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Wi-Fi off, devices out: do parent-set technology rules play a role in adolescent sleep?

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ABSTRACT

There is limited evidence surrounding the relationship between parent-set technology rules and adolescent sleep. This study had two aims: 1) to investigate the relationship between presence of and compliance to parent-set technology rules and adolescent sleep outcomes and daytime sleepiness; 2) to investigate if compliance, non-compliance, or the absence of rules could moderate the relationship between Fear of Missing Out (FoMO) and Bedtime Procrastination (BtP) on sleep outcomes and daytime sleepiness. A total of 711 adolescents aged 12–18 years old (46% Female, M_{age} = 15.1, SD = 1.2) were recruited through secondary schools in South Australia. Participants completed a survey containing self-report measures about their sleep, daytime sleepiness, FoMO, BtP, the presence/absence of technology rules in their house, and their compliance to these rules. The study design was cross sectional. Results indicated that the presence of a parent-set technology rule was associated with earlier bedtimes regardless of compliance. Earlier lights out times and increased sleep duration were observed in adolescents who always complied to their rules compared to those who did not comply or did not have parent-set technology rules. BtP and FoMO were associated with later bedtimes, later lights out times, longer sleep onset latency, shorter sleep duration, and more daytime sleepiness. However, parent-set rules did not moderate the links between BtP/FoMO and adolescent sleep. Whilst longitudinal investigations are warranted to examine the directionality of these relationships, the present study suggests that parent-set technology rules may play an important role in protecting adolescent sleep.

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1. Introduction

Adolescence is a period of many biological, psychological, and social changes, including, but not limited to, sleep, identity, independence, and relationships with caregivers and peers [1]. Sleep and wake timing during adolescence tends to drift later, due to the maturation of the two bioregulatory processes of sleep: reduced sleep homeostatic pressure and delayed circadian timing [2]. The average sleep duration recommended for adolescents is approximately 9.35 h a night for optimal cognitive functioning [3]. However, many adolescents in their home environments are not meeting this nightly sleep need, receiving ~7–8 h per night [4,5]. This discrepancy between sleep need assessed in the laboratory and sleep in the home environment highlights that psychosocial factors, such as school start times, socialising, device use, and bedtime autonomy, are likely to be contributing to sleep loss [2].

In a recent systematic review and meta-analysis, parent-set rules have been suggested as a practical and promising intervention to improve adolescent sleep [6]. Not only are parents usually motivated and invested in the wellbeing of their children, but parents' proximity to their adolescents means that they are also in prime position to monitor and support them in achieving their sleep goals [6]. Thus far, most of the evidence on parent-set rules in the context of sleep has investigated the effects of parent-set bedtimes [6]. Parent-set bedtimes have been associated with earlier bedtimes and longer sleep duration [7,8], with some evidence to suggest they might also have protective effects against adolescent depression and suicidal ideation [9]. However, the consensus is that there is not yet a "sound" evidence base for other

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parent-set rules, such as those surrounding evening technology use, on sleep outcomes [6].

Parent-set rules regarding evening technology use have emerged in households over the last decade along with the development of portable technology [10]. Having a parent-set rule which limits device use (e.g., technology is removed from the bedroom overnight) has been associated with earlier bedtimes, longer time in bed [6,11], and increase of 36–54 min of total sleep time [10]. Similarly, having a rule that restricts access to the internet in the evening (i.e., a Wi-Fi rule) has the potential to limit the amount of activities available to use on mobile devices and time spent on them [12]. Importantly, when parent-set rules around media use were absent, electronic media was more likely to be used for longer durations and used in the hour before sleep [11].

However, this poses a question-what if adolescents do not comply to their rules? Frequent instances of non-compliance to parent-set device rules were reported by many parents and adolescents in a qualitative study [12]. While some adolescents did comply with their rules and reported that these were helpful in preventing excessive mobile device use, many other adolescents reported difficulty with self-control when it came to using mobile devices [12]. Furthermore, parents often express frustration and difficulty with implementing device rules and then monitoring their adolescent's compliance to them [12]. One study found that adolescents whose parents enforced rules about how late they could use cell phones slept for longer durations than adolescents who 'sometimes' had rules, and those who did not have rules [10]. However, another study found parents' enforcement of screentime usage did not predict TST [13]. The evidence base for parent-set technology rules and their relationship with sleep outcomes is still emerging [6] and therefore warrants further work. Furthermore, how parent-set technology rules relate to daytime functioning, to the best of our knowledge, is yet to be understood [6]. Consequently, the present study aimed to investigate the relationship between compliance to parent-set technology rules, and sleep outcomes, including daytime sleepiness.

It is possible that individual traits might play a role in compliance, where some adolescents are more likely to comply with parents' or researchers' rules, while others might not be [12,14]. Fear of Missing Out (FoMO) and Bedtime Procrastination (BtP) may each impact on adolescents' likelihood of complying with parent set rules. FoMO is defined as a general state of anxiety at missing out on rewarding experiences others may be having that often pushes social media engagement as a means to satisfy a psychological need [15,16]. BtP is defined as going to bed later than intended, despite the absence of external barriers preventing one from doing so [17]. Other research has found FoMO and social media use to be associated with later bedtimes, increased pre-sleep cognitive arousal, longer SOL, and less TST [18]. In one study, those with higher FoMO scores used social media for longer and were more likely to experience negative sleep outcomes (e.g., less TST, poorer sleep quality; [19]. For those who experience FoMO it appears there may be choice to trade sleep for remaining engaged on social media for the reward of continuing to connect with peer groups [20]. For BtP, research has found higher scores were associated with insufficient sleep in adolescents [21], and in young adults BtP was associated with later bedtimes, later rise times, and more eveningness tendencies [22]. Additionally, those higher in BtP spent signficantly more time using their mobile phones before bed [22]. Here it is possible that those who are bedtime procrastinators might have good intentions for healthy sleep habits, but experience this form of self-regulatory failure where a short-term gain is prioritised over the negative consequence of adequate sleep [23].

Taken together, it could be that adolescents who experience FoMO and/or bedtime procrastination may benefit from parent-set technology rules to assist them with regulating their evening media use to achieve better sleep. However, it is also possible that the level of compliance to these rules could moderate the relationship between these individual differences and sleep/daytime sleepiness outcomes. Therefore, the final aim of the present study will be to investigate whether compliance, non-compliance, or the absence of parent-set technology rules could moderate the relationship between the individual traits of FoMO/BtP and sleep/daytime sleepiness.

2. Method

2.1. Participants

A total of 78 secondary schools around metropolitan Adelaide, South Australia were approached for participant recruitment. Of those approached, 8 schools participated and provided a sample of students from grades 7–12 from June to September 2019. A total of 711 responses were collected (52.7% male, M_{age} = 15.1, SD = 1.2, range = 12–18 years old). Socioeconomic status (SES) of the sample according to the Socioeconomic Indexes for Areas Score (SEIFA; [dataset] [24] was M = 7.48, SD = 2.41, range from 1 = SES disadvantage – 10 = SES advantage, indicating that the sample was mostly representative of adolescents in middle-upper socioeconomic status in Australia. Ethics approval for this study was granted by the Social and Behavioural Ethics Committee at Flinders University, the Department of Education South Australia, and Catholic Schools Ethics South Australia.

2.2. Procedure

Interested schools were invited to participate in an online survey on adolescent sleep and technology use (see Materials). Informed consent was obtained from both adolescents and parents using an opt-out procedure. Students read the information sheet and provided their consent to participate on the day of data collection. At least one researcher was present at each school on the day the survey was distributed, to ensure students could ask the researcher any questions regarding their participation or the survey itself. The survey was part of a larger study on adolescent sleep and technology use and took ~35 min to complete. Participating schools were provided with a sleep education presentation for their students after data collection was complete.

2.3. Materials

2.3.1. Parent set rules

Participants were asked whether their parents implemented one of three different parent-set technology use rules at home on school nights to which they answered *Yes* or *No* (*1) Do you have a rule in your house where your phone is put in a certain place overnight (i.e., out of your bedroom?); 2) Do you have a rule or time in your house when devices/electronics are to be put away?; 3) Do you have a rule or time in your house when the WiFi/Internet is turned off for the night?).* Participants who answered "*Yes*" to at least one parent-set technology rule were also asked whether they *always* complied with their rule(s) (i.e., *Do you always comply with these rules?*) by indicating *Yes* or *No*. Following this, participants were categorised into one of three technology rule groups: (1) those with a parent-set rule(s) and comply, (2) those with a parent-set rule(s) and do not comply, and (3) those with no parent-set technology rules.

2.3.2. Sleep

Sleep items were derived from the School Sleep Habits Survey (SSHS; [25]. Each participant was asked to indicate the time they

got into bed (bedtime), the time they turned out the lights (lights-out time), the number of minutes they estimate it took for them to fall asleep (sleep onset latency; SOL), and the time they wake up (sleep offset) on weekdays/nights. Using these variables, total sleep time (TST) could be calculated. The present study focused only on school nights, as previous research has found parent-set rules are often not enforced on weekend nights (e.g., 91% of a sample of 1926 adolescents reported having no rules for their cell phone on weekends; [11]. The SSHS is a valid self-report measure of sleep pattern estimates in adolescents that has been validated against sleep diaries (school nights: for TST $\alpha = 0.61$, for bedtime/sleep onset $\alpha = 0.76$, for sleep offset $\alpha = 0.71$) and actigraphy (school nights: for TST $\alpha = 0.53$, for bedtime/sleep onset $\alpha = 0.70$, sleep offset $\alpha = 0.77$; [25].

2.3.3. Daytime sleepiness

The Pediatric Daytime Sleepiness Scale (PDSS) is an 8-item scale used to measure daytime sleepiness in adolescent populations [26]. Each adolescent was asked to respond to a series of questions regarding their daytime functioning over the last week using a 5-point scale ranging from 0 = *Never* to 4 = *Always*, with higher scores indicating more daytime sleepiness (score range from 0 to 32). This measure was used to determine whether the presence or absence of parent-set rules for adolescents could impact daytime functioning in adolescents. Internal consistency for the 8 items in our sample was acceptable (Cronbach's alpha = 0.79).

2.3.4. Sleep hygiene and demographics

Known sleep hygiene and demographic covariates were measured to ensure these could be controlled for in analyses. Each participant indicated the number of caffeinated beverages they would drink per school day on average, as this has been associated with negative sleep outcomes [7]. Light exposure was also measured as this has been identified as a risk factor to adolescent sleep [7]. Participants were asked to indicate on a 4-point scale how often they sleep with lights on in their bedroom overnight (0 = Never − 4 = Every night) as measured in the National Sleep Foundation's *2011 Sleep in America Poll* [27]. Questions regarding the frequency, clock time, and duration of naps during the week on school days were also asked as napping has been known to delay sleep onset [28] and decrease sleep duration [29]. Participants were asked to indicate frequency (once a week-everyday), what time they nap (e.g., 4pm) and the duration of that nap in hours and minutes.

Demographic information collected included gender, age, year level, and postcode. Home postcodes were collected to calculate socioeconomic status (SES), as SES has been found to be associated with sleep [30].

2.3.5. Fear of Missing Out (FoMO)

The iNOD *(Index of Nighttime Offline Distress)* is a 10-item self-report measure of difficulty disengaging from social media at night time [19,31]. The questionnaire has two subscales that measure concerns about "staying connected" to peers via social media at night time to avoid missing out, and "following etiquette" regarding perceptions of either the self or others' social expectations of night time interactions [19]. Each item (e.g., *"I would feel left out from my friends if I could not use social media at night"*) is measured on a 5-point scale from 0 = *not at all true of me* to 4 = *extremely true of me*, with higher scores indicating higher levels of difficulty disengaging from social media (score range 0–40). The iNOD has been validated for use with adolescents aged 10–18 years old [19]. Internal consistency for the 10 items was good (Cronbach's alpha = 0.87).

2.3.6. Bedtime procrastination (BtP) scale

The Bedtime Procrastination Scale is a 9-item self-report measure of self-regulation and procrastination around bedtime [17]. Each adolescent was asked to respond to a series of questions regarding their tendency to procrastinate going to bed and self-regulation to cease evening activities (e.g., *"I easily get distracted by things when I would actually like to go to bed"*) on a 5-point scale ranging from 1= *(almost) never* to 5 = *(almost) always*, with higher scores indicating higher levels of bedtime procrastination (score range 9–45). The scale had good internal reliability, as demonstrated by a Cronbach's alpha of 0.72.

2.4. Statistical analyses

Data were analysed using IBM SPSS Statistics v.27 and macro PROCESS v.3.5 (Model 1; [32]. Univariate general linear models (GLMs) were used to assess the links between parent-set rule groups and each of the sleep and sleepiness variables. GLMs were also used to assess the main effects of BtP and FoMO on sleep outcome variables/daytimes sleepiness. Least Significant Difference (LSD) adjusted pairwise post-hoc analyses allowed for comparisons between the three groups on each outcome variable. PROCESS was used to test for an interaction between BtP/FoMO and parent-set technology rule group on the sleep outcome variables/daytime sleepiness. Age and gender were controlled for in each model. Other covariates (e.g., caffeine, SES) were controlled for if they were significantly correlated to the outcome variable. Supplementary Table 1 presents zero order correlations between sleep variables, FoMO/BtP, daytime sleepiness, and covariates.

3. Results

3.1. Sample characteristics

Approximately half of the sample had at least one of the three parent-set technology rules in their household (49.0%, N = 337). A total of 235 (33.1%) participants had a rule where their phone is taken out of their bedroom overnight. Also, 235 (33.1%) of participants had a rule where all electronic devices are put away overnight, and 66 (9.3%) had a rule where the WiFi is turned off. A total of 176 (25.6%) participants reported having one of the parent-set technology rules, 127 (18.5%) participants had two of the rules, and 34 (4.9%) had all three rules. The probability of having at least one parent-set technology rule significantly decreased with age, $r = -0.160$, $p < 0.001$. For those who had a parent-set technology rule, 131 (51.8%) indicated that they always complied to these rules, while 123 (48.2%) indicated they do not always comply to their rules. There was significant difference between rule group and age, $F(2, 697) = 8.9$, $p < 0.001$, where those who had no rules were older in age compared to those who had rules and complied ($p < 0.001$), and those who had no rules and did not comply ($p = 0.002$). There was no significant difference in age between those who had rules and complied, and those who had rules and did not always comply, $p = 0.79$ (Fig. 1). Descriptive statistics are presented in Fig. 2. Descriptive statistics as well as main effects for rule groups on sleep variables, daytime sleepiness, FoMO, and BtP can be seen in Table 1. While gender was not a focus of this paper, FoMO, BtP, sleepiness and all sleep variables except lights out significantly differed between gender (Supplementary Table 3).

3.2. Are parent-set technology use rules associated with adolescent sleep and sleepiness?

A series of univariate general linear models were run to assess the impact parent-set technology rules (presence of parent-set rule

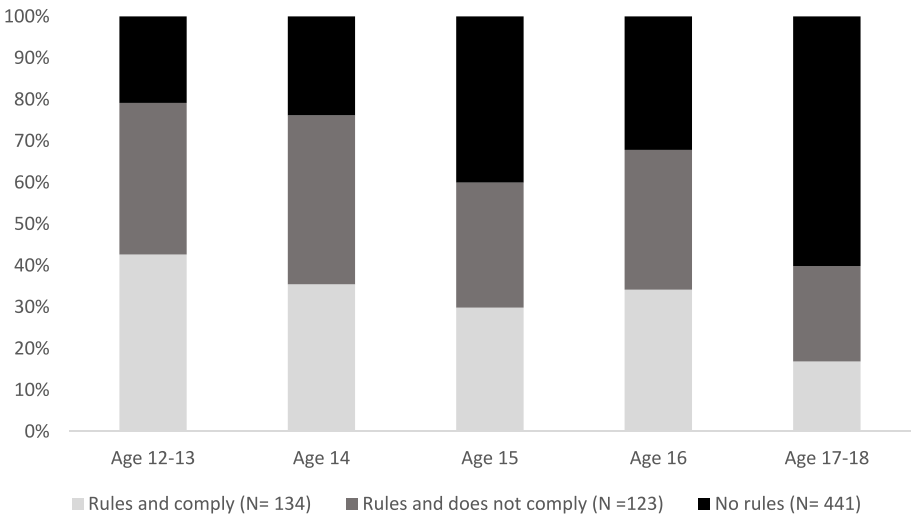

Fig. 1. Presence and compliance of parent-set rules by age\.

and/or compliance to rule) had on bedtimes, lights out times, SOL, TST and daytime sleepiness (PDSS scores) on school nights. The main effect of parent-set technology rules on bedtimes was significant ($p < 0.001$). Post-hoc analyses revealed that those who had no rules went to bed 22.1 min later than those who had a rule and complied to it ($p < 0.001$, $d = 0.62$), and 11.3 min later than those who had a rule and did not always comply to it ($p = 0.033$, $d = 0.33$). However, there was no difference in bedtimes between the two groups that had technology rules, regardless of whether they complied or not ($p = 0.10$).

The main effect of the parent-set technology rules on lights out times was also significant ($p < 0.001$). Those who had a parent-set rule and complied to it turned their lights-out 34.5 min earlier compared to those with no rules ($p < 0.001$, $d = 0.70$), and 32.2 min earlier than those who had rules but did not comply to them ($p < 0.001$, $d = 0.63$). However, there was no significant difference in lights out times between those who did not comply to their parent-set rule(s) and those with no rules ($p = 0.72$).

The main effect of the parent-set rule variable on TST was also significant ($p = 0.006$). As with lights out times, those who had a rule and complied to it obtained 22 more minutes of TST on school nights compared to those with no rules ($p = 0.004$, $d = 0.43$) and 25.1 more minutes of TST compared to those who did not comply to their parent-set rule(s) ($p = 0.008$, $d = 0.35$). There was also no significant difference in TST on school nights between those who did not comply to their parent-set rule(s) and those with no rules ($p = 0.68$). Finally, there was no significant main effect of parent-set technology rules for SOL ($p = 0.33$) or daytime sleepiness ($p = 0.09$). All sleep and sleepiness measures changed significantly with age (Supplementary Table 2); however, the parent-set rule effects on sleep did not change with age (no significant age by group interaction, all p > 0.05).

3.3. Do parent-set technology use rules moderate the link between FoMO/bedtime procrastination and adolescent sleep/daytime sleepiness?

Analyses yielded main effects of FoMO on bedtimes, lights out time, SOL, TST, and daytime sleepiness. FoMO was associated with later bedtimes, $b = 0.76$, SE = 0.33, $p = 0.018$, 95% CI [0.13, 1.4], later lights out times, $b = 1.41$, SE = 0.27, $p < 0.001$, 95% CI [0.88, 1.9], longer SOL, $b = 0.020$, SE = 0.009, $p = 0.021$, 95% CI [0.003, 0.037], less TST, $b = -1.23$, SE = 0.25, $p < 0.001$, 95% CI [−1.7, −0.74], and more daytime sleepiness, $b = 0.201$, SE = 0.049, $p < 0.001$, 95% CI [0.11, 0.30]. When the parent-set technology rule variable was added as a moderator, moderation analyses revealed there was no significant interaction between parent-set rule group and FoMO on any of the sleep outcome variables or daytime sleepiness.

For bedtime procrastination (BtP), there was a main effect of BtP on bedtimes, lights out time, SOL, TST, and daytime sleepiness. BtP was associated with later bedtimes, $b = 2.36$, SE = 0.26, $p < 0.001$, 95% CI [1.8, 2.8], later lights out times, $b = 3.09$, SE = 0.20, $p < 0.001$, 95% CI [2.7, 3.5], longer SOL, $b = 0.036$, SE = 0.007, $p < 0.001$, 95% CI [0.022, 0.051], less TST, $b = -2.67$, SE = 0.19, $p < 0.001$, 95% CI [−3.1, −2.3], and higher daytime sleepiness scores, $b = 0.46$, SE = 0.039, $p < 0.001$, 95% CI [0.39, 0.54]. When the parent-set technology rule variable was added as a moderator, analysis revealed no significant interaction between parent-set technology rule group and bedtime procrastination (BtP) scores on any of the sleep outcome variables. However, there was a significant interaction between BtP and parent-set technology rule group on daytime sleepiness scores, R^2 *change* = 0.07, $F(2, 588) = 3.28$, $p = 0.03$. Post-hoc pairwise comparisons revealed that higher bedtime procrastination scores were associated with higher daytime sleepiness scores (PDSS) for all three groups. However the effect was greater for those with no parent-set rules, $b = 0.48$, SE = 0.04, $p < 0.001$, 95% CI [0.40, 0.57] compared to those with parent-set rules (rule and comply: $b = 5.48$, SE = 2.72, $p = 0.044$, 95% CI [0.15, 10.81]; and those with a rule but *not* always complying: $b = 6.06$, SE = 2.78, $p = 0.029$, 95% CI [0.59, 11.52]). For those who had parent-set technology rules, there was no significant difference in PDSS scores ($p = 0.76$) between those who indicated they do always comply and those who indicated they do not.

4. Discussion

The aim of this study was to investigate the relationship between parent-set technology rules and how compliance to these rules might relate to sleep and daytime sleepiness in adolescents. Additionally, we aimed to investigate the links between sleep and BtP as well as FoMO, and whether parent-set technology rules might moderate these links. Our findings suggest that parent-set technology rules may play a protective role in adolescent sleep, but also that adolescents' compliance to these rules may be important for achieving earlier lights out times and more TST on school nights. The findings also suggest that parent-set rules may

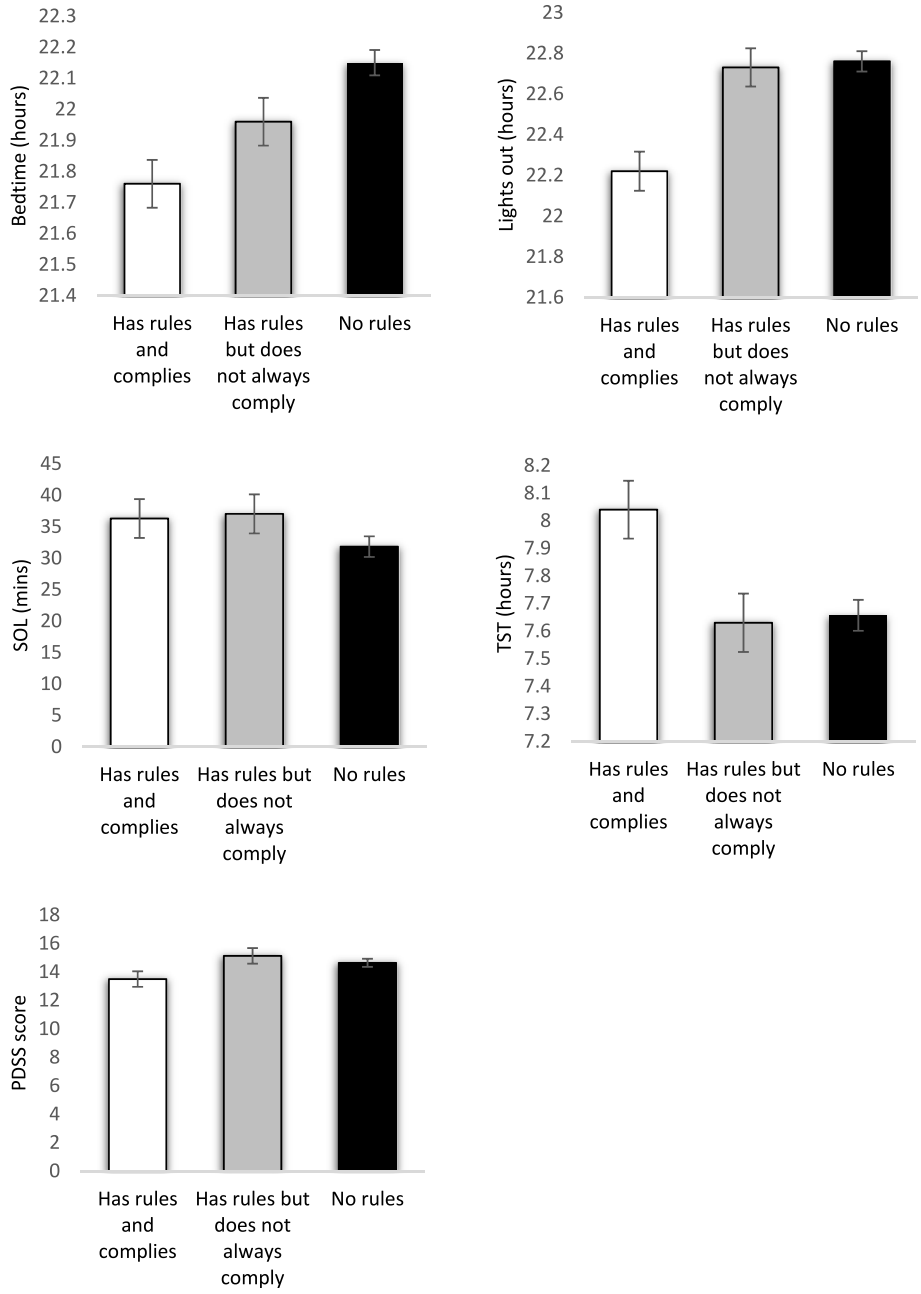

Fig. 2. Estimated marginal means and standard error for rule group and sleep outcome measures.

Table 1
Estimated marginal means (standard error) of self-reported sleep variables on school nights, daytime sleepiness, FoMO and BtP scores for those who had parent-set technology rules and either do or do not always comply to their rules, and those without parent rules.[a,b].

	Has rules and complies N = 131	Has rules and does NOT comply N = 123	No rules N = 441	
Bedtime (hrs)[b,c]	21.7 (0.8)	21.9 (0.8)	22.2 (0.4)	$F(2, 648) = 9.20$, $p < 0.001$
Lights out (hrs)[a,b]	22.3 (0.9)	22.7 (0.9)	22.8 (0.5)	$F(2, 648) = 11.29$, $p < 0.001$
SOL (mins)	36.5 (3.1)	37.1 (3.1)	31.8 (1.6)	$F(2, 650) = 1.66$, $p = 0.19$
TST (hrs)[a,b]	8.0 (0.1)	7.6 (0.1)	7.7 (0.6)	$F(2, 614) = 5.09$, $p = 0.006$
PDSS score	13.5 (0.5)	15.1 (0.5)	14.6 (0.3)	$F(2, 634) = 2.49$, $p = 0.084$
iNOD score	7.6 (0.5)	9.5 (0.6)	9.2 (0.3)	$F(2, 692) = 2.99$, $p = 0.051$
BtP score[a,b]	24.3 (0.5)	28.9 (0.5)	29.0 (0.2)	$F(2, 690) = 32.2$, $p < 0.001$

Note: SOL = sleep onset latency; TST = total sleep time; PDSS = Pediatric Daytime Sleepiness Scale (score range 0–32); iNOD = Index of Nighttime Offline Distress (score range 0–40); BtP = Bedtime Procrastination Scale (score range 9–45).

[a] Adjusted for covariates: age, gender, naps, caffeine, evening light.

[b] [a]Sig. difference between Comply and Non Comply group; [b]Sig difference between Comlpy and No Rules group; [c]Sig. difference between Non Comply and No Rules group.

not be potent enough to weaken the relationship between the adolescent's levels of FoMO or BtP and sleep outcomes. This study adds to the emerging evidence base regarding parent-set technology rules and their relationship with sleep outcomes [6].

Consistent with previous research, we found that the presence of having at least one parent-set technology rule was associated with earlier bedtimes on school nights [6,10,11]. This was compared to the group of adolescents who did not have any rules. Interestingly, compliance did not appear to matter in the case of bedtimes, where no significant difference was found between those adolescents who always complied to their parent-set technology rules and those who had rules but did not always comply. This finding suggests that simply setting a parent-set technology rule could be protective of bedtimes for adolescents regardless of their compliance to it. However, when it came to lights out times and TST, compliance to the rules did matter. Adolescents who had at least one parent-set technology rule and indicated that they always complied to their rule(s), turned their lights out 34 min earlier and obtained 22 more minutes of TST on school nights compared to their peers who did not have rules. They also turned their lights out 32.2 min earlier and obtained 25.1 min more TST on school nights compared to their peers who had parent-set technology rules but did not always comply to them. It should be noted there was no significant difference in lights out times and TST for those who had rules yet did not always comply and those who had no rules. The improvement in TST in our study is similar to that found in a one-week mobile phone restriction study (i.e., 19 min increase in TST [14]; and the 27 min increase in TST found in a school-based motivational sleep education program that involved parents [33]. This is meaningful, as it appears parents setting a rule and monitoring compliance could help adolescents receive possible benefits of earlier lights out times and longer TST on school nights that are comparable to a one-week researcher led mobile phone restriction intervention and a school-based motivational intervention.

Moreover, our findings support those of [10] who found in a survey of parents of children aged 6–17 years, that adolescents whose parents always enforced rules about how late they could use cell phones slept more than adolescents whose parents only sometimes enforced these rules, or had no rule at all. However, our findings contrast those of [13]; who found that parental enforcement of a rule regarding evening screen time did not significantly predict adolescents' self-reported sleep duration, and also [34] who found parental control over technology use did not predict improvements in adolescent sleep. We propose that the difference in these findings could be explained by the populations surveyed: in our study we collected data from students, whereas [13,34] surveyed parents. Arguably, whether adolescents perceive they have a parent-set rule for technology and their report on compliance is likely to be more valuable than asking parents. There is a possibility parents may respond in a socially desirable way for both sleep patterns and parent-set rules [35]. Only 50% of adolescents reported having at least one parent-set technology rule compared to Ref. [13] where 70% of parents reported having pre-bedtime screen rules [34]. asked parents to report their control over their adolescent's technology use, however in our study 48.2% of adolescents reported that they do not always comply to their rules. It is possible a parent may perceive they have control, and their adolescent is following the rules, but this may not always be the case. Parents may not be the most accurate source of this information due to the many biopsychosocial factors in adolescence (e.g., increased autonomy, circadian phase delay, academic/social commitments, desire to use devices and compliance to rules; [35]. For sleep, previous evidence suggests that parents of adolescents may overestimate the amount of sleep their child obtains on both school nights and weekends (i.e., for sleep duration parents reported 35–45 min more on school nights and 40–90 min more on weekends compared to adolescent reports; [35].

For SOL and daytime sleepiness, our findings indicated parent-set technology rules were not related to the time it took adolescents to fall asleep on school nights or next-day daytime functioning. This is in line with a previous meta-analysis that found no association between technology use and SOL [7]. Alternately, a long SOL (and perception of daytime sleepiness) could be explained by a mismatch between circadian timing and the sleep attempt [2], rather than technology use or the presence or absence of a technology rule.

Our study additionally aimed to investigate the role of FoMO and BtP in this context. In line with previous research, FoMO was associated with later bedtimes, later lights out times, longer SOL, less TST [18,19], and more daytime sleepiness. However, we did not find interaction effects between FoMO and parent-set technology rules, perhaps indicating that parent-set technology rules do not attenuate the relationship between FoMO and sleep outcomes in adolescents. This highlights the need to develop alternate intervention strategies to address the cognitive and behavioural factors of FoMO on sleep outcomes [18] as parent-set technology rules may not be potent enough to address the potential impact FoMO may have on sleep.

Also in line with previous research, BtP was associated with less TST [21] and also later bedtimes, later lights out times, longer SOL, and more daytime sleepiness. Between our rules groups it was found that those who did not always comply to their rules and those who had no rules self-reported a higher tendency for bedtime procrastination compared to those who had parent-set technology rules and indicated they always complied to them. For the moderation, although we did not find an interaction between BtP and parent-set technology rules on any of the sleep outcome variables, we did find a significant interaction for daytime sleepiness scores. Here, a stronger association was found between BtP and sleepiness for adolescents who did not have any parent-set technology rules, compared to those who did. Therefore, it is possible that parent-set technology rules may act as a buffer to the potential negative impacts of bedtime procrastination on next-day daytime functioning. Taken together however, it appears that the association between adolescents' individual tendencies (i.e., FoMO and BtP) and sleep outcomes (i.e., bedtimes, lights out times, SOL, and TST) do not substantially change as a function of parent-set technology rules. For BtP this also highlights the need to develop an alternate strategy to mitigate the potential that bedtime procrastination has to displace the sleep process [23].

It is possible parental *monitoring* of compliance could explain some of the findings in this study, especially between those who had rules and always complied, and those who had rules but did not always comply. Previous research has indicated that parental monitoring has been associated with better sleep quality and longer sleep opportunity, but also that inconsistency (e.g., to enforce rules) has been associated with poorer sleep quality [6]. Therefore, it could be posed that adolescents that indicated they always complied to their rules, were more likely to have parents who/that were monitoring their compliance to the rules they had set, which may have been a crucial factor associated with the sleep benefits received in this group. Arguably, other parenting factors may have contributed to these findings. Currently, there is an insufficient evidence base in the area of parenting factors that have investigated autonomy granting, permissiveness, and non-specific household rule-setting, and only an emerging evidence base for monitoring and inconsistency, and their associations with sleep in adolescents [6].

4.1. Limitations and future directions

Whilst the present study addressed the dearth of scientific investigation into the influence of parental rules on adolescents' sleep, we did not ask about parental monitoring of rules and compliance to them. Therefore, we are unable to determine if parents were monitoring the rules in the group of adolescents who complied to their rules, or whether there might be another reason to explain compliance (e.g., avoiding punishment, agree with the rules). Additionally, we are unable to determine what percentage of time our "did not always comply" group complied vs did not comply with their parent-set rules (e.g., does the group consist of adolescents who complied 85% of the time or only 5% of the time?). One strength of our study that should be noted is controlling for a number of significant covariates known to affect adolescent sleep (i.e., caffeine, naps, gender, age, light, SES). By doing so, we can be more confident of the unique relationships between parent-set rules and sleep. However, for SES it should be noted that most of our sample came from similar, more affluent SES backgrounds. It would of value for future research to investigate some of the racial, ethnic, and social disparities that could influence sleep and/or parental rule setting [36]. Other variables to be considered in future research is the role of mental health (e.g., depression, anxiety, stress), age and gender on sleep and parent-set rules. Although the current study's cross-sectional design precludes causal conclusions to be drawn, it provides justification for future experimental research to test whether parent-set technology rules could be a promising intervention to improve adolescent sleep.

5. Conclusion

The presence of at least one parent-set technology rule is associated with adolescents achieving an earlier bedtime on school nights compared to their peers who do not have rules (regardless of compliance). However, the presence of a parent-set technology rule was not associated with earlier lights out times and increase TST on school nights. Here, compliance mattered, where earlier lights out times and more TST on school nights was only associated with compliance to parent-set technology rules. While getting into bed is an important step for beginning the sleep process, the moments in which adolescents turn their lights out and attempt sleep is arguably the most important intervention point. Consequently, compliance to parent-set technology rules may need to be monitored by parents to ensure adolescents receive any potential benefits from parent-set technology rules. This study further highlights the negative relationship between BtP and FoMO on sleep outcomes. As BtP and FoMO did not change as a function of parent rules, it appears having parent-set rules could be beneficial for adolescents regardless of their level of BtP/FoMO. Future research is needed to continue investigating the external (e.g., parent-set technology rules) and internal mechanisms (e.g., BtP/FoMO) to improve adolescent sleep.

Conflict of interest

Michael Gradisar is the CEO of Wink Sleep Pty Ltd which provides online training of the treatment of teen sleep problems. All other authors have no conflicts of interest to declare.

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CRediT authorship contribution statement

Meg Pillion: Conceptualization, Data curation, Writing – original draft, Conception and design of study, acquisition of data, analysis and/or interpretation of data, Drafting the manuscript, revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published. **Michael Gradisar:** Conceptualization, Supple styling, Data curation, Writing – original draft, Conception and design of study, analysis and/or interpretation of data, revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published. **Kate Bartel:** Conceptualization, Writing – original draft, Conception and design of study, revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published. **Hannah Whittall:** Data curation, Writing – original draft, acquisition of data, Drafting the manuscript, Approval of the version of the manuscript to be published. **Jessica Mikulcic:** Data curation, Writing – original draft, acquisition of data, Drafting the manuscript, Approval of the version of the manuscript to be published. **Alexandra Daniels:** Data curation, Writing – original draft, acquisition of data, Drafting the manuscript, Approval of the version of the manuscript to be published. **Benita Rullo:** Data curation, Writing – original draft, acquisition of data, Drafting the manuscript, Approval of the version of the manuscript to be published. **Michal Kahn:** Conceptualization, Data curation, Writing – original draft, Conception and design of study, analysis and/or interpretation of data, Drafting the manuscript, revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published.

Appendix A. Supplementary data

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