.6$ min, and the average daily sleep time was $6.7 \pm 1.3$ h. Scores for the FSS, ESS, and PSQI were $38.2 \pm 8.9$, $6.3 \pm 3.3$, and $4.9 \pm 2.4$, respectively. The data for all variables and subjects are summarized in Table 1.

With respect to irregular bedtime frequency, from the total number of students, $26.9\%$ were in the low frequency group (<1 night per week), $38.8\%$ were in the intermediate frequency group (1–3 nights per week), and $34.4\%$ were in the high frequency group (>3 nights per week). Nearly half of all subjects (46.9%) had an average daily sleep time <7 h. It is worth noting that the average daily sleep time was negatively correlated with irregular bedtime frequency ($r = -0.22$, $p < 0.05$). The distribution of average daily sleep time across irregular bedtime frequency groups is shown in Table 2.

Multivariable regression analysis revealed irregular bedtime frequency and average daily sleep time had a significant positive correlation with PSQI scores ($r = 0.61$, $p < 0.001$), but not ESS or FSS scores. With adjustment for average daily sleep time, this
relationship with PSQI scores was evident for the intermediate and high frequency
groups compared to low irregular bedtime frequency group (partial r = 0.18, p = 0.02;
partial r = 0.15; p = 0.05, respectively).

Discussion

Having an irregular bedtime schedule is considered to be one of the behaviours that
are detrimental to achieving good quality sleep. The results of the present study
support this idea and show that an irregular bedtime schedule most likely affects sleep
quality. We found some detrimental associations between an irregular bedtime
schedule and daytime functioning, although relationships concerning ESS and FSS
scores did not reach statistical significant values. We postulate that the irregular
bedtime frequency may cause disturbances to the circadian cycle affecting sleep
quality. Previous studies have shown circadian system disturbances as characterised
by disturbances in sleep architecture and sleep quality, and an inability to either fall
asleep or stay awake. These disturbances are also known to be associated with fatigue,
vigilance problems, decreased productivity, and negative health effects [10,33]. In
addition, environmental factors like light or noise can affect sleep quality in people
trying to obtain sufficient sleep after a shift in bedtime (e.g., trying to sleep until later
in the morning).
We found that students with a frequently irregular bedtime also had a shorter average sleep time per day, which could further put them at risk of sleep insufficiency. This finding may be partially explained by the daytime activity schedules of these students (involving either classes or recreation) limiting their ability to get enough sleep in the morning.

According to our data, there is a high prevalence of both an irregular bedtime schedule and short daily sleep time in undergraduate students in Taiwan. These findings are compatible with those of studies from other countries, thereby suggesting that poor sleep in university students may be a universal and prevalent problem of modern society [22,23,25]. In reviewing the research on sleep patterns in university students, Hicks et al. found the median sleep time to have dropped by about 1 hour over the past 20 years [34]. Lifestyle, social and academic schedules, and insufficient sleep education could all contribute to the aetiology of chronic sleep insufficiency and poor sleep in university students [22,23,35].

Reasons for the development of an irregular sleep schedule in young adults are not well understood, though are likely to be multi-factorial, including biological,
behavioural, and social factors. Social cues, subjects’ motivation, activities, and environmental factors all play important roles in setting human circadian rhythms; these can also entrain the sleep-wake cycle in terms of fine-tune adjustments to the intrinsic circadian rhythm [10]. Two endogenous circadian cycle expression patterns of alertness and sleepiness have been observed in the general population, with people typically being either a morning type (M-type), or an evening type (E-type) [36]. One study found that behaviour, especially in terms of sleep/wake schedule, differed between the two types, with the E-type tending to vary their times of going to bed and waking [37]. Taillard et al. found that the E-type was associated with an increased need for sleep as well as irregular sleeping habits, but not with subjective daytime sleepiness [38]. Further research is needed to clarify the underlying mechanism by which an irregular bedtime schedule develops.

Although we found that the consequences of an irregular bedtime schedule may be less significant than those of sleep insufficiency, the long-term effect should not be overlooked. It remains necessary that the importance of maintaining a regular sleep schedule be addressed. Students with an irregular bedtime schedule should be encouraged to make their bedtime more regular, and to increase their total sleep time. This might help to increase the sleep quality and daytime functioning of these
students. A structured approach to enhancing the sleep hygiene and relevant knowledge of university students has been developed, but the effectiveness of this approach remains to be confirmed [35].

The present study has some limitations. First, the self-reported estimation of average daily sleep time and irregular bedtime frequency may have been influenced by a recall bias. An objective assessment method such as actigraphy is required for more accurate measurements of these parameters. Moreover, the university medical students we studied might not be representative of the more general population of university students in Taiwan. A randomised, population-based study with a large sample size will be required to confirm our findings. A further limitation of our cross-sectional study is the difficulty in establishing causality. It is possible that subjects who have poor sleep quality (e.g., sleep onset difficulty or sleep fragmentation) could develop inadequate sleep habits, including an irregular sleep schedule. Longitudinal studies are thus required to clarify the cause-and-effect relationships between an irregular bedtime schedule and poor sleep quality. Finally, there are many different inadequate sleep habits and sleep-related behaviours likely to have a detrimental impact on sleep quality in normal subjects. Only one of these, an irregular bedtime schedule, was investigated in the present study, and future studies should take more of these factors
into consideration.

Conclusions

The results of the present study suggest that there is a high prevalence of both an irregular bedtime schedule and insufficient sleep among university students in Taiwan. Students with an irregular bedtime schedule may also experience poor sleep quality. Further research exploring the mechanisms involved in an irregular bedtime schedule, and the effectiveness of interventions for improving this condition is encouraged.

Competing interests

The authors declare no competing interests.

Authors’ contributions

JHK participated in designing the study, conducting the interviews, and performing data analysis, and drafted the manuscript. CSC participated in designing and coordinating the study. Both authors read and approved the final manuscript.

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conducting the interviews and data management.
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### Tables

**Table 1: Mean (SD) results of all measures for both genders and all subjects**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Female (n = 81)</th>
<th>Male (n = 79)</th>
<th>Total (n = 160)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOL (min)</td>
<td>15.2 (11.3)</td>
<td>12.9 (9.8)</td>
<td>14.2 (10.6)</td>
</tr>
<tr>
<td>SE (%)</td>
<td>89.0 (14.4)</td>
<td>91.1 (10.5)</td>
<td>90.1 (12.6)</td>
</tr>
<tr>
<td>ADST (h)</td>
<td>6.8 (1.4)</td>
<td>6.6 (1.1)</td>
<td>6.7 (1.3)</td>
</tr>
<tr>
<td>ESS</td>
<td>6.7 (3.2)</td>
<td>5.9 (3.4)</td>
<td>6.3 (3.3)</td>
</tr>
<tr>
<td>FSS</td>
<td>38.0 (8.5)</td>
<td>38.5 (9.4)</td>
<td>38.2 (8.9)</td>
</tr>
<tr>
<td>PSQI</td>
<td>5.0 (2.4)</td>
<td>4.8 (2.3)</td>
<td>4.9 (2.4)</td>
</tr>
</tbody>
</table>

SOL, sleep onset latency; SE, sleep efficiency; ADST, average daily sleep time; ESS, Epworth Sleepiness Scale; FSS, Fatigue Severity Scale; PSQI, Pittsburg Sleep Quality Index

There was no significant difference (p < 0.05) between genders with any variable.
Table 2: Number (%) of subjects in each irregular bedtime frequency group with an average daily sleep time <7 h/day, 7–8 h/day, or >8 h/day

<table>
<thead>
<tr>
<th>ADST*</th>
<th>Irregular bedtime frequency*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>14 (8.8)</td>
</tr>
<tr>
<td></td>
<td>Intermediate</td>
<td>17 (10.6)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>12 (7.5)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>43 (26.9)</td>
</tr>
</tbody>
</table>

ADST, average daily sleep time

* An irregular bedtime event was defined as >1 h shift from the usual bedtime. This occurred <1 night/week for the low-frequency group, 1–3 nights/week for the intermediate-frequency group, and >3 nights/week for the high-frequency group.

*Chi-Square analysis indicated that average daily sleep time differed significantly across the irregular bedtime frequency groups ($\chi^2 = 11.68, p = 0.022$); as supported by a significant Spearman correlation ($r = -0.22, p = 0.05$).
Table 3: Results of multivariable regression of irregular bedtime frequency and average daily sleep time on PSQI, ESS, and FSS scores

<table>
<thead>
<tr>
<th></th>
<th>ESS</th>
<th>FSS</th>
<th>PSQI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intermediate FIB (p-value)</strong></td>
<td>(0.389)</td>
<td>(0.132)</td>
<td>(0.02*)</td>
</tr>
<tr>
<td>Zero-order r</td>
<td>-0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Partial r</td>
<td>0.07</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td><strong>High FIB (p-value)</strong></td>
<td>(0.015*)</td>
<td>(0.124)</td>
<td>(0.05*)</td>
</tr>
<tr>
<td>Zero-order r</td>
<td>0.18</td>
<td>0.09</td>
<td>0.20</td>
</tr>
<tr>
<td>Partial r</td>
<td>0.19</td>
<td>0.12</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>ADST (p-value)</strong></td>
<td>(0.314)</td>
<td>(0.359)</td>
<td>(&lt;0.001*)</td>
</tr>
<tr>
<td>Zero-order r</td>
<td>0.02</td>
<td>-0.11</td>
<td>-0.59</td>
</tr>
<tr>
<td>Partial r</td>
<td>0.08</td>
<td>-0.07</td>
<td>0.56</td>
</tr>
<tr>
<td><strong>Total r (p-value)</strong></td>
<td>(0.09)</td>
<td>(0.196)</td>
<td>(&lt;0.001*)</td>
</tr>
</tbody>
</table>

FIB, frequency of irregular bedtime; ADST, average daily sleep time; ESS, Epworth Sleepiness Scale; FSS, Fatigue Severity Scale; PSQI, Pittsburgh Sleep Quality Index; r, correlation coefficients.

The multivariable regression analysis was done by setting the intermediate and high FIB as dummy variables in comparison to the low FIB group.

*p < 0.05