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Original Article

Protective and risk factors associated with adolescent sleep: findings from Australia, Canada, and The Netherlands

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ABSTRACT

Background: Sleep is vital for adolescent functioning. Those with optimal sleep duration have shown improved capacity to learn and decreased rate of motor vehicle accidents. This study explored the influence of numerous protective and risk factors on adolescents' school night sleep (bedtime, sleep latency, total sleep time) simultaneously to assess the importance of each one and compare within three countries.
Method: Online survey data were collected from Australia, Canada, and The Netherlands. Overall, 325 (137 male), 193 (28 male), and 150 (55 male) contributed to data from Australia, Canada, and The Netherlands, respectively (age range 12–19 years).
Results: Regression analyses showed mixed results, when comparing protective and risk factors for sleep parameters within different countries, with combined behavioural factors contributing to small to large shared portions of variance in each regression (9–50%). One consistent finding between countries was found, with increased pre-sleep cognitive emotional sleep hygiene related to decreased sleep latency (*beta* = –0.25 to –0.33, $p < 0.05$). Technology use (mobile phone/Internet stop time) was associated with later bedtime, or less total sleep, with the strength of association varying between device and country.
Conclusion: Results indicate that when designing interventions for adolescent sleep, multiple lifestyle factors need to be considered, whereas country of residence may play a lesser role.

1. Introduction

Sleep is critical for adolescents' daily functioning [1,2]. With longer sleep duration, adolescents have improved capabilities to learn, remember and perform well academically [3,4], and decreased rates of motor vehicle accidents [5], whereas less than seven hours of sleep per night is associated with higher rates of delinquency and crime [6]. Poorer mental health is associated with adolescents who obtain less than seven hours sleep per night, compared to adolescents who sleep seven to nine hours per night [7]. Earlier bedtimes, shorter sleep latencies (ie, the time it takes to fall asleep) and longer sleep length are also related to lower anxiety, depressed mood, suicidal ideation, and fatigue scores [8,9].

The transition from middle childhood to adolescence is marked, for some, by an increase in the time it takes for sleep pressure to accumulate, and a delay in the circadian rhythm [10]. Consequently, adolescents may struggle to fall asleep at a time which allows for an adequate sleep opportunity during the school week, when sleep may be constrained by school start times [10]. In addition to biological factors, extrinsic factors also play a part in delaying bedtimes, increasing sleep latency and decreasing sleep time, particularly on school days. As adolescents' sleep can be affected by a plethora of environmental factors, it is important to understand the relative influence of such factors so that appropriate interventions may minimise their impact. Whilst we review many influential factors here, it is important to note that most research studies investigate one-to-a-few factors without consideration of the majority of risk and protective factors [11]. Thus, the primary aim of the present study will be to analyse the relative importance of multiple risk and protective factors associated with adolescents' sleep, such as *technology use, substance use, pre-sleep cognitive and emotional arousal, home environment,* and *after school sport*, and to ascertain whether these factors pertain to adolescent sleep in a similar manner for different countries.

Age is a potential risk factor, with older adolescents sleeping less than younger adolescents – a phenomenon found across Australia, Europe, North America, and Asia [12,13]. Gender is also influential on sleep, with girls sleeping more than boys, yet girls' time in bed decreasing at a larger rate than boys for each increasing year of age [13].

Concerning adolescents' "screen consumption," multiple studies, particularly surveys, have found links between *technology use* and

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later bedtimes (eg, Gamble et al. [14]) and short sleep duration and longer sleep latency (eg, Hysing et al. [15]). However, some controlled laboratory experiments (eg, Heath et al. [16]; van der Lely et al. [17]; Weaver et al. [18]) have found little-to-no negative causal effects of pre-bed technology use on sleep. Indeed, a meta-analysis found, if anything, that technological devices are predominantly related to adolescents' later bedtimes [11].

The link between substance use and adolescent sleep remains unclear [11]. Although there seems to be no association between sleep latency and *alcohol* or *tobacco use*, links between these substances and sleep duration and bedtime are less distinct, with the potential for moderating or mediating factors, such as negative family interactions [11]. In terms of *caffeine*, its use is associated with less total sleep, especially when consumed in the evening [11,19]. However, links between caffeine use and sleep latency and bedtime are varied [19].

Sleep hygiene comprises multiple factors, such as pre-sleep cognitive and emotional arousal, physiological arousal, sleep environment, sleep stability, behavioural arousal, and daytime sleep (ie, napping [20]). Good sleep hygiene has typically benefitted adolescent sleep parameters (eg, Bartel et al. [11]; Storfer-Isser et al. [20]). Less pre-sleep worry in adolescents has shown to be related to decreased sleep latency [11], and less cognitive and emotional arousal prior to bed has been shown to relate to earlier bedtimes, a shorter sleep latency, and longer sleep time [20].

Adolescents' sleep has consistently shown to be enhanced when their *home environment* is positive [11,21–24]. A home environment encompasses many components, such as stress of demands [25], conflict [24] and disorganisation [22]. Sufficient sleep may be supported in a positive home environment, where a foundation is laid for health promoting behaviours [26], and less chaos is present [22]. Similarly, *parent-set bedtimes* are consistently linked with longer sleep durations, but not sleep latency [11], above the effects of age [27], thus improving adolescents' daytime wakefulness and decreasing their fatigue [28].

Activities outside of school (ie, extracurricular, work, study, sport) have been proposed to shorten sleep [29,30]. Although a meta-analysis found a beneficial relationship between *physical activity* and bedtime, the association between other activities on bedtime, sleep latency or total sleep time was not found [11]. Moreover, access to *indoor room lighting* may also decrease adolescents' sleep, even at low lux [31].

Despite the multiple factors which have been proposed to positively or negatively affect adolescents' sleep, these variables have not been studied simultaneously or in multiple countries, to determine the strength of their influence, when accounting for the presence of each other. Considering sleep broadly impacts daily functioning [1–3,5,29], it is within the best interests of the scientific community to determine which extrinsic factors provide the largest contribution in assisting, and hindering, the chances of a teenager getting to bed early, falling asleep quickly, and sleeping for longer. Such knowledge can direct healthcare professionals, parents, and adolescents themselves in achieving these sleep goals. In line with this, we created an online survey to collect data on adolescents' technology use, substance use, home environment, parent-set bedtime, and physical activity, at a single time point. In doing so, all factors could be analysed together, thus assessing which variables were more highly associated with adolescent bedtime, sleep latency, and total sleep than others. The added benefit of sampling across multiple countries was to assess the generalisability of findings to various adolescent populations across the globe.

2. Methods

2.1. Participants

A total of 460 588, and 354 adolescents commenced the survey from Australia, Canada, and The Netherlands, respectively. Of those, 325 (137 male), 193 (28 male), and 150 (55 male) contributed to data from the 178-item questionnaire battery, respectively. See Table 1 for descriptive statistics and frequencies for each sample.

2.2. Materials

All variables, other than caffeine, alcohol, and tobacco use, pre-sleep cognitive-emotional arousal, and sleep reduction, asked adolescents about their school day and weekend habits separately. Only school day data were reported, as restriction of sleep, imposed by school start times, offers a larger threat for daytime consequences [28], as well as altered weekend behaviour patterns (eg, decreased prevalence of parent-set bedtimes on weekend nights [27,28]. Demographic information on age, gender, and school were collected.

2.2.1. Sleep

Participants were asked about their bedtime (*At what time do you usually go to bed to sleep at night?),* sleep onset latency (*How long does it usually take you to fall asleep?*), awakenings after sleep onset, wake-up time, time out of bed and total sleep time (*How many hours do you usually sleep?),* over the previous two weeks. Answers reported for bedtime, sleep latency, and total sleep were used for analyses. Adolescents were also asked if they had any health conditions affecting their sleep, using a free text response. As this survey was aimed at looking at the general population of adolescents in

Table 1
Descriptive statistics and frequencies: Australia, Canada, The Netherlands M ± SD (N)/percentage yes (N).

Variable (scale range)	Australia	Canada	Netherlands
Age (12–19 years)	15.85 ± 1.34 (323)	15.90 ± 1.60 (193)	16.38 ± 1.86 (149)
Weekday BT (decimal)	22.71 ± 1.16 (322)	23.06 ± 1.22 (192)	22.53 ± 0.91 (150)
Weekday SOL (min)	44.57 ± 41.27 (322)	48.34 ± 41.18 (192)	36.59 ± 28.53 (148)
Weekday TST (min)	451.36 ± 74.05 (317)	429.65 ± 78.90 (189)	472.12 ± 65.33 (149)
Mobile stop time (weekday, decimal)	22.07 ± 2.04 (123)	22.04 ± 2.01 (93)	22.43 ± 1.63 (99)
Internet stop time (weekday, decimal)	21.97 ± 1.82 (174)	22.32 ± 1.73 (125)	22.19 ± 1.63 (100)
Cognitive emotional arousal (ASHS-r cognitive emotional scale;1–6)	3.77 ± 1.07 (323)	3.59 ± 1.14 (192)	4.44 ± 0.92 (148)
Caffeine after 6 pm (1–6)	2.34 ± 1.54 (324)	3.13 ± 1.26 (193)	3.02 ± 1.61 (150)
Home environment (CHAOS; 1–5)	2.53 ± 0.89 (295)	2.79 ± 1.02 (169)	2.07 ± 0.72 (141)
Sports after school/week (min)	102.16 ± 138.79 (274)	116.24 ± 172.12 (165)	151.62 ± 122.38 (139)
Daytime functioning (SRSQ; 9–27)	17.6 ± 4.16 (245)	19.06 ± 3.95 (172)	16.18 ± 3.65 (141)
Tobacco (after 6 pm)	4.94% (324)	6.74% (193)	8.00% (150)
Alcohol (after 6 pm)	16.05% (324)	17.1% (193)	18.67% (150)
Parent-set BT	38.33% (300)	40.23% (174)	72.70% (143)

Note. ASHS-r = Adolescent Sleep Hygiene Scale – revised, BT = bedtime, CHAOS = Confusion Hubbub and Order Scale, SOL = weekday sleep onset latency, SRSQ = Sleep Reduction Screening Questionnaire, TST = weekday total sleep time.