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How internal and external cues for bedtime affect sleep and adaptive functioning in adolescents

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ABSTRACT

Objective: To determine whether the main reason for bedtime is associated with sleep and adaptive functioning in adolescents.
Methods: Participants were 1374 adolescents (X age = 16.8 years, SD = 0.58; 33.6% male) from Helsinki, Finland. Adolescents completed a questionnaire battery including the Munich Chronotype Questionnaire, Strengths and Difficulties Questionnaire, Beck Depression Inventory, and items drawn from the School Sleep Habits Survey, and the Pittsburgh Sleep Quality Index.
Results: On school nights, adolescents whose parents set their bedtime, and those who went to bed when they were tired went to bed earlier, obtained more sleep and had earlier midpoint of sleep than adolescents who went to bed when they have finished messaging/socializing or when their television show had finished. Adolescents who went to bed when they had finished their homework had sleep that fell in between these groups. On weekends, adolescents whose parents set their bedtime went to bed earlier and had an earlier midpoint of sleep. However, there were no differences between groups in terms of sleep duration once the need to rise for school in the morning was removed. Adolescents who went to bed on school nights when they were tired or once their homework was finished had better adaptive functioning.
Conclusions: These results provide support for two very different approaches to help optimize the sleep of adolescents: either by implementing parental regulation of bedtimes across adolescence, or by encouraging adolescents to use their bodily cues to indicate when it is time for bed, rather than relying on an external cue.

1. Introduction

Adolescents are among the most sleep restricted people worldwide, with few obtaining sleep that falls within the recommended range of 8–10 h per night [1–3]. As adolescents' sleep opportunities are curtailed most in the morning by the need to rise for school, the time that adolescents go to bed is a key determinant of how much sleep they obtain [4]. Later bedtimes are argued to occur due to the confluence of psychosocial and biological factors of adolescent development [5–9]; M. A. [10]. Much work has been done to determine how the types of activities adolescents engage in immediately before sleep impact subsequent sleep [11,12], the assumption being that what adolescents do before going to bed causally impacts their sleep. While this research has revealed associations between evening activities and subsequent sleep [12,13], adolescents' decision-making regarding bedtimes remains understudied. This is a critical gap in the literature to address because the factors that prompt adolescents' decision to go to bed may be a more salient predictor of subsequent sleep than activities prior to bed. For example, an adolescent who plays video games for an hour before their parent-mandated bedtime is likely to have an earlier bedtime and more sleep than an adolescent who plays video games until they feel too tired to continue playing, or until their friends' finish playing online [14–17]. Thus, even though the activity before bed is the same, the reason that triggers bedtime is different and may differentially impact sleep. Knowing why adolescents go to bed when they do may help to extend our understanding of the risk and protective factors for adolescent sleep health and thus enable creating targeted interventions aimed at improving sleep [5].

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We address this gap in the literature by examining the main reason for adolescents going to bed on school nights and weekends and whether this is associated with bedtime, sleep onset latency, chronotype [18], and total sleep time in a large sample of Finnish adolescents. In addition, we investigated a range of salient adaptive functioning measures, including depressed mood, daytime sleepiness, emotional symptoms, hyperactivity/inattention, and conduct problems. We made a conceptual categorization between external and internal bedtime cues to compare reasons for bedtime across three categories: (a) externally-derived bedtimes, such as those set by parents, (b) bedtimes that are self-derived by a time limited cue (for example, a TV show ends, homework is competed, or the adolescent begins to feel tired), and (c) bedtimes self-derived by a non-time limited cue, such as when adolescents finish socializing or messaging. Existing research indicates that adolescents whose parents set their bedtimes have earlier bedtimes, more sleep and better daytime functioning that adolescents who do not [15,17]. While no direct evidence compares other reasons determining bedtimes, we argue that time limited cues may be more protective of adolescent sleep and subsequent functioning than non-time-limited cues because they have an inherent "end-point" that signals bedtime [14,18]. Adolescents who go to bed after they have finished socializing or messaging spend time before bed involved in an activity that is engaging and often reinforcing; activities that they must choose to cease to go to bed. Van den Bulck postulates that these types of unstructured activities are most likely to displace other activities, such as sleep, that are similarly unstructured [18], especially when media use occurs immediately before bed [19]. Thus, an engaging activity without an inherent end-point, coupled with a biological and psychosocial milieu (ie, the puberty related changes to sleep circadian and homeostatic systems together with social changes including greater autonomy and increased homework and extracurricular activities) permissive of late night wakefulness results in later bedtimes and less sleep.

We hypothesize that bedtime, and total sleep time will vary according to the main reason for going to bed. Specifically, adolescents who have an externally-derived reason for going to bed (parent-set betimes), will have an earlier bedtime, more sleep, and better adaptive functioning than adolescents with internally-derived reasons for going to bed. Further, we hypothesize that adolescents who have an internally-derived reason that is non-time-limited, such as when they finish socializing or messaging, will have significantly later bedtimes, less sleep and worse adaptive functioning than adolescents who have an externally-derive reason for bedtime and those who have an internally-derived reason that is time-limited (eg, when finishing homework, or when a TV show finishes). We will also examine the effect of different reasons for going to bed on sleep onset latency, which is an index of the alerting effects of a pre-bed activity [5], to determine whether any of the reasons are associated with poorer sleep quality.

2. Methods

The SleepHelsinki!-study is a population-based cohort study initiated in September 2016. We used the Finnish Population Register Centre to identify all adolescents born between 1.1.1999 and 31.12.2000 (n = 10,476) who resided in Helsinki and whose native language was registered as Finnish (72% of the total sample). The register thus included 7539 adolescents (3789 born in 1999 and 3750 born in 2000), of whom 50% were males. We sent invitation letters to all registered adolescents to participate in the SleepHelsinki! −study Phase 1, which consisted of an online survey primarily targeting sleep, health and behavior. The estimated time for filling in the questionnaire was 30 min.

Altogether, 1411 adolescents (19% of the initial cohort) responded to the on-line survey, with valid responses from 1374 (18%) participants. The age of the respondents did not differ from the initial cohort mean age ($p = 0.34$), but the respondents were more often females (34% males, $p < 0.0001$). All respondents signed an electronic consent form for Phase 1. Ethical permission was obtained from The Hospital District of Helsinki and Uusimaa Ethics Committee for gynaecology and obstetrics, pediatrics and psychiatry (Decision number 50/13/03/03/2016).

In order to detect different reasons for going to bed at both school nights and weekends, we included two questions from the School Sleep Habits Questionnaire [20] in the online survey: adolescents were asked what their main reason for going to bed on school nights was, and, similarly, on weekends. They were given multiple response choices: (a) My parents have set my bedtime, (b) I feel sleepy, (c) I finish my homework, (d) My TV shows are over, (e) My brother(s) or sister(s) go to bed, (f) I finish socializing, (g) I get home from my job, or (h) Other (specify). For the current study we selected those adolescents who had reported their primary reason for school night bedtimes to be based on either parent-set bedtimes, sleepiness, homework, finishing a TV show, or, socializing (n = 1111). Those who had responded "*My brother(s) or sister(s) go to bed*" (n = 11), "*I get home from my job*" (n = 1) were excluded due to small group size, and those who had responded "*Other (specify)*" (n = 250) reported such heterogeneous reasons for their bedtime that these could not be categorized, and were thus excluded from further analyses. These reasons included statements such as, "I decide to", "I just want to," "I finish my hobby," "It's my routine," "I have nothing else to do," "I don't want to be tired in the morning,", and "I need to sleep at least xx hours." Following this rationale for weekend nights, we selected those adolescents who had reported their primary reason for weekend night bedtimes to be based on either parent-set bedtimes, sleepiness, finishing a TV show, or, socializing (n = 1283). We excluded those participants who reported their primary bedtime reason during weekends as "*My brother(s) or sister(s) go to bed*" (n = 7), "*I finish my homework* "(n = 9), "*I get home from my job*" (n = 0), or "*Other (specify)*" (n = 72). 1326 participants were included in the school night and/or weekend night analyses. Descriptive details of the participants are presented in Table 1.

2.1. Background information

Parental education was used as a measure of socio-economic status (SES). Participants were asked to report the highest educational attainment of their parents, and the highest report was selected as the basis for classifying participants' SES as (1) lower (2) middle, or, (3) upper. Lower SES included minimum compulsory educational attainment. Education attained beyond this (ie, vocational school, technical college) was classified as middle level SES. SES was classified as upper level if either parent had a university-level degree.

2.2. Sleep questionnaires

Bedtime, sleep onset latency (SOL), total sleep time (TST) for both school nights and weekends, and, chronotype on free nights were derived from responses to the Munich Chronotype Questionnaire [21], which is a validated method for sleep assessment. Chronotype was estimated using the midpoint between sleep onset and sleep offset on nights when adolescents do not have school the next day, which reflects the timing of the individuals circadian clock [21].

To evaluate daytime sleepiness, we used one question from the Pittsburgh Sleep Quality Index [22] (PSQI): "*During the past month, how often have you had trouble staying awake while driving, eating*

Table 1
Demographic characteristics and descriptive differences between groups with different reasons for going to bed on school nights.

	Full Sample	Primary bedtime reason on school nights					
		Parents	Tired	Homework	TV	Messaging or socializing	p
N (%)	1326	74 (6.7)	650 (58.6)	134 (12.1)	70 (6.3)	183 (16.5)	
age (M, SD)	16.8 (0.58)	16.6 (0.57)	16.9 (0.58)	16.8 (0.59)	16.8 (0.59)	16.8 (0.60)	0.006
Sex, male (%)	446 (33.6)	37 (50)	231 (36)	16 (12)	32 (46)	50 (27)	0.0001
Parent educ. (%)							0.188
Lower	29 (2)	3 (4)	14 (2)	1 (1)	3 (5)	3 (2)	
Middle	312 (24)	15 (21)	155 (25)	29 (22)	22 (33)	44 (25)	
Upper	945 (71)	54 (75)	455 (73)	103 (77)	42 (63)	131 (74)	
School report[a]	8.65 (0.89)	8.57 (0.89)	8.55 (0.89)	9.12 (0.68)	8.45 (0.77)	8.60 (0.98)	0.003

[a] Grade point average scale = 4–10, with higher scores indicating greater academic achievement; data available from 1299 participants in the full sample. Parental education available from 1286 participants. P-values obtained from one-way ANOVAs.

meals, or engaging in social activity?" The response choices include four options referring to the last month: (a) Not during the past month, (b) Less than once a week, (c) Once or twice a week, or, (d) Three or more times a week. Scores could range from 1 to 4, with a higher score indicating more daytime sleepiness.

2.3. Psychological questionnaires

We evaluated the adolescents' adaptive functioning using the Strengths and Difficulties Questionnaire (SDQ) [23,24], which is a validated 25-item questionnaire. Subscales included in our study were (1) hyperactivity, (2) emotional symptoms, and, (3) conduct problems. Scores for each subscale could range from 0 to 10, with higher scores indicating worse behavioral outcomes. The SDQ has been validated for use with adolescents [24]. Cronbach's alpha for the present sample was 0.64.

We calculated a total sum score from responses to the Beck Depression Inventory-Second Edition (BDI-II) [25,26] in order to evaluate depressed mood. Potential scores ranged from 0 to 63, with higher scores indicating greater depressed mood. This measure has been established as a reliable and valid tool for assessing depressed mood in adolescents [26]. Cronbach's alpha for the present sample was 0.94.

2.4. Statistical methods

All statistical analyses were completed using IBM SPSS Statistics version 24.0 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Significance was set at $p < 0.05$. The descriptive statistics were investigated using Pearson correlations, t-tests, chi-square tests and ANOVAs. After preliminary inspection of the data we compared the five groups which were formed based on what was their primary reason for going to bed during school nights or free nights. The following covariates were considered: age, sex, and parental education. The differences in these variables were investigated between the four different groups, and as age and sex differed significantly, they were added as covariates in ANCOVAs. Baseline differences between the groups were analysed using one-way ANOVAs. The unequal group sizes were adjusted for by selecting sum of squares II in the ANOVAs. After initial comparisons of the groups, Tukey HSD post-hoc tests were done to investigate the differences between groups.

3. Results

3.1. Reasons for going to bed on school nights

Descriptive characteristics of participating adolescents, together with their main reason for going to bed on school nights, are provided in Table 1. Most adolescents (58.6%) reported going to bed on school nights when they were tired, with smaller proportions going to bed because their parent/s set their bedtime (6.7%), because they finished their homework (12.1%), because their TV shows were finished (6.3%), or because they had finished messaging or socializing (16.5%). Tukey post hoc t-tests showed that adolescents who went to bed because their parent/s had set their bedtime were significantly younger than those who went to bed when they were tired and those who went to bed when they finished messaging or socializing, $p < 0.05$. Significant sex-differences were also found between the groups, with the parent-set bedtime and TV watching groups containing a significantly higher proportion of males than the messaging/socializing group and the homework group. The group who went to bed when they were tired contained significantly fewer males than those with a parent-set bedtime and TV watching groups, but fewer females than those who went to bed when they have finished their homework or finished messaging or socializing, all $p < 0.05$. Adolescents who went to bed because they had finished their homework had significantly higher grade point averages than any of the other four groups, $p < 0.05$.

Results examining the relationship between reason for going to bed on school nights and sleep and adaptive functioning are provided in Table 2. Post hoc comparisons show that adolescents whose parents set their bedtime on school nights, and those who go to bed when they are tired, had better sleep than adolescents who went to bed when their TV shows ended or when they had finished messaging/socializing. Specifically, they go to bed earlier, take less time to fall asleep, obtain more sleep, and their sleep midpoint on free days is earlier; indicating an earlier chronotype. Adolescents who go to bed once they finished their homework have sleep that fell in between these four groups. Adaptive functioning also differed according to the main reason for going to bed. Adolescents who go to bed when they finish their homework report lower levels of depressed mood, and fewer emotional problems, conduct problems and hyperactivity. However, they report greater difficulty staying awake during the day than adolescents who go to bed when they are tired. Adolescents who go to bed when tired report the least difficulty staying awake during the day, while parent-set bedtimes do not show the same benefits in terms of psychological functioning as it does for sleep. In addition, adolescents who primarily go to bed on school nights after they finish messaging or socializing have the worst psychological functioning outcomes.

3.2. Reasons for going to bed on weekends

The demographic characteristics of adolescents according to their main reason for going to bed on weekend nights are given in Table 3. The sleep and psychological functioning descriptive statistics for the four main reasons for going to be on weekends are shown in Table 4. Unlike school night sleep and adaptive

Table 2
Estimated marginal means (M) and standard error (SE) for school nights, controlled for age and sex. Bedtime refers to actual lights-off time.

	Primary bedtime reason on school nights							
	Parents (P)	Tired (T)	Homework (H)	TV	Messaging or socializing (M)	F	η_p^2	
	M (SE)						*p*	Post hoc tests
School night bedtime	22:57 (0:07)	23:10 (0:02)	23:31 (0:05)	23:50 (0:07)	23:42 (0:05)	17.60	0.06	<0.001	P, T < H, TV, M H < TV
School night SOL, minutes	18.0 (2.00)	17.8 (0.66)	16.2 (1.48)	25.5 (2.01)	21.2 (1.24)	5.05	0.02	<0.001	P, T, H < TV T, H < M
School night TST, hours	7.5 (0.14)	7.4 (0.05)	7.0 (0.10)	6.7 (0.14)	6.9 (0.09)	13.79	0.05	<0.001	P, T > H, TV, M
Chronotype on free nights, midpoint	5:20 (0:09)	5:35 (0:03)	5:30 (0:06)	6:09 (0:09)	6:14 (0:05)	13.58	0.05	<0.001	P, T, H < TV, M
BDI sum score	12.97 (1.29)	10.33 (0.40)	9.54 (0.87)	11.27 (1.23)	12.36 (0.75)	2.72	0.01	0.03	H < P, M T < M
SDQ: Emotional symptoms	4.12 (0.28)	3.91 (0.09)	3.94 (0.21)	4.12 (0.29)	4.52 (0.18)	2.47	0.01	0.04	T, H < M
SDQ: Conduct problems	1.91 (0.17)	1.82 (0.06)	1.39 (0.13)	1.98 (0.17)	2.02 (0.11)	4.14	0.002	0.002	H < P, T, TV, M
SDQ: Hyperactivity	3.93 (0.26)	3.80 (0.09)	3.36 (0.20)	3.83 (0.27)	4.41 (0.17)	4.57	0.02	0.001	H < T < M
PSQI: Difficulty staying awake	1.84 (0.11)	1.78 (0.04)	2.06 (0.08)	1.94 (0.11)	2.05 (0.07)	4.97	0.02	0.001	T < H, M

F-values, partial eta square (η_p^2) values, and p-values obtained from one-way ANCOVAs controlling for age and sex. SOL = sleep onset latency; TST = total sleep time; BDI = Beck's Depression inventory; SDQ = Strengths and Difficulties questionnaire; PSQI = Pittsburgh Sleep Quality Index.

Table 3
Descriptive differences between groups with different reasons for going to bed on free nights.

	Primary bedtime reason on free nights				
	Parents	Tired	TV	Messaging or socializing	p
N (%)	25	895	105	258	
age (M, SD)	16.6, 0.53	16.8, 0.58	16.7, 0.55	16.9, 0.60	0.001
Sex (% male)	40	34	28	34	0.56
Parent educ.					0.15
Lower	0	24	1	2	
Middle	4	218	19	64	
Upper	20	628	81	182	

P-values obtained from one-way ANOVAs.

functioning, bedtime and chronotype are the only factors that differed significantly according to the reason for bedtime on weekends. Adolescents with parent-set bedtimes on weekends go to bed significantly earlier and have an earlier midpoint of sleep on free nights, indicating an earlier chronotype, than the remaining groups, while adolescents who go to bed on weekends after they finish messaging or socializing have the latest bedtimes and latest midpoint of sleep, all $p < 0.05$.

4. Discussion

The present study sampled a group of 1326 adolescents to determine whether the main reason for school night and weekend bedtime was associated with sleep and adaptive functioning. On school nights, adolescents whose parents set their bedtimes and those who went to bed when they were tired had significantly better sleep than adolescents who went to bed after they finished watching TV, or after they finished messaging or socializing. Adolescents who went to bed when they finished their homework had sleep that fell in between these groups. Adolescents whose parents set their bedtimes went to bed approximately 45 min earlier, obtained 45 min more sleep, and had a sleep midpoint on free nights that was approximately 45 min earlier than the adolescents who go to bed after their TV shows have finished or they have finished messaging or socializing. This additional sleep, totaling an extra 3 h 45 m across 5 nights every school week, has the potential to confer significant benefits to alertness and cognitive performance for these adolescents [27]. While the finding that parent-set bedtimes confer a benefit to sleep is consistent with previous work [15,17], less was known about how using subjective introspection of tiredness as a cue for bedtime impacted sleep, thus representing a novel finding. Indeed, given the social and biological milieu of adolescents is permissive of wakefulness into the evening, it could be argued that using tiredness as a trigger for bedtime may not be effective at safeguarding sleep. These results, however, suggest the opposite. These adolescents reported the least difficulty maintaining wakefulness during the day, indicating that these benefits extend to daytime alertness as well as sleep. However, it is important to note that these adolescents still reported average sleep durations that were well short of the sleep recommended for this age group [3,28], obtaining approximately 7.5 h of sleep on school nights. Thus, using the cue of tiredness does not necessarily ensure adequate sleep.

When considering the main reason for going to bed on weekends, group differences were only seen in weekend bedtime and sleep midpoint on free nights. This difference in findings between school nights and weekends suggests that the reasons triggering bedtime on school nights are the most salient in terms of sleep and adaptive functioning. This may be due to the removal of fixed waketimes to get up for school. Once this is removed, adolescents are free to obtain their desired sleep, irrespective of the reason or the time that they went to bed. Thus, adolescents whose bedtimes are later on weekends make up for this by sleeping in the next day.

4.1. Strengths and limitations

This study recruited a large sample of Finnish adolescents to address a novel area of research. These findings are informative for families, public policy makers and clinicians alike. In terms of limitations, first, these results may not generalize equally to other countries or cultures. For example, in this study, approximately one in eight students went to bed on school nights because they finished their homework. On weekends, so few adolescents went to bed after completing homework, this was not able to be included as

Table 4
Estimated marginal means (M) and standard error (SE) for weekend nights, controlled for age and sex. Bedtime refers to actual lights-off time.

	Primary bedtime reason on weekend nights							
	Parents (P)	Tired (T)	TV	Messaging or socializing (M)	F	η_p^2		
	M (SE)						p	Post hoc tests
Weekend bedtime	23:51 (0:16)	0:41 (0:03)	0:44 (0:08)	1:19 (0:05)	18.53	0.04	<0.001	P < T, TV < M
Weekend SOL	15.8 (2.93)	14.5 (0.50)	18.6 (1.44)	15.2 (0.92)	2.54	0.01	0.06	
Weekend TST	9.1 (0.25)	9.3 (0.04)	9.3 (0.12)	9.1 (0.08)	1.36	0.003	0.25	
Sleep midpoint on free nights	4:39 (0:16)	5:34 (0:03)	5:41 (0:08)	6:08 (0:05)	17.7	0.04	<0.001	P < T, TV < M
BDI sum score	14.38 (2.15)	10.50 (0.33)	10.06 (0.98)	11.41 (0.62)	1.68	0.004	0.17	
SDQ: Emotional symptoms	4.07 (0.47)	4.03 (0.08)	3.75 (0.23)	4.26 (0.15)	1.28	0.003	0.28	
SDQ: Conduct problems	1.89 (0.28)	1.76 (0.05)	1.80 (0.14)	1.96 (0.09)	1.42	0.003	0.24	
SDQ: Hyperactivity	3.61 (0.45)	3.76 (0.07)	3.76 (0.22)	4.10 (0.14)	1.63	0.004	0.18	
PSQI: Difficulty staying awake	1.95 (0.18)	1.82 (0.03)	1.97 (0.09)	1.93 (0.06)	1.71	0.004	0.16	

F-values, partial eta square (η_p^2) values, and p-values obtained from one-way ANCOVAs controlling for age and sex. SOL = sleep onset latency; TST = total sleep time; BDI = Beck's Depression inventory; SDQ = Strengths and Difficulties questionnaire; PSQI = Pittsburgh Sleep Quality Index.

a category in subsequent analyses. Finnish students start school relatively late by international standards, with typical school start times of approximately 8:15am to 9:00am. They do not typically attend night school, have a modest amount of homework, and, despite being ranked above the OECD average of students academically, report relatively low levels of school-work related anxiety [29]. This stands in stark contrast to other top-ranking countries, such as Singapore and Korea, where students begin school early, have high volumes of homework, frequently attend evening classes, report among the highest levels of school-work related anxiety worldwide, and spend a large part of their weekends also studying [29–31]. For these students, going to bed when they finish their homework may be associated with worse sleep and adaptive functioning [32]. This, however, remains speculative and warrants further research attention.

Another key limitation that should be considered when interpreting these findings is the use of a cross-sectional, retrospective and observational design which limits causal conclusions. For example, it is impossible to know whether adolescent who are messaging or socializing immediately before bed have delayed bedtime due to this or if, perhaps, adolescents who go to bed later simply chose to fill this additional time with messaging and socializing. Similarly, we cannot indicate the mechanisms involved. For example, it may be that longer exposure to blue light from screens delays melatonin onset and thus the internal cue of tiredness. Future research using an experimental design would be worthwhile. This type of design would be worthwhile in evaluating an intervention involving parent-set bedtimes and would help to control for other demographic and familial factors that may differ between families who choose to maintain parental limit-setting around bedtimes and those who do not. Alternatively, ecological momentary assessment methods could be used to assess within-subjects' variations to the reasons determining bedtime from one night to the next as well as use of electronic media each evening and evaluate how these factors affect sleep and daytime functioning.

5. Concluding remarks

Among the reasons for going to bed, both parent-set bedtimes (an externally derived cue) and going to bed when they were tired (an internally derived cue) were advantageous in terms of subsequent sleep, but only using tiredness as a cue for bedtime conferred an advantage to daytime alertness. This provides two very different approaches which may improve the sleep health of adolescents, either by having parents maintain limit-setting around bedtimes across adolescence, or by encouraging adolescents to use their bodily cues to recognize when it is time for bed, rather than relying on external cues, such as finishing homework, waiting for a TV program to finish, or waiting until they have finished messaging or socializing for the night [14,18,19]. These very different approaches could be considered in the context of what is likely to work best for each adolescent and family, to improve the sleep of this sleep deprived group.

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