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Chronic sleep restriction triggers inadequate napping habits in adolescents: a population-based study

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Abstract:	Background: The prevalence of chronic sleep restriction during adolescence is a major public health issue. Napping has been adopted to alleviate sleep pressure complaints. However, it also has the potential to amplify sleep restriction due to a vicious cycle triggered by delayed sleep times. The aim of this study was to investigate sleep and napping habits in a sample of Brazilian adolescents. Methods: This study enrolled 1554 high school students and included the evaluation of sleep times, daytime sleepiness, sleep quality, and circadian preference. The students were asked about their napping routine, i.e., its frequency and duration per week. Results: The adolescent sleep recommendation was achieved by only 27.6% of the sample. Napping habit was reported by 58.1%, with 36.2% of nappers informing naps in 1-2 times per week. Prolonged naps were reported by 44.9% of nappers. Nappers had later median bedtime (23:30) and reduced time in bed (TIB) (median = 07:00 h) compared to non-nappers. The frequency of nappers who did not achieve satisfactory TIB was higher than non-nappers. In addition, nappers reported increased daytime sleepiness and poor sleep quality. Later bedtimes and reduced TIB were associated with longer nap duration. Increased sleepiness and poor sleep quality were linked to a higher nap frequency. Conclusions: This exploratory survey demonstrated a severe sleep restriction faced by Brazilian adolescents. Napping can be an efficient strategy to counteract sleep restriction, but it needs to be adopted with caution due to the detrimental effects of frequent and prolonged naps on nocturnal sleep.

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1. Introduction

Adolescence is a critical stage of life in which many maturation processes take place, including changes in sleep regulation. It is well known that sleep is essential to mental function and academic achievement in this age bracket [1,2]. Homeostatic and circadian changes have been considered as pivotal factors determining adolescent's sleep: the process S (homeostatic) tends to be slower during adolescence, delaying sleep onset into the night; and the process C (circadian) is modified by the lengthening of the intrinsic circadian period [3–8]. These bioregulatory changes combined with psychosocial pressures (e.g. bedtime autonomy and excessive screen time use) contribute to the manifestation of the delayed sleep phase [9,10]. Thus, several studies have stressed that the combination of later sleep times with early school start times have contributed to both the prevalence of chronic sleep restriction among adolescents [11–16] and the enhancement of mood and behavior problems [4].

The chronic sleep restriction commonly seen in adolescence has become a major public health issue [14,17–19]. The National Sleep Foundation has recommended 8-10 hours of sleep per day as appropriate when considering cognitive, emotional, and physical health during adolescence [20]. When the recommended sleep is not achieved, the accumulated sleep pressure contributes to mounting complaints of daytime sleepiness, and consequently, to the adoption of napping by adolescents [21–23].

One of the more evident consequences of sleep restriction in adolescence is excessive daytime sleepiness, which, in some of the teens, has been associated with the occurrence of napping [24]. Besides reducing daytime sleepiness, napping has been used in anticipation of future sleep deprivation or routinely as a sociocultural habit [25,26]. Benefits to attention, concentration, reaction time [27], declarative and procedural memory consolidation [21,28,29], and to executive functions [30,31] and working memory [32,33] improvements have been reported through naps.

Although there is no consensus about the recommendation of naps among adolescents [34], there are studies in adults endorsing the positive role of short naps (up to 30 minutes) that occur near the circadian dip [26,35], in order to avoid subsequent nocturnal sleep disruption [35]. The sleep restriction experienced by adolescents prompts frequent and prolonged napping behaviors in their routine, which could increase alertness into the night, and thus promoting later sleep times [23,36,37].

The relationship between napping and nocturnal sleep has been investigated in studies involving both adults and adolescents. Taking naps seems to be an alternative to compensate poor sleep quality and short sleep duration in middle-aged adults [38]. Since then, only one study demonstrated this cause-effect relationship in adolescents [24]. The authors found that shorter sleep duration predicted prolonged naps but also napping habits predicted both reduced sleep duration and sleep efficiency in the next nocturnal sleep episode. Although there are many studies describing sleep and nap habits, few investigations have been dedicated to unveiling the relationship between nocturnal sleep and daytime naps in adolescents. Therefore, this work aimed to characterize sleep and napping occurrence in a representative sample of Brazilian adolescents (aged 14-19 years) and to evaluate the potential association between nocturnal sleep and daytime naps.

2. Methods

2.1. Sample and data collection

This cross-sectional investigation of epidemiological approach enrolled a total of 1554 adolescents from public high schools of the city of Curitiba, state of Paraná (PR), Brazil (25°25′S, 49°16′W). Initially, 1627 students fulfilled the questionnaires but 73 were excluded due to the poor completion of the survey. The schools were randomly selected based on the sectors arranged by the State Department of Education (SEED-PR), consisting of 9 sectors spread across the city (each sector was represented for one school).

The sample size was estimated considering a finite population from the equation: $n = [N. \sigma^2. (Z\alpha/2)^2]/[(N-1).E^2 + \sigma^2. (Z\alpha/2)^2]$, where n = number of individuals; $Z\alpha/2$ = critical value corresponding 95% of confidence interval; E = the maximum error of the estimate; N = population size; σ = population standard deviation. Since the population size (number of high school enrollments registered by SEED-PR) was 55390 in 2019, the recommended sample size of 1569 was considered representative.

The sample was composed only of early morning shift students (classes started at 07:30). The data collection occurred between March and June 2019 and all students informed assent prior to participation. Informed consent was also provided by parents or legally responsible. Thereafter, the data collection was done inside the classroom during normal class hours. The questionnaires included demographic information, the Pediatric Daytime Sleepiness Scale (PDSS), the Morningness-Eveningness Scale (M/E) and the Pittsburgh Sleep Quality Index (PSQI). In addition, the students were asked about nap habits, including the frequency and duration of their naps per week. All the questionnaires were available through electronic means (tablet devices) and students were oriented by one member of the research team.

2.2. Measures

2.2.1. Pediatric Daytime Sleepiness Scale (PDSS)

PDSS was translated and validated to the adolescent Brazilian population [39]. This scale evaluates excessive daytime sleepiness in children and adolescents through 8 questions with 5-point Likert-type from never (0) to always (5). Through the sum of points, scores ranged from 0 (low sleepiness) to 32 (high sleepiness) with higher scores meaning greater daytime sleepiness.

2.2.2. Morningness/Eveningness Scale (M/E)

Circadian preference was measured by the M/E scale which has been validated and adapted to adolescent Brazilian populations [40] with questions about time-of-day to perform activities (e.g. sleep/wake times, physical exercise, leisure, scholar activities). 10 multiple-choice questions compose this scale providing a final score by means of answers’ sum. The maximum score is 43 with higher values indicating a morningness tendency whereas lower values would indicate eveningness tendency.

2.2.3. Pittsburgh Sleep Quality Index (PSQI)

The Brazilian version of PSQI was validated and adapted to the adolescent population [41]. PSQI is a well-established survey for quality and quantity of sleep in the previous month composed of 19 questions grouped into seven components, ranked by 0 to 3 ranges scores. These components are divided into (C1) subjective sleep quality, (C2) sleep latency, (C3) sleep duration, (C4) habitual sleep efficiency, (C5) sleep disturbances, (C6) use of sleep medication and (C7) daytime dysfunction. In addition, PSQI provides self-report bedtime and wakeup time behaviors. A global score is generated by the sum of these components that produce ranges from 0 to 21, indicating worse sleep quality in higher scores. The original questionnaire [42] recommended a discriminatory score between "good sleepers" and "poor sleepers" using a cutoff score of 5 points. Poor sleepers are classified with scores greater than 5 points in PSQI [43].

2.2.4. Occurrence of naps

The nap habit was reported by a single question ("*Do you usually take naps during the day?*"). Adolescents who informed "*yes*" in this question were grouped as nappers. Two additional questions related to frequency and duration of naps were asked to nappers. The frequency and duration of naps was rated in five categories: frequency of naps per week (<1x, 1-2x, 3-4x, 5-6x, and >6x) and duration of naps per episode (<15min, 15-30min, 30-45min, 45-60min, and >60min).

2.3. Statistical analyses

Continuous variables were expressed as mean and standard deviation whereas categorical variable was described as frequency distribution. The Kolmogorov-Smirnov test was used to test data normality. Since all data presented non-parametric distribution, the Mann-Whitney test was performed. Linear regression analysis was performed to explore relationships between the frequency and duration of naps with sleep variables adjusted by gender, age, and year of high school.

Chi-square tests were performed to investigate differences among categorical variables (gender, year of high school, sleepiness in classroom, recommended sleep duration and satisfactory TIB duration) in nappers and non-nappers. The significant differences were explored by calculating the standardized residual for each cell in each contingency table. According to Sharpe [44], the highest residual values tend to contribute to the magnitude of the Chi-square test. In addition, a Bonferroni adjustment was done to avoid the probability of a Type I error [45]. The analysis was executed using both SPSS version 25 (IBM Corp., Armonk, NY, USA) and Python version 3.7 (Spyder IDE). The significance level was defined by $p<0.05$ and the effect sizes were reported for all analyses.

2.4. Ethical aspects

This study was approved by the Local Research Ethics Committee (CEP – Universidade Federal do Paraná, Brazil) 72937617.1.0000.0102 number of process authorized in October 2017, in compliance with the Declaration of Helsinki.

3. Results

3.1. Demographic characterization

The demographic characteristics of the sample are shown in Table 1 and the sample characterization based on sleep variables is listed in Table 2. The population that the sample was extracted from is composed of the following ethnic groups [data from the Statistical Synopsis of Basic Education/Brazilian Ministry of Education (2019) (www.gov.br/inep)]: White (59.55%), Black (1.02%), Mixed (9.08%), Yellow/Asian (0.43%), Indigenous (0.24%), Undeclared (29.68%). Data about socioeconomic status (SES) were also extracted by a scholar census developed by the Brazilian Ministry of Education (www.gov.br/inep). As the SES data were not updated during the year of data collection for this study (2019), data from the last SES scholar census available (2015) will be reported instead. According to this census, the sample that took part in this study was from schools with students reporting monthly family income between 2.5 to 7 minimum salary and parents with high school or college/university education.

The sample was composed by 54.7% of girls and the mean age was 15.8 (aged 14-19 years) (Table 1). A small portion of the participants worked during the out-of-school shift (19.8%). Health problems and use of medication was reported by 25.1% and 23.1% of the participants, respectively; only 6.8% reported use of medications to sleep. Alcohol intake was reported by 15.1% and smoking by 2.7% of the participants. Regarding stimulant drink intake, almost half of the participants reported caffeine ingestion (48.4%) at least once per day. This proportion was reduced when adolescents were asked specifically about energy drink ingestion (10.6%) (Table 1).

The average bedtime and wake time was 23:10 and 06:15 hours, respectively (Table 2). The mean time in bed (TIB) was of 07:05 hours with only 27.6% (n = 429) of adolescents getting the recommended amount of sleep (more than 8 h) [20]. Most of adolescents reported insufficient TIB (70.9% informed “Never” or “Sometimes” satisfactory TIB duration). Furthermore, 39.5% of the sample reported that they “Frequently” or “Always” felt sleepiness in the classroom (Table 2). The mean score of daytime sleepiness assessed by PDSS was 17.75 points. Morningness/Eveningness Scale varied from 11 to 43 (mean 25.20 points) and the PSQI global score was 6.33 points (Table 2).

3.2. Napping habits

Most of the adolescents reported taking naps during the week (58.1%). Among nappers, more than one-third (36.2%) reported infrequent naps (1-2 x/week), and 28.6 % reported naps three to four times per week. Prolonged naps were prevalent among nappers with 44.9% reporting more than 60 minutes of nap duration (Figure 1).

The group of nappers included more girls (59.6%) than boys (40.4%, Chi-squared $\chi^2(1) = 20.73$, $p<0.001$, Table 3). A higher proportion of adolescent workers did not take naps during the week (28.6% *vs* 13.4%, Chi-squared $\chi^2(1) = 54.93$, $p<0.001$. Alcohol ingestion was higher in nappers than non-nappers (16.8% vs 12.7%, Chi-squared $\chi^2(1) = 4.91$, $p=0.02$). In relation to stimulant drink intake, only soda and energy drink differed between groups. Both types of stimulants were more used, at least once per day, for nappers [47.8% (soda); 11.1% (energetics)] than non-nappers [40.5% (soda); 9.8% (energetics); soda: $\chi^2(4) = 10.74$, $p=0.03$, energetics: $\chi^2(4) = 10.15$, $p=0.04$]. The other demographic variables did not differ between groups.

Nappers reported later bedtimes (median = 23:30) than non-nappers (median = 23:00, $p < 0.001$, Table 3). Further, median sleep latency was higher in nappers (20 min) than non-nappers (15 min, $p=0.01$). Nappers exhibited shortened TIB (median = 07:00) compared to non-nappers (median = 07:30, p <

0.001). The frequency of nappers who did not achieve the recommended sleep duration (< 8 h) was higher (76.2%) than non-nappers (67.1%, Chi-squared χ^2 (1) = 15.55, $p < 0.001$). Nappers reported more sleepiness in classroom (21.7%) than non-nappers (10.4%, Chi-squared $\chi^2(4) = 83.85$, $p < 0.001$) as well as less satisfaction with the TIB duration (23.7%) compared to non-nappers (14.6%, Chi-squared $\chi^2(4) = 56.50$, $p < 0.001$). Nappers showed higher scores of sleepiness on the PDSS (median = 19; non-nappers = 16, $p<0.001$) and poorer sleep quality as assessed by the PSQI (median = 6; non-nappers = 5, $p < 0.001$). The score in M/E scale revealed a greater proportion of evening types in nappers (median = 24) compared with non-nappers (median = 27, $p < 0.001$).

The relationship between frequency and duration of naps with sleep variables among nappers was explored by multiple linear regressions (Table 4). Frequency and duration of naps were listed as dependent variables. Sleep variables (bedtime, sleep latency, wake time, and TIB) as well as daytime sleepiness (PDSS), Morningness/Eveningness Scale (M/E), and sleep quality (PSQI) were considered as independent variables. Gender, age, and year of high school were used to adjust variables in the analysis. Two models were used for this analysis: TIB was excluded in model 1 whereas bedtime was excluded in Model 2. These models were required due to the multicollinearity detected between bedtime and TIB. Later bedtimes ($\beta = 0.08$) and reduced TIB ($\beta = -0.07$) were associated with prolonged nap duration. Increased daytime sleepiness ($\beta = 0.20$) and poor sleep quality ($\beta = 0.10$) were linked to more frequent naps during the week. The tendency to eveningness was also related to the higher frequency of naps ($\beta = -0.09$).

4. Discussion

This investigation assessed sleep and napping habits in a representative sample of adolescents. Insufficient sleep was associated with increased daytime sleepiness (inside or outside the classroom) and poor sleep quality. Napping was revealed as a common practice in our study sample showing a pattern of frequent and prolonged naps. However, nappers exhibited more sleepiness, insufficient nocturnal TIB (self-reported), and poorer sleep quality. In addition, nappers reported circadian preference toward eveningness. The multiple regression models showed that both later bedtimes and shorter TIB were linked to longer naps. A positive relationship was identified between daytime sleepiness, poor sleep quality, and frequent naps. On the other hand, circadian preference was negatively associated with frequent naps, revealing that the higher the eveningness score, the higher reports of naps during the week.

Similarly to previous studies [24,38,46,47], in our sample reduced TIB was associated with increased naps, reinforcing the idea that poor sleep duration plays a pivotal role in triggering daytime naps in adolescents. We suggest that the adolescents in this study have used naps to compensate for their elevated daytime sleepiness [46,47], which may be supported by the higher scores on the PDSS and the increased frequency of self-reported sleepiness in the classroom. Prolonged naps have the potential to reduce homeostatic sleep pressure at night, resulting in delayed sleep onset times [46]. This proposal is supported by the positive relationship between bedtime and nap duration in our regression models, even though we cannot infer the direction of causation between these variables.

Attempts to elucidate the cause-effect relationship between nocturnal sleep and napping habits have been made in adolescents and middle-aged adults. For example, using multilevel random-effects models, Häusler and colleagues were able to determine the direction of causation between these variables among adults (mean age 60.7) [38]. Poor sleep quality and shorter sleep duration were linked to next-day napping. On the other hand, napping was not related to same-day nocturnal sleep. Only subjects who reported afternoon naps presented a reduction in the same-day sleep duration. Therefore, napping seems to be a manner to cope sleep curtailment and poor sleep quality, but depending on the timing of nap, it could be detrimental to same-day nocturnal sleep duration [38]. In adolescents, the direction of causation is not yet clear, even though mixed model analyses have already been done by Jakubowski and collaborators [24]. This investigation found that short sleep duration promoted next-day napping, and vice-versa. Future investigations must be devoted to elucidating the direction of causation between these variables in adolescents, since the benefits of napping have the potential to be reversed due to its detrimental role in nocturnal sleep.

Many investigations have elucidated the benefits of napping on adolescent's mental performance, but few studies have focused on the effects of inadequate napping habits, such as prolonged naps. Prolonged naps, typically rich in SWS, have the potential to change subsequent nocturnal sleep architecture by modifying the distribution of sleep stages during the night. Since the need for SWS has already been partially satiated, homeostatic pressure is reduced and the next episode of nocturnal sleep tends to be more superficial and less restorative. According to Milner & Cote, healthy young adults should ideally nap for approximately 10 to 20 min [26]. Frequent nappers are able to engage in healthy daytime naps, that is, with a short duration, greater amounts of non-rapid eye movement (NREM) 1 and 2 and less slow wave sleep (SWS) [48]. Even after acute sleep restriction brief naps seem to be better than longer ones in ameliorating alertness and cognitive performance [48]. Unfortunately, as shown in this study, chronically sleep restricted adolescents tend to engage in non-habitual (1-2 x a week) prolonged napping (60 min or more). Ultimately, inadequate napping habits triggered by chronic sleep restriction could generate long-term problems related to learning and sleep-dependent memory consolidation that are crucial to academic performance in adolescents [4,23,49].

School schedules have been linked to chronic sleep restriction and napping habits in adolescents [4,18,50]. Early school schedules may be the final straw that triggers the vicious cycle between sleep restriction and inadequate napping habits. The alternative to delay school schedules seems to be feasible to solve this situation, since it is not possible to modify the delayed sleep phase during puberty. Whereas later school times are not adopted in most educational settings, the increased proportion of nappers reported in the literature reflects the inadequate sleep hygiene practices that adolescents are forced into in order to attend school classes.

This study's main limitation is the use of subjective measure to assess sleep and napping patterns, however, it would not have been feasible to collect sleep data through actigraphy or polysomnography in such a large sample as the one in this study (n = 1554). Furthermore, we endeavoured to offset this issue by using widely established and validated tools to assess sleep patterns such as the PSQI and the PDSS. Since these questionnaires do not distinguish between sleeping patterns on the weekdays versus weekends, we were not able to assess whether or not the adolescents in our sample experienced '*social jetlag'* [51], and if so, its severity. On a related topic, we did not collect information regarding diagnosed sleep disorders such as insomnia, or the use of psychotropic medications in general (besides hypnotics), which could have helped to disentangle the effects of puberty and development alone on sleep and napping patterns from those originating from a sleep or mental health disorder. It would have been helpful to assess potential changes across development in sleep and napping behaviour by comparing early (14 y.o.) and late (19 y.o.) adolescents, however, the sample size in each of these age groups was too unbalanced (208 vs 16). Finally, it would also have been interesting to include questions regarding the use of electronic devices before bed, as this has been shown to also affect the sleep patterns of adolescents [52,53].

5. Conclusions

Despite several studies demonstrating the benefits of napping in mental and well-being, this study showed that adolescents generally use napping to alleviate sleep restriction symptoms. Thus, a vicious cycle is triggered, since early school times lead to acute sleep restriction, which in turn may promote napping behavior, and in this study we have shown that napping contributes to later bedtimes and further sleep restriction (Figure 2). Our results highlight the importance of discussing later school starting times with educators, parents, and policy makers, and of implementing healthy napping habits during adolescence. Considering that napping is a culturally-embedded habit in the Brazilian population [54], these actions will be useful to improve sleep quantity and quality, and to promote advantages to mental performance and well-being.

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References

[1] Touitou Y, Touitou D, Reinberg A. Disruption of adolescents' circadian clock: The vicious circle of media use, exposure to light at night, sleep loss and risk behaviors. J Physiol Paris 2016;110:467–79. https://doi.org/10.1016/j.jphysparis.2017.05.001.

[2] Touitou Y. Adolescent sleep misalignment: A chronic jet lag and a matter of public health. J Physiol Paris 2013;107:323–6. https://doi.org/10.1016/j.jphysparis.2013.03.008.

[3] Carskadon MA. Sleep in Adolescents: The Perfect Storm. Pediatr Clin North Am 2011;58:637–47. https://doi.org/10.1016/j.pcl.2011.03.003.

[4] Crowley SJ, Wolfson AR, Tarokh L, Carskadon MA. An update on adolescent sleep: New evidence informing the perfect storm model. J Adolesc 2018;67:55–65. https://doi.org/10.1016/j.adolescence.2018.06.001.

[5] Tarokh L, Saletin JM, Carskadon MA. Sleep in adolescence: Physiology, cognition and mental health. Neurosci Biobehav Rev 2016;70:182–8. https://doi.org/10.1016/j.neubiorev.2016.08.008.

[6] Illingworth G. The challenges of adolescent sleep. Interface Focus 2020;10. https://doi.org/10.1098/rsfs.2019.0080.

[7] Alfonsi V, Scarpelli S, D'Atri A, Stella G, De Gennaro L. Later school start time: The impact of sleep on academic performance and health in the adolescent population. Int J Environ Res Public Health 2020;17. https://doi.org/10.3390/ijerph17072574.

[8] Hagenauer MH, Perryman JI, Lee TM, Carskadon M a. Adolescent changes in the homeostatic and circadian regulation of sleep. Dev Neurosci 2009;31:276–84. https://doi.org/10.1159/000216538.

[9] Crowley SJ, Acebo C, Carskadon MA. Sleep, circadian rhythms, and delayed phase in adolescence. Sleep Med 2007;8:602–12. https://doi.org/https://doi.org/10.1016/j.sleep.2006.12.002.

[10] Carskadon MA, Vieira C, Acebo C. Association between puberty and delayed phase preference. Sleep 1993;16:258–62. https://doi.org/10.1093/sleep/16.3.258.

[11] Bonnar D, Gradisar M, Moseley L, Coughlin AM, Cain N, Short MA. Evaluation of novel school-based interventions for adolescent sleep problems: Does parental involvement and bright light improve outcomes? Sleep Heal 2015;1:66–74. https://doi.org/10.1016/j.sleh.2014.11.002.

[12] Nahmod NG, Lee S, Buxton OM, Chang AM, Hale L. High school start times after 8:30 AM are associated with later wake times and longer time in bed among teens in a national urban cohort study. Sleep Heal 2017;3:444–50. https://doi.org/10.1016/j.sleh.2017.09.004.

[13] Das-Friebel A, Gkiouleka A, Grob A, Lemola S. Effects of a 20 minutes delay in school start time on bed and wake up times, daytime tiredness, behavioral persistence, and positive attitude towards life in adolescents. Sleep Med 2020;66:103–9. https://doi.org/10.1016/j.sleep.2019.07.025.

[14] Louzada F. Adolescent sleep: A major public health issue. Sleep Sci 2019;12:1. https://doi.org/10.5935/1984-0063.20190047.

[15] Louzada FM, Da Silva AGT, Peixoto CAT, Menna-Barreto L. The adolescence sleep phase delay: Causes, consequences and possible interventions. Sleep Sci 2008;1:49–53. https://doi.org/10.1111/j.1365-294X.2011.05110.x.

[16] Mello L, Louzada F, Menna-Barreto L. Effects of school schedule transition on sleep-wake cycle of Brazilian adolescents. Sleep Hypn 2001;3:106–11.

[17] Campbell IG, Burright CS, Kraus AM, Grimm KJ, Feinberg I. Daytime sleepiness increases with age in early adolescence: A sleep restriction dose–response study. Sleep 2017;40:1–8.

[18] Carskadon MA, Acebo C. Regulation of sleepiness in adolescents: Update, insights, and speculation. Sleep 2002;25:606–14. https://doi.org/10.1093/sleep/25.6.606.

[19] Ribeiro S, Stickgold R. Sleep and school education. Trends Neurosci Educ 2014;3:18–23. https://doi.org/10.1016/j.tine.2014.02.004.

[20] Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, DonCarlos L, et al. National Sleep Foundation's updated sleep duration recommendations: Final report. Sleep Heal 2015;1:233–43. https://doi.org/10.1016/j.sleh.2015.10.004.

[21] Lau EYY, McAteer S, Leung CNW, Tucker MA, Li C. Beneficial effects of a daytime nap on verbal memory in adolescents. J Adolesc 2018;67:77–84. https://doi.org/10.1016/j.adolescence.2018.06.004.

[22] Ong JL, Lo JC, Gooley JJ, Chee MWL. EEG changes accompanying successive cycles of sleep restriction with and without naps in adolescents. Sleep 2017;40. https://doi.org/10.1093/sleep/zsx030.

[23] Short MA, Chee MWL. Adolescent sleep restriction effects on cognition and mood. 1st ed. Elsevier B.V.; 2019. https://doi.org/10.1016/bs.pbr.2019.02.008.

[24] Jakubowski KP, Hall MH, Lee L, Matthews KA. Temporal Relationships between Napping and Nocturnal Sleep in Healthy Adolescents. Behav Sleep Med 2016;2002:1–13. https://doi.org/10.1080/15402002.2015.1126595.

[25] Ficca G, Axelsson J, Mollicone DJ, Muto V, Vitiello M V. Naps, cognition and performance. Sleep Med Rev 2010;14:249–58. https://doi.org/10.1016/j.smrv.2009.09.005.

[26] Milner CE, Cote K a. Benefits of napping in healthy adults: impact of nap length, time of day, age, and experience with napping. J Sleep Res 2009;18:272–81. https://doi.org/10.1111/j.1365-2869.2008.00718.x.

[27] Faraut B, Andrillon T, Vecchierini MF, Leger D. Napping: A public health issue. From epidemiological to laboratory studies. Sleep Med Rev 2017;35:85–100. https://doi.org/10.1016/j.smrv.2016.09.002.

[28] Nishida M, Walker MP. Daytime naps, motor memory consolidation and regionally specific sleep spindles. PLoS One 2007;2:e341–e341.

https://doi.org/10.1371/journal.pone.0000341.

[29] Mednick S, Nakayama K, Stickgold R. Sleep-dependent learning: A nap is as good as a night. Nat Neurosci 2003;6:697–8. https://doi.org/10.1038/nn1078.

[30] Kaida K, Takeda Y, Tsuzuki K. The effects of short afternoon nap and bright light on task switching performance and error-related negativity. Sleep Biol Rhythms 2013;11:125–34. https://doi.org/10.1111/sbr.12013.

[31] Slama H, Deliens G, Schmitz R, Peigneux P, Leproult R. Afternoon nap and bright light exposure improve cognitive flexibility post lunch. PLoS One 2015;10:1–16. https://doi.org/10.1371/journal.pone.0125359.

[32] MacDonald KJ, Lockhart HA, Storace AC, Emrich SM, Cote KA. A daytime nap enhances visual working memory performance and alters event-related delay activity. Cogn Affect Behav Neurosci 2018;18:1105–20. https://doi.org/10.3758/s13415-018-0625-1.

[33] Lo JC, Lee SM, Teo LM, Lim J, Gooley JJ, Chee MWL. Neurobehavioral Impact of Successive Cycles of Sleep Restriction With and Without Naps in Adolescents. Sleep 2016;40. https://doi.org/10.1093/sleep/zsw042.

[34] Ohayon M, Wickwire EM, Hirshkowitz M, Albert SM, Avidan A, Daly FJ, et al. National Sleep Foundation's sleep quality recommendations: first report. Sleep Heal 2017;3:6–19. https://doi.org/10.1016/j.sleh.2016.11.006.

[35] Lovato N, Lack L. The effects of napping on cognitive functioning. Prog Brain Res 2010;185:155–66. https://doi.org/10.1016/B978-0-444-53702-7.00009-9.

[36] Gradisar M, Wright H, Robinson J, Paine S, Gamble A. Adolescent napping behavior: Comparisons of school week versus weekend sleep patterns. Sleep Biol Rhythms 2008;6:183–6. https://doi.org/10.1111/j.1479-8425.2008.00351.x.

[37] Gradisar M, Terrill G, Johnston A, Douglas P. Adolescent sleep and working memory performance. Sleep Biol Rhythms 2008;6:146–54.

https://doi.org/10.1111/j.1479-8425.2008.00353.x.

[38] Häusler N, Marques-Vidal P, Haba-Rubio J, Heinzer R. Does sleep predict next-day napping or does napping influence same-day nocturnal sleep? Results of a population-based ecological momentary assessment study. Sleep Med 2019;61:31–6. https://doi.org/10.1016/j.sleep.2019.04.014.

[39] Felden ÉPG, Carniel JD, Andrade RD, Pelegrini A, Anacleto TS, Louzada FM. Translation and validation of the Pediatric Daytime Sleepiness Scale (PDSS) into Brazilian Portuguese. J Pediatr (Rio J) 2016;92:168–73. https://doi.org/10.1016/j.jped.2015.05.008.

[40] Finimundi M, Barin I, Bandeira D, Souza DO. Validação da escala de ritmo circadiano - Ciclo vigília/sono para adolescentes. Rev Paul Pediatr 2012;30:409–14. https://doi.org/10.1590/S0103-05822012000300016.

[41] Passos MHP, Silva HA, Pitangui ACR, Oliveira VMA, Lima AS, Araújo RC. Confiabilidade e validade da versão brasileira do Índice de Qualidade do Sono de Pittsburgh em adolescentes. J Pediatr (Rio J) 2017;93:200–6. https://doi.org/10.1016/j.jped.2016.06.006.

[42] Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ, III CFR, et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 1989;28:193–213. https://doi.org/10.1016/0165-1781(89)90047-4.

[43] Bertolazi AN, Fagondes SC, Hoff LS, Dartora EG, da Silva Miozzo IC, de Barba MEF, et al. Validation of the Brazilian Portuguese version of the Pittsburgh Sleep Quality Index. Sleep Med 2011;12:70–5. https://doi.org/10.1016/j.sleep.2010.04.020.

[44] Sharpe D. Your chi-square test is statistically significant: Now what? Pract Assessment, Res Eval 2015;20:1–10.

[45] MacDonald PL, Gardner RC. Type I error rate comparisons of post hoc procedures for I × J chi-square tables. Educ Psychol Meas 2000;60:735–54. https://doi.org/10.1177/00131640021970871.

[46] Mizuno K, Okamoto-Mizuno K, Iwata K. Napping Behaviors and Extracurricular Club Activities in Japanese High School Students: Associations with Daytime Sleep Problems. Clocks & Sleep 2019;1:367–84. https://doi.org/10.3390/clockssleep1030030.

[47] Lovato N, Lack L, Wright H. The napping behaviour of Australian university students. PLoS One 2014;9:9–12. https://doi.org/10.1371/journal.pone.0113666.

[48] Tietzel AJ, Lack LC. The Short-Term Benefits of Brief and Long Naps Following Nocturnal Sleep Restriction. Sleep 2001;24:293–300. https://doi.org/10.1093/sleep/24.3.293.

[49] Lo JC, Ong JL, Leong RLF, Gooley JJ, Chee MWL. Cognitive Performance, Sleepiness, and Mood in Partially Sleep Deprived Adolescents: The Need for Sleep Study. Sleep 2016;39:687–98. https://doi.org/10.5665/sleep.5552.

[50] Carskadon MA, Dement WC. Normal Human Sleep. Fifth Edit. Elsevier Inc.; 2011. https://doi.org/10.1016/B978-1-4160-6645-3.00002-5.

[51] Wittmann M, Dinich J, Merrow M, Roenneberg T. Social Jetlag: Misalignment of Biological and Social Time. Chronobiol Int 2006;23:497–509. https://doi.org/10.1080/07420520500545979.

[52] Malheiros LEA, da Costa BGG, Lopes MV V, Chaput J-P, Silva KS. Association between physical activity, screen time activities, diet patterns and daytime sleepiness in a sample of Brazilian adolescents. Sleep Med 2021;78:1–6. https://doi.org/https://doi.org/10.1016/j.sleep.2020.12.004.

[53] Hisler G, Twenge JM, Krizan Z. Associations between screen time and short sleep duration among adolescents varies by media type: evidence from a cohort study. Sleep Med 2020;66:92–102. https://doi.org/https://doi.org/10.1016/j.sleep.2019.08.007.

[54] Merdad RA, Merdad LA, Nassif RA, El-Derwi D, Wali SO. Sleep habits in adolescents of Saudi Arabia; distinct patterns and extreme sleep schedules. Sleep Med 2014;15:1370–8. https://doi.org/10.1016/j.sleep.2014.06.008.