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The Monday Blues? The Impacts of Catch-up Sleep Duration and Social Jet Lag on Insufficient Weekday Sleep with Different Weekend Sleep Strategies

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Weekend catch-up sleep (CUS) is a strategy commonly used to cope with insufficient sleep during weekdays. Previous studies focused more on the usefulness of CUS in compensating for the sleep loss on weekday nights, but might have overlooked its possible negative influence due to "social jet lag (SJL)" resulting from the changes in the sleep-wake schedule. Thus, this study aimed to fill this gap by exploring the effects of different weekend sleep patterns, with different degrees of CUS and SJL, on subsequent sleep and daytime functioning with an experimental design. The study included 69 young healthy adults as participants. They were randomly assigned to three groups: a "delayed weekend sleep schedule" group (G1: n = 20), a "delayed weekend sleep schedule + CUS" group (G2: n = 24), and a "delayed weekend rising schedule + CUS" group (G3: n = 25). All participants had to go through a two-week study period: a baseline week and an experimental week. During the baseline week, participants had to restrict their time in bed (TIB) to 7 hours each night; during the experimental week, they were required to follow a regular sleep schedule with a restricted TIB of 7 hours on weekday nights, and to follow one of three experimental sleep patterns on weekends. The weekend sleep pattern of G1 consists of no CUS and 2 hours of SJL; G2 was composed of 2 hours of CUS and 2 hours of SJL; G3 involved 2 hours of CUS and 1 hour of SJL. Upon awakening from the last nights of the baseline and experimental periods, each participant rated their subjective sleepiness on the Stanford Sleepiness Scale (SSS) and emotion on the Profile of Mood State (POMS), and then came to the laboratory to complete the Psychomotor Vigilance Task (PVT) and the Continuous Performance Test (CPT) on the following Monday morning. Those groups with CUS (G2 and G3) showed higher wake after sleep onset (WASO) on weekend nights in the experiment period than the baseline. G3, compared to the other two groups, showed a trend of decreased negative emotion after the experimental night. However, G1 and G2 showed increased negative emotion compared to their baseline. The findings suggest that CUS might not be a good coping strategy to compensate for insufficient sleep on weekdays. More CUS might lead to larger SJL, which was found to be related to elevated levels of negative mood. The possible compensatory effect of CUS might be cancelled out by the negative effect of SJL.

Keywords: *Catch-Up Sleep, Insufficient sleep, Monday Blues, Social Jet Lag*

Extended Abstract

Sleep is important for our physical and mental health. The National Sleep Foundation recommends that the appropriate sleep duration for adults is between 7 and 9 hours (Hirshkowitz et al., 2015), although many people do not achieve this. Despite the increasing attention paid to the effects of insufficient sleep, few studies have examined compensatory sleep patterns such as delayed sleep-wake schedules and extended sleep duration during free days (Roenneberg et al., 2003).

Sleep deprivation can cause an accumulation of sleep debt on weekdays. Belenky et al. (2003) examined the effects of 7 days of restricted sleep on subjective sleepiness and cognitive performance. In the severe sleep restriction group (time in bed = 3 hours), cognitive performance declined continuously across the 7 days and then recovered rapidly during the recovery condition. Dinges et al. (1997) reported a similar result during sleep restriction and recovery conditions. Weekend catch-up sleep (CUS) is commonly used to compensate for sleep loss. Numerous studies have indicated the compensatory effect of CUS. For instance, Im et al. (2017) found that weekend CUS was associated with shorter sleep durations on weekdays and lower body mass index (BMI). Oh and colleagues (2019) identified a similar result. Kim et al. (2020) did not find a significant difference in BMI between subjects with and without weekend CUS but did find a lower prevalence of metabolic syndrome in subjects with weekend CUS. Similarly, Kim and Hwang (2021) found that weekend CUS was associated with metabolic disturbance: people with no CUS on weekends were more likely to be obese and to have type-2 diabetes or hypercholesterolemia. Oh's group (2019) found that subjects with weekend CUS reported better health-related quality of life. These findings suggest that CUS has a protective effect on health by reducing the impact of insufficient sleep.

According to the two-process model of sleep regulation (Borbely, 1982), sleep debt increases during prolonged wakefulness and decreases during sleep. It explains the accumulation of sleep debt on weekdays and the possible compensatory effect of CUS. In addition, CUS not only compensates for the sleep debt that is associated with the homeostatic process of sleep (Process S) but also affects the circadian regulation of sleep (Process C). However, studies on CUS have overlooked its possible effect on circadian regulation. Roenneberg and colleagues (2003) first addressed this issue by developing the Munich ChronoType Questionnaire (MCTQ) to measure the difference in sleep-wake schedules on work and free days. The MCTQ adopts the concept of mid-sleep time, defined as the midpoint between sleep onset and waking up time, as the anchor point for the sleep period (Roenneberg et al., 2003; Terman et al., 2001). Wittmann and colleagues (2006) posited that mid-sleep time on work days is unavoidably influenced by social demands on work days (social clock). Conversely, mid-sleep time on free days is more likely to be determined by circadian time (biological clock). Thus, the difference between mid-sleep time on work days and free days might reflect a discrepancy between one's social clock and biological clock, and is defined as "social jet lag" (SJL) (Wittmann et al., 2006).

SJL has been found to be associated with many negative effects on physical and mental health, including higher risk of depression (Levandovski et al., 2011; Polugrudov et al., 2016), increased probability of obesity (Roenneberg et al., 2012), and metabolic dysfunction (Parsons et al., 2015). Most studies in the field have focused either on the compensatory effect of CUS or the negative effect of SJL, yet their simultaneous effects on insufficient weekday sleep have not yet been examined. We therefore investigated the compensatory effect of CUS in individuals with the same level of SJL and the effects of SJL in individuals with the same CUS duration and insufficient weekday sleep.

Method

Participants

Sixty-nine volunteers (34 women, age range 20–35, average 22.02 years) participated in the study. All of the participants were free of neurological, psychiatric, and sleep disorders, and none reported drug or substance use. Potential participants who were shift-workers, had irregular sleep, or who had evening or morning chronotypes were excluded.

Procedures

Each participant was required to complete the screening questionnaires, which included demographic information, the Owl and Lark Questionnaire (OLQ) to measure chronotype, the Insomnia Severity Index (ISI) to evaluate the severity of sleep disturbance, the Beck

Depression Inventory (BDI-II) to measure depression symptoms, and the Beck Anxiety Inventory (BAI) to measure anxiety symptoms. All of the participants provided informed consent before the experiment began.

The study was conducted over a 2-week period: a baseline week and an experimental week. During the baseline week, the participants were asked to restrict their time in bed to 7 hours a night and to maintain a regular sleep and wake schedule on weekdays and on the weekend. During the experimental week, the participants were required to restrict their time in bed to 7 hours on weekdays but not on weekends. The participants were randomly assigned to one of three groups with different weekend sleep schedules: a “delayed weekend sleep schedule” group (G1: $n = 20$), a “delayed weekend sleep schedule + CUS” group (G2: $n = 24$), and a “delayed rising schedule + CUS” group (G3: $n = 25$). The participants in G1 again slept for 7 hours but delayed their bedtime and rising time by 2 hours at the weekend (SJL = 2, CUS = 0). The participants in G2 went to bed 1 hour later than on weekdays and got up 3 hours later, giving them a 2-hour weekend CUS (SJL = 2, CUS = 2). Those in G3 went to bed at the same time as on weekdays but got up 2 hours later, giving them a 2-hour weekend CUS (SJL = 1, CUS = 2). Each participant was asked to wear an actigraph and to keep a sleep diary every day. After the last night of the baseline and experimental weeks, all of the participants were requested to evaluate their subjective sleepiness using the Stanford Sleepiness Scale (SSS) and their emotional state using the Profile of Mood State (POMS) the following Monday morning. Then, they went to the laboratory to complete two cognitive tasks: the Psychomotor Vigilance Task (PVT) and the Continuous Performance Test (CPT).

Data analyses

Chi-square tests were used to examine group differences in the categorical variables. A one-way ANOVA was used to examine the differences between the three groups’ demographic variables and scores on the screening questionnaires. Then, a three-way ANOVA with mixed design was used to compare the differences in sleep-related variables between weekday and weekend nights, the baseline and experimental weeks, and the three groups. Group differences in the Sunday night sleep-related variables between the baseline and experimental weeks were examined using a two-way ANOVA with a mixed design. Subjective sleepiness, emotion ratings, and cognitive performance on Monday morning were also examined.

Results

Socio-demographic Characteristics

There were no significant differences between the three groups in terms of demographic variables, including age, sex, BMI, and years of education. The responses to the screening questionnaires showed that none of the participants had emotional or sleep disturbances.

Manipulation check: Experimental design

A three-way ANOVA was performed to check the experimental manipulation. Significant three-way interactions were found in bed time ($F(2, 66) = 120.96$, $p < .001$, $\eta_p^2 = .79$), wake time ($F(2, 66) = 24.89$, $p < .001$, $\eta_p^2 = .43$), total sleep time ($F(2, 66) = 13.16$, $p < .001$, $\eta_p^2 = .29$), and time in bed ($F(2, 66) = 58.93$, $p < .001$, $\eta_p^2 = .64$). These results confirmed that the sleep-related variables during weekdays and weekends differed between the three groups, suggesting that the experimental manipulation was successful.

Sleep-related Variables During Weekdays and Weekends

The three-way ANOVAs showed significant three-way interactions in sleep onset latency (SOL: $F(2, 66) = 5.04$, $p = .009$, $\eta_p^2 = .13$) and wake time after sleep onset (WASO: $F(2, 66) = 3.24$, $p = .046$, $\eta_p^2 = .09$). Post-hoc comparisons showed a significant simple main effect of group on SOL for the weekend of the experimental week ($F(2, 264) = 3.09$, $p = .05$, $\eta_p^2 = .02$). The SOL for G3 on the weekend was higher than that on weekdays during the experimental week ($F(1, 132) = 4.99$, $p = .03$, $\eta_p^2 = .04$) and the baseline week ($F(1, 132) = 5.00$, $p = .03$, $\eta_p^2 = .04$). A group difference for WASO was found for the weekend of the experimental week ($F(2, 264) = 3.24$, $p = .04$, $\eta_p^2 = .02$). The WASOs of G2 and G3 for the weekend of the experimental week were higher than those for the baseline week (G2: $F(1, 132) = 21.81$, $p < .001$, $\eta_p^2 = .14$; G3: $F(1, 132) = 6.98$, $p = .01$, $\eta_p^2 = .05$), and the WASO of G2 for the weekend of the experimental week was higher than that for weekdays ($F(1, 132) = 20.53$, $p < .001$, $\eta_p^2 = .13$). However, there was no significant group difference or interaction of the sleep-related variables on Sunday night.

Subjective Sleepiness, Emotional State, and Cognitive Performance on Monday Morning

Two-way ANOVAs showed significant two-way interactions in the fatigue subscale of the POMS ($F(2, 66) = 5.51$, $p = .01$, $\eta_p^2 = .14$) and the total POMS score ($F(2, 66) = 3.39$, $p = .04$, $\eta_p^2 = .09$). G3 scored lower on the fatigue subscale during the experimental week than during the baseline week ($F(1, 66) = 8.51$, $p = .01$, $\eta_p^2 = .11$). Although the other two groups showed no significant difference between the baseline and experimental weeks, there was a reverse tendency, with higher scores during the experimental week. There was no significant difference or interaction of cognitive performance between the groups during the two weeks.

Discussion

This study examined the compensatory effect of CUS and SJL with an experimental manipulation of weekend sleep patterns. The results did not support the compensatory effect of CUS. With the same level of SJL (2 hours) but a difference in CUS (G1 = 0, G2 = 2 hours), no significant differences were found in sleep-related variables on Sunday night or cognitive and emotional functioning on Monday morning. In addition, fatigue ratings on the POMS showed the same tendency of higher values in the experimental than the baseline condition in both groups. This finding suggests that CUS may not be an effective coping strategy for insufficient weekday sleep. The findings of this study are not consistent with those of Belenky et al. (2003) or Dinges et al. (1997). This inconsistency may be because the difference in sleep durations during weekdays (total sleep time = 5.52–5.71 hours) and weekends (6.67–7.24 hours) was not as large as the difference in the sleep restriction (total sleep time = 4.98 hours) and recovery conditions (7.94 hours) of Dinges et al. (1997). Thus, we did not find a difference in subjective sleepiness between the two groups. Furthermore, the cognitive task was not performed immediately after awakening, which might have had a confounding effect on the cognitive performance results.

One possible reason for the lack of a compensatory effect of CUS is the impact of SJL. Yang et al. (2001) found that a 2-hour delayed sleep-wake schedule on Friday and Saturday, which can be defined as 2 hours of SJL, led to an average delay of 31.6 minutes in the circadian phase. This deficit caused lower sleepiness on Sunday night and more negative emotion and poor performance on Monday morning. Our results demonstrated no compensatory effect of CUS when there were 2 hours of SJL. However, the group with 1 hour of SJL (G3) showed a different pattern from the other two groups with 2 hours of SJL. G3 had a lower level of fatigue during the experimental condition than the baseline condition. This finding suggests that the compensatory effect of CUS might be cancelled out by a higher level of SJL.

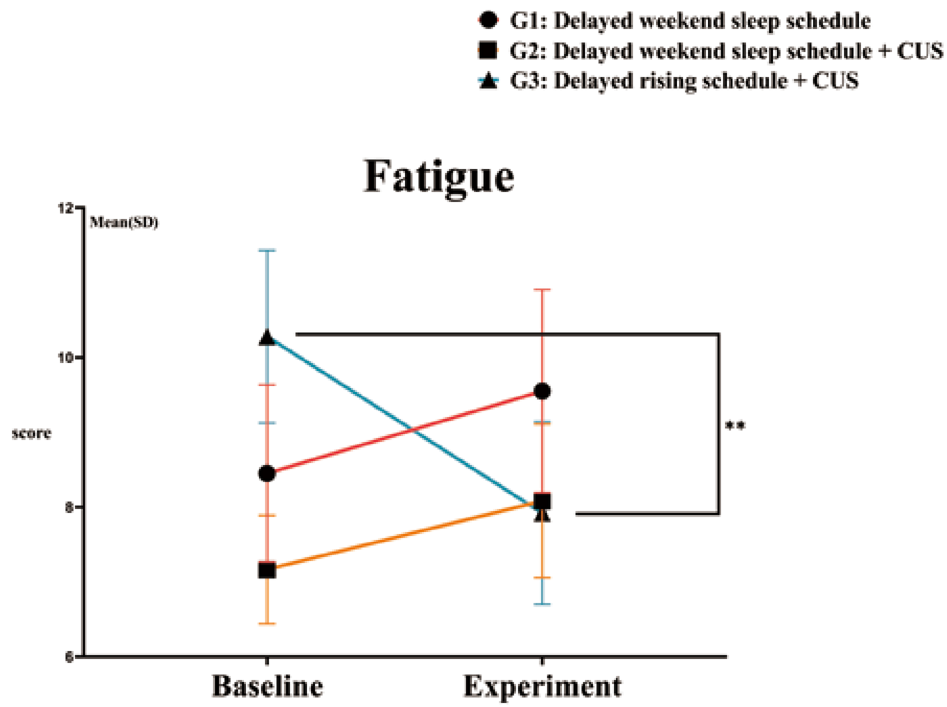
These findings also provide partial evidence for the effects of SJL with the same duration of CUS. G3, with 1 hour of SJL, showed a decrease in negative emotion during the experimental week compared with the baseline week, while G2 showed an increase in negative emotion. This suggests that a higher level of SJL can result in more negative emotions. This finding is consistent with the findings of previous studies (Levandovski et al., 2011; Polugrudov et al., 2016), in which SJL was suggested to be a risk factor for depression.

Furthermore, we found that G2 and G3, the two groups with CUS, had higher WASO on the weekend of the experimental week than that of the baseline week. In contrast to the study by Wittmann and colleagues (2006), which proposed that individuals have better sleep quality when following their habitual sleep time (biological clock), our participants had poor sleep quality on the weekend with CUS. Sleep quality did not differ between the groups with different lengths of SJL. Process S seems to play an important role in weekend sleep quality.

The results of our study suggest that weekend CUS is not an appropriate coping strategy for weekday insufficient sleep. Contrary to its possible compensatory effect, CUS might lead to more negative emotion by increasing SJL. When weekend sleep is prolonged to compensate for the sleep debt during weekdays, strategies to minimize SJL, such as increasing time in bed by advancing bedtime while delaying rising time, should be considered.

Figure

The fatigue subscale (POMS) of the three groups during the baseline and experimental conditions



** $p < .01$.