



Original Article

Sleep deprivation: prevalence and associated factors among adolescents in Saudi Arabia

Maliha Nasim^{a, b}, Maissa Saade^{a, b}, Fadia AlBuhairan^{c, d, *}^a King Abdullah International Medical Research Center, Riyadh, Saudi Arabia^b King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia^c Aldara Hospital and Medical Center, Saudi Arabia^d Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

ARTICLE INFO

Article history:

Received 8 March 2018

Received in revised form

30 July 2018

Accepted 6 August 2018

Available online 10 October 2018

Keywords:

Adolescent

Sleep deprivation

Short sleep duration

Epidemiological survey

Behaviors

Saudi Arabia

ABSTRACT

Objective: A limited number of studies have examined sleep deprivation (SD) among adolescents in Saudi Arabia. This study estimates SD prevalence and associated factors within a nationally representative sample of adolescents in Saudi Arabia.

Methods: A secondary data analysis of Jeeluna®, a national cross-sectional school-based survey, was undertaken. Jeeluna assessed health risk behaviors and health status among adolescents (aged 10–19 years) in schools across Saudi Arabia. Based on self-reports of daily average sleep duration, binary logistic regression was used to investigate potential association among SD, socio-demographics, and various health behavior factors.

Results: Data from 12,121 adolescents (male 51%, female 49%) were analyzed. Early- and middle-stage adolescents constituted the majority (81%) of the sample. SD (sleep <7 h/day) was reported by 46% on weekdays and 33% on weekends. Three-fourths of all adolescents reported feeling unrefreshed on awakening. The adjusted odds ratio (A-OR) for SD was higher for adolescents of older age (18–19 years) (OR 1.18, CI 1.05–1.32), female gender (OR 1.23, CI 1.14–1.34), lower perceived socioeconomic status (OR 1.51, CI 1.28–1.78), and those eating less than three main meals per day (OR 1.17, CI 1.09–1.27). In contrast, A-ORs were lower among adolescents reporting television and computer screen exposure of ≥2 h per day (OR 0.81, CI 0.75–0.88; OR 0.83, CI 0.77–0.91), and those taking daytime naps (≥3 days) per week (OR 0.87, CI 0.81–0.94).

Conclusions: Sleep deprivation is highly prevalent among adolescents in Saudi Arabia, with reported prevalences being higher on weekdays versus weekends. The study identifies multiple associated factors that can inform preventive strategies and programs to support adolescent sleep and well-being.

© 2018 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Sleep deprivation (SD) is a growing problem among adolescents. In fact, sleep deprivation among adolescents has been called a silent global concern on an “epidemic scale” [1,2]. There are numerous studies highlighting the serious physical, psychological, and social impacts of SD on the health and well-being of adolescents. SD among adolescents has been associated with increased risk of being overweight/obese [3], future risk of excessive weight

gain [4,5], and cardiometabolic risk [6–8]. The relationship between SD and mental health disturbances among adolescents is also well documented, with SD negatively affecting cognitive state, mood, and emotional stability [9,10]. SD is associated with increased risk of developing depression, anxiety, suicidal ideation, and self-harm [11–13]. Furthermore, sleep-deprived adolescents exhibit poor concentration, decision-making skills, as well as symptoms of excessive daytime sleepiness (EDS) [9,11]. Adolescents with SD are more likely to be involved in unintentional accidents and injuries (particularly motor vehicle crashes) [14] and other health risk behaviors [15–18] compared to those with adequate sleep. Poor academic performance [18–21] and school absenteeism [22] are also commonly reported in this group.

Previous studies have reported multiple biological, demographic, and environmental factors to be associated with SD in

* Corresponding author. Aldara Hospital and Medical Center, Yardville Compound, PO Box 1105, Riyadh, 11431, Saudi Arabia. Fax: +966 (11) 225 5696.

E-mail addresses: fabuhairan@ALDARAMED.COM, fadia.albuhairan@gmail.com (F. AlBuhairan).

adolescents. These include stage of adolescence (age) [23], gender [24], socioeconomic status [24], environmental demands on time (academic responsibilities and maintaining peer friendship) [25], technology use [26], and lifestyle factors (caffeinated beverage consumption [27,28], cigarette smoking, khat [28], and alcohol use). All the aforementioned factors have been linked to delayed sleeping times in adolescents. Furthermore, early school start times have also been implicated as a major cause of sleep insufficiency in adolescents [29].

A steady decline in self-reported sleep times has been observed among adolescents. In the United States, the proportion of students regularly getting ≥ 7 h of night-time sleep fell from 72% in 1991 to 63% in 2012 [24]. Similarly, in Europe, the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study reported that 33% of adolescents sleep < 8 h per day [8]. To our knowledge, there are few studies reporting SD among adolescents from the Middle East [30–33]. This is supported by the lack of studies from Middle Eastern countries included in a systematic review addressing features of inadequate sleep in adolescents [4]. In the Kingdom of Saudi Arabia, two school-based cross sectional studies have reported average sleep duration among adolescents to be between 7 and 7.2 h daily [32,34]. One study of 2863 individuals reported that 31% of school students were sleeping < 7 h whereas 50% were sleeping < 8 h per day [32]. These studies, however, were not nationally representative samples and looked at sleep duration among specific age groups of adolescents. No other study has reported SD prevalence in a sample of participants that covers the whole age spectrum (10–19 years) of adolescence in the country.

This study aims to estimate the prevalence of SD among a nationally representative sample of adolescents in Saudi Arabia and to identify associated factors. Such findings may be used to highlight the issue of SD among adolescents in the country and to guide future educational/behavioral/policy changes that can improve sleep sufficiency in this important subgroup of the population.

2. Methods

2.1. Background of the Jeeluna® study: study design and data collection

The “Jeeluna®” study [35] was the first nationally representative, epidemiological, school-based, cross-sectional, observational health survey conducted in 2011/2012 across all 13 regions of Saudi Arabia. Jeeluna is the Arabic term for “our generation.” Prior to this study, nationally representative adolescent health indicators were unavailable in the country. The objective of the Jeeluna study was to assess the health risk behaviors and health status of adolescents in Saudi Arabia. Schools in Saudi Arabia are gender segregated, and education falls under the responsibility of the Ministry of Education. Intermediate schools include grades 7–9, and secondary schools include grades 10–12. Upon successful completion of grade 12, students are eligible to pursue further education at the university/college level.

2.2. Jeeluna study design

Jeeluna is a national study of students attending intermediate and secondary public and private schools in Saudi Arabia. Subjects were selected using multistage, cluster random sampling. The final data included 282 schools, with a school response rate of 97.5% and a student response rate of 32%. Ethical approval for the Jeeluna study was granted by the Institutional Review Board (IRB) at King Abdullah International Medical Research Center and Saudi Arabian Ministry of Education.

2.3. Jeeluna study data collection

Standardized, structured training of 52 teams of data collectors occurred in all 13 regions of Saudi Arabia. A total of 34 training workshops took place, conducted by the principal investigator or another trainer who had received “train the trainer” training. Each team consisted of two data collectors and two phlebotomists/nurses. Collection involved a three-step process: (1) administering a self-report questionnaire; (2) taking anthropometric measurements; and (3) performing blood sampling. Steps 1 and 2 were conducted by data collectors and step 3 by nurses/phlebotomists. Data collectors also ensured that only students with signed consent and assent forms were included in the study and were available to answer any student questions on the study.

2.3.1. Jeeluna survey

The survey was compiled by adopting items focused on adolescent health behaviors from the Youth Risk Behavior Survey (YRBS) and the Global Based Student Health Survey [36,37]. In addition, questions that assessed psychosocial history (home and education) were guided by clinical tools. The final tool was reviewed and refined by experts and piloted in a sample of adolescents. In total, 103 questions were asked that covered 11 domains; family (9), education (5), dietary behaviors (15), activity (physical and sedentary) (12), safety (8), sleep (4), bullying and violence (7), tobacco and substance use (22), health (4), health services (7), and health knowledge (10).

2.4. Secondary survey: data variables selected for this study

To fulfill our study objectives, relevant data variables related to socio-demographics, health risk behaviors, and sleep were extracted from the Jeeluna study dataset and analyzed.

Sleep duration was assessed by participants' answering the following two self-reported questions; How many hours do you usually sleep on each weekday? How many hours do you usually sleep on each weekend day? Response options for both questions were < 5 , 6, 7, 8, 9, and ≥ 10 (hours). Weekly frequency of taking a daytime nap was based on asking the participant the number of days per week in which they took an afternoon nap. Response options ranged from 0, 1, 2, 3, 4, 5, 6 days, with the last option being daily.

In addition to sleep, other variables of interest included the following: gender, age group based on stages of adolescence (early: 10–14 years; middle: 15–17 years; late: 18–19 years); body mass index (BMI) percentiles (determined from BMI for age growth charts); self-reported socioeconomic status (SES); academic performance; television screen time per day (hours); Internet use per day (hours); video game playing per day (hours); daily soda and energy drink consumption; number of meals per day; engagement in physical activity (number of days per week for at least 30 min each day); cigarette tobacco use in the past month; and frequency of afternoon napping per week.

2.5. Defining sleep deprivation

Currently, there is no universally accepted definition for SD. Published studies use different cut-off values for determining SD. Another complicating factor is that different guidelines use different age brackets for defining the various stages of adolescence. Furthermore, the age brackets differ with regard to the number of hours of sleep that are recommended. These factors make it complicated to find a single-unit measure to define SD across all three stages of adolescence (early, middle, and late). Other studies have used < 7 h and < 8 h to describe SD in adolescents

[32,38]. For this study, the operational definition of our outcome variable, SD, has been based on the National Sleep Foundation (NSF) sleep duration guidelines [39]. NSF guidelines were informed by a comprehensive systematic review of all published literature looking at sleep duration and health, as well as sleep expert recommendations [39].

According to the guidelines, adolescents in the 6- to 13-year and the 14- to 17-year age groups are not recommended to sleep <7 h per day [39]. As these two age groups cover the majority of adolescents in our study sample (81%), we adopted <7 h sleep to define SD. This criterion of <7 h would also be appropriate for late-stage adolescents (≥ 18 years of age) for whom guidelines recommend sleeping a minimum of 7–9 h per day [38].

2.6. Data analysis

Descriptive statistics of sample sociodemographic, health behavior, and sleep characteristics were reported in terms of frequency and percentage, with the corresponding standard error. All reported percentages were adjusted for the complex sampling design. To determine the variables associated with sleep deprivation, we conducted logistic regression in which sleep deprivation was included as dependent variable and the following variables as independent variables: gender; age group based on stages of adolescence (early: 10–14 years; middle: 15–17 years; late: 18–19 years); body mass index (BMI) percentiles (determined from BMI for age growth charts); self-reported socioeconomic status (SES); academic performance; television screen time per day (hours); Internet use per day (hours); video game playing per day (hours);

daily soda and energy drink consumption; number of meals per day; engagement in physical activity (number of days per week for at least 30 min each day); cigarette tobacco use in the past month; and frequency of afternoon napping per week.

Results were reported in terms of odds ratio, standard error, 95% confidence interval, and p value of the final parsimonious logistic model. Significance was declared at $\alpha < 0.05$. Statistical analysis was performed using SAS Version 9.4 (SAS Institute, Cary, NC).

3. Results

3.1. Sample characteristics

Table 1 shows the sociodemographic and health behavior characteristics of participants. A total of 12,121 adolescents between 10 and 19 years of age participated in the study (mean age 15.7 years). The sample was fairly evenly distributed between the two genders. Middle-stage adolescents, aged 15–17 years, made up the majority of the sample (53%), followed by early-stage (10–14 years) adolescents (28%). A considerable percentage of adolescents were either overweight/obese (30%) or underweight (15%). Most adolescents perceived their socioeconomic status to be similar to that of their peers (72%).

In general, dietary habits were reported to be poor; 89% of participants reported daily soft drink consumption and 40% reported daily energy drink consumption. Close to half the sample (43%) reported not eating three main meals per day. Furthermore, large proportions of adolescents reported daily engagement in sedentary activities (watching ≥ 2 h of television [43%], computer

Table 1
Sample characteristics.

Sociodemographics	Frequency	(%) ^a	SE (%)	Health behaviors	Frequency	(%) ^a	SE (%)
Stage of adolescence ^b				Physical exercise per week			
Early (10–14 y)	3254	27.96	1.4	<3 days	8544	71.16	0.6
Middle (15–17 y)	6461	53.05	1.11	≥ 3 days	3388	28.84	0.6
Late (18–19 y)	2406	18.99	1.1	Total	11,932	100	
Total	12,121	100		TV screen time			
Gender				<2 h	6843	57.32	0.6
Male	6290	51.17	1.47	≥ 2 h	5092	42.68	0.6
Female	5831	48.83	1.47	Total	11,935	100	
Total	12,121	100		Video game time			
Body mass index				<2 h	10,396	86.66	0.43
Underweight <5th percentile	1812	14.57	0.44	≥ 2 h	1599	13.34	0.43
Healthy weight 5th to <85th percentile	6612	55.26	0.52	Total	11,995	100	
Overweight ≥ 85 th percentile to <95th percentile	1712	14.11	0.32	Computer (Internet) screen time			
Obese ≥ 95 th percentile	1912	16.06	0.48	<2 h	8270	69.4	0.68
Total	12,048	100		≥ 2 h	3621	30.6	0.68
Academic performance				Total	11,891	100	
Poor	222	1.68	0.16	Daily soda consumption			
Average	330	2.75	0.19	No	1350	11.45	0.38
Above average	11,180	93.85	0.31	Yes	10,670	88.55	0.38
Don't know	202	1.71	0.13	Total	12,020	100	
Total	11,934	100		Daily energy drink consumption			
Self-reported SES				No	7230	60.49	0.68
Poorer than others	847	7.25	0.27	Yes	4782	39.51	0.68
Similar to others	8410	71.68	0.53	Total	12,012	100	
Better than others	2474	21.07	0.51	No. of main meals per day			
Total	11,731	100		<3 meals	5241	43.45	0.63
				≥ 3 meals	6749	56.55	0.63
				Total	11,990	100	
				Smoking cigarettes (in past 30 days)			
				No	11,138	93.44	0.35
				Yes	811	6.56	0.35
				Total	11,949	100	

A total of 12,121 adolescents aged 10–19 years were included in the analysis, however all totals do not sum to 12,121 due to missing responses from some participants. SE (%), standard error of percent.

^a Adjusted for complex sampling design.

^b Stages of adolescence based on age group categorization from healthy children.org (American Academy of Pediatrics).

time [31%], video game playing [13%]). Reported physical activity levels among adolescents were poor, with the majority (71%) exercising <3 days per week. Table 1 provides details.

3.2. Sleep characteristics of sample

The prevalence of adolescents reporting SD during the week was high overall. Nearly half (46%) of the sample reported SD during weekdays in contrast to a third (33%) during weekends. The majority of adolescents (76%) rarely or never felt refreshed in the morning after waking from sleep. Furthermore, frequent daytime napping was highly prevalent, with nearly 60% of participants taking daytime naps three or more times per week (Table 2).

3.3. Factors associated with sleep deprivation

Pearson χ^2 bivariate analysis showed that the following factors were significantly associated with sleep deprivation: stage of adolescence ($p = 0.0006$), gender ($p < 0.0001$), socioeconomic status ($p < 0.0001$), academic performance ($p < 0.0001$), meal servings per day ($p < 0.0001$), screen time (television and computer use) ($p < 0.0001$), playing video games ($p = 0.0006$), physical activity ($p = 0.0014$), and daytime napping ($p < 0.0001$).

Table 3 presents the findings of adjusted binary logistic regression analysis. Females (odds ratio [OR] 1.23, confidence interval [CI] 1.14–1.34) and older (18–19 years old) adolescents (OR 1.18, 95% CI 1.05–1.32) were more likely to report SD. Adolescents who considered themselves to be “poorer than others” in socioeconomic status (OR 1.51, CI 1.28–1.78) and adolescents who reported eating fewer than three meals per day (OR 1.17, CI 1.09–1.27) were also more likely to report SD (Table 3).

In contrast, adolescents reporting screen exposure to television and computers (Internet) for ≥ 2 h per day (OR 0.81, CI 0.75–0.88; OR 0.83, CI 0.77–0.91) were less likely to report SD. Likewise, adolescents who frequently napped ≥ 3 days per week (OR 0.87, CI 0.81–0.94) had a decreased likelihood of reporting SD (Table 3).

4. Discussion

This is the first study to report the prevalence of SD for a nationally representative sample of adolescents in Saudi Arabia. In fact, the present study's weekday estimated prevalence of SD is the highest reported figure to date, with close to half the sample (46%) sleeping hours that are not recommended by the National Sleep Foundation. Furthermore, this study is the first to assess SD

Table 3

Factors associated with SD: Results of the binary logistic regression model (N = 12,121).

Parameter	A-OR	SE	95% CI	p
Gender				
Male	1			
Female	1.23*	0.05	1.14–1.34	0.000
Stage of adolescence (age group)				
Early (10–14 y)	1			
Middle (15–17 y)	0.96	0.04	0.89–1.06	0.369
Late (18–19 y)	1.18*	0.07	1.05–1.32	0.005
Body mass index				
Underweight	0.89	0.06	0.77–1.02	0.104
<5th percentile				
Healthy weight	0.95	0.05	0.85–1.06	0.34
5th to <85th percentile				
Overweight	1			
≥ 85 th to <95th percentile				
Obese ≥ 95 th percentile	0.93		0.81–1.07	0.309
Self-reported SES				
Better than others	1			
Like others	1.12*	0.05	1.02–1.23	0.021
Poorer than others	1.51*	0.13	1.28–1.78	0.000
Self-reported academic performance				
Below average	1			
Average	1.47	0.28	1.02–2.13	0.04
Above average	0.99	0.15	0.74–1.33	0.95
Don't know	1.46	0.32	0.96–2.23	0.077
Television screen time				
<2 h	1			
≥ 2 h	0.81*	0.03	0.75–0.88	0.000
Computer (Internet) screen time				
<2 h	1			
≥ 2 h	0.83*	0.04	0.77–0.91	0.000
Video game screen time				
<2 h	1			
≥ 2 h	0.96	0.06	0.85–1.08	0.451
No. of main meals per day				
≥ 3	1			
<3	1.17*	0.05	1.09–1.27	0.000
Daily energy drink consumption				
Yes	1			
No	1.01	0.04	0.93–1.01	0.755
Cigarette smoking in the past month				
No	1			
Yes	1.05	0.08	0.89–1.22	0.574
Frequency of physical exercise (30 min) per week				
<3 days	1			
≥ 3 days	0.92	0.04	0.85–1.01	0.091
Afternoon nap frequency per week				
<3 naps	1			
≥ 3 naps	0.87*	0.04	0.81–0.94	0.001

A-OR, adjusted odds ratio (1 is the reference variable); CI, confidence interval; SE, standard error; SES, socioeconomic status.

*Significance is declared at $p < 0.05$. Probability is modeled as sleeping <7 h.

Table 2
Sleep characteristics of sample.

	Stage of adolescence (age group in years)							
	Early (10–14)		Middle (15–17)		Late (18–19)		Total	
	n	%	n	%	n	%	n	%
Sleep duration, weekdays								
<7 h	1725	26.74	3527	54.68	1198	18.57	5418	45.65 ^a
≥ 7 h	1449	26.74	2816	51.97	1153	21.28	6450	54.35
Sleep duration, weekends								
<7 h	1049	26.36	2052	51.56	879	22.09	3980	33.47 ^b
≥ 7 h	2140	27.05	4297	54.32	1473	18.62	7910	66.53
Afternoon napping per week								
<3 naps	1556	32.7	2464	51.78	739	15.53	4759	39.98
≥ 3 naps	1633	22.86	3896	54.53	1616	22.62	7145	60.02
Feeling refreshed in the morning								
Never, rarely	2366	26.28	4841	53.78	1795	19.94	9002	75.69
Sometimes, often, always	823	28.46	1513	52.32	556	19.23	2892	24.31

^a Denotes prevalence of sleep deprivation reported in the sample on weekdays.

^b Denotes prevalence of sleep deprivation reported in the sample on weekends.

across all stages of adolescence (early, middle, and late) in Saudi Arabia.

The high prevalence of SD among adolescents in our study mirrors a global trend of SD affecting high proportions of the adolescent population in many countries, such as the United States [24], Europe [8], China [38], Japan [40], and Kuwait [41]. In addition, it extends and corroborates previous work in Saudi Arabia undertaken by Hazzaa et al., who reported the prevalence of SD (sleeping <7 h) among adolescents to be 31% in 2009–2010 [32,33]. It is interesting to note that high SD prevalences have also been reported among children and adults in Saudi Arabia. A recent study of 2025 Saudi adults reported that 33.8% were sleeping <7 h [42]. Given the high prevalence of SD in Saudi society, it is plausible that the sleep behavior of adolescents is being influenced by the sleep habits and patterns of their parents [43]. Sleeping <7 h may have a greater impact on adolescents compared to adults, as adolescents biologically have an increased sleep need (ie, require more sleep hours per day) compared to adults. Indeed, the National Sleep Foundation sleep duration recommendations of 2015 state that sleeping 6 h for adults 18–64 years “may be appropriate” [39]. The same sleep duration in adolescents, however, is not recommended.

A number of factors could explain the high prevalence of SD among adolescents observed in the country. It is well documented that puberty in adolescents shifts biological circadian rhythms, delaying release of the sleep-inducing hormone melatonin, with levels peaking later at night (23:00–8:00) [44] and resulting in delayed sleep onset [2,45–47]. Puberty therefore biologically predisposes adolescents to encounter difficulties in initiating sleep early and waking up early. In addition to biology, a number of environmental factors may be contributing to the SD observed among adolescents in our study. For example, sleeping late may be a cultural and behaviorally acceptable normal habit for the general Saudi population. Many social activities tend to occur during the late hours of the night; retail shops and restaurants stay open quite late throughout the week, with most shopping malls closing their doors at 23:00. It is therefore not unusual to see young children and adolescents out in public places late at night. One study observing sleeping habits in 1035 Saudi adolescents in Jeddah reported average school night sleeping time on weekdays to be 23.55 h, with more than a third of individuals sleeping after midnight [34]. Sleep deprivation therefore may be an outcome of evening orientation and later chronotype in our sample. A study among a sample of adolescents (Vollmer et al.) reported that circadian rhythms can be shifted to “eveningness” or evening-type orientation by factors that prolong daylight into evening and night hours, such as artificial nocturnal light, electronic media use, and other factors [47]. Furthermore, climatic zones can also influence chronotype, with adolescents living in the subtropics having later chronotypes. Saudi Arabia is a country with a subtropical climate; however, to objectively assess the relationship between chronotype and sleep deprivation among our sample, further in-depth studies are needed that collect data on adolescent sleep timings. Late sleep times in households may arise when parents are unaware of the importance of getting enough sleep; the differences in sleep need among adults, children, and adolescents in terms of required daily sleep hours; and fundamentally the consequences that sleep deprivation can have on their own health and that of their adolescents. A study addressing problems and challenges regarding sleep medicine in Saudi Arabia reported that most of the Saudi public were unaware of the adverse physical, psychological, and social effects of sleep deprivation [48]. As such, parents themselves may be less strict in insisting that their children and adolescents go to sleep at set times. In fact, parental knowledge regarding child sleep, child sleep needs, and sleep hygiene practices are known to be associated with “indices of healthy sleep.” Parents with more knowledge on child

sleep report earlier bedtimes on weekdays and weekends [49]. School start times in Saudi Arabia may be another disrupting factor. On weekdays, children and adolescents in Saudi Arabia have exceptionally early wake times because the majority of schools begin at 07:00. Multiple studies have shown that early school start times are linked to SD, and that by delaying school start times, weeknight sleep duration in adolescents is increased [49]. To improve adolescent sleep duration at night, the American Academy of Pediatrics issued a policy statement in 2014 recommending that “middle and high schools should aim for school start times no earlier than 8:30 am” [50]. In fact, our study did show much higher prevalence of SD among adolescents during weekdays (46%) (note: a time when schools are open) compared to weekends (33%), suggesting that early school start times could be an influencing factor for the SD reported by Saudi adolescents in our sample.

Female gender, older age among adolescents, those who perceived themselves to be poorer than others, and those who ate fewer main meals per day were identified as having increased likelihood of SD among our sample. Population based studies in the United States reinforce our findings that female adolescents report sleeping fewer hours than their male counterparts. Girls tend to undergo pubertal changes earlier than boys, which may account for the difference seen in SD. The association between increasing adolescent age and SD has been established in previous studies [51]. Older adolescents are more independent and autonomous than younger adolescents; as such they are less likely to have parents monitoring their sleep times [52]. They may also be more likely than younger adolescents to have access to personal electronic devices (smartphones the nocturnal use of which has been associated with SD) and to be more likely to socialize online. The association of lower SES increasing likelihood of adolescents reporting SD has been published in a few studies. It has been postulated that families of low SES have lower awareness of sleep hygiene practices and that their homes may be less organized and more noisy [53]. Saudi households also tend to be large in size, with the average family size ranging between 5.5 and 6.4 persons per household [54]. Coupled with low SES, it is conceivable that adolescents from poorer households may not have access to their own room and may have to share rooms and beds with siblings [55]. Bedroom sharing is known to impede the ability to sleep adequately and is associated with later nocturnal sleep times, later wake times, and SD [56].

Our study showed that daytime napping and prolonged screen time exposure (to television and the Internet) was negatively associated with SD. Daytime napping is common among school and university students in the country [57,58]; for instance, one study reported that 41% of elementary students take daytime naps. This was also the case in our study, in which a significant number of adolescents reported taking daytime naps. Although daytime napping is thought to delay sleep time and to contribute to shorter nocturnal sleep duration [59] in adolescents, it has also been found to work as a mechanism to compensate for sleep deficits during weekdays and weekends [58,60]. Further studies are needed to better explain the napping behavior among adolescents in Saudi Arabia and to understand the temporal relationship between daytime napping behavior and SD in this population.

As for prolonged screen time exposure (television or Internet use unrelated to schoolwork), our results showed that adolescents were less likely to have SD when compared to those with less screen time exposure. This finding contradicts the published literature on this topic [26]. However, our results are in line with another study that looked at lifestyle correlates of SD among adolescents within Saudi Arabia. The study by Al-Hazzaa found that adolescents watching >5 h had a 1.505 odds of sleeping 8 h or more [33]. It appears that in the context of Saudi Arabia, there is a level of

repeatability to our findings, it is not clear why prolonged screen exposure would increase sleep duration among adolescents in the country, and further in-depth studies are needed.

The limitations of our study include its cross-sectional design, which make it impossible to determine the temporal relationship between our variables of interest and SD or to make any inferences on SD causality. Furthermore, the question assessing sleep duration was self-reported; responses are subjective and therefore prone to measurement and recall bias, which can affect the validity and accuracy of reported sleep durations. The question itself “How many hours do you sleep?” relied upon students remembering when they go to bed and when they wake up, and giving an average estimate of their sleep hours. Again, the value would be subject to both recall and measurement bias. Asking about exact sleep times and wake times from the participants would have been a more accurate method of calculating their sleep durations. Objective measures such as actigraphy or polysomnography would be the preferred method to accurately assess sleep times. Finally, lack of a universal definition for defining SD means that different studies use different cut-off numbers of hours to define the outcome, making comparisons between studies difficult.

5. Conclusion

Sleep deprivation among adolescents in Saudi Arabia is a significant public health concern. Almost one-half of all adolescents in the study suffered from SD during weekdays, and nearly three-fourths reported not feeling refreshed in morning. Frequent daytime napping during the week was also observed. We found that a number of biological, demographic, lifestyle, and environmental factors were significantly associated with SD among Saudi adolescents. Given the health, academic, and societal impact of SD, there is an urgent need for preventive strategies. Delaying school start times would be a good first step. Promoting adolescent and public awareness of the importance of adequate sleep and consequences of sleep deprivation, in addition to recommending sleep hygiene behaviors, would also help address the problem.

Acknowledgements

We would like to thank King Abdullah International Medical Research Center, (grant number RC08092) for funding this project. We would also like to thank Dr. Anwar Ahmed for his generous guidance and advice in addition to Mr. Abin Thomas and Dr. Mohammed Hussein for their valuable statistical input in this project.

Conflict of interest

The authors declare that they have no conflicts of interest, financial or otherwise.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: <https://doi.org/10.1016/j.sleep.2018.08.031>.

References

- [1] Stanford Medicine News Center, Stanford Medicine Website. Richter R. Among teens, sleep deprivation an epidemic. Available at: <https://med.stanford.edu/news/all-news/2015/10/among-teens-sleep-deprivation-an-epidemic.html>. [Accessed 14 October 2018].
- [2] Hagenauer MH, Perryman JI, Lee TM, et al. Adolescent changes in the homeostatic and circadian regulation of sleep. *Dev Neurosci* 2009;31:276–84.
- [3] Sivertsen B, Pallesen S, Sand L, et al. Sleep and body mass index in adolescence: Results from a large population-based study of Norwegian adolescents aged 16 to 19 years. *BMC Pediatr* 2014;14:204.
- [4] Shochat T, Cohen-Zion M, Tzischinsky O. Functional consequences of inadequate sleep in adolescents: a systematic review. *Sleep Med Rev* 2014;18:75–87.
- [5] Thind H, Davies SL, Lewis T, et al. Does short sleep lead to obesity among children and adolescents?: current understanding and implications. *Am J Lifestyle Med* 2014;9(6):428–37.
- [6] Quist JS, Sjodin A, Chaput JP, et al. Sleep and cardiometabolic risk in children and adolescents. *Sleep Med Rev* 2015;29:76–100.
- [7] Knutson KL. Sleep duration and cardiometabolic risk: a review of the epidemiologic evidence. *Best Pract Res Clin Endocrinol Metab* 2010;24:731–43.
- [8] Rey-Lopez JP, de Carvalho HB, de Moraes AC, et al. Sleep time and cardiovascular risk factors in adolescents: the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) study. *Sleep Med* 2014;15:104–10.
- [9] Lo JC, Ong JL, Leong RL, et al. Cognitive performance, sleepiness, and mood in partially sleep deprived adolescents: the Need for Sleep Study. *Sleep* 2016;39(3):687–98.
- [10] Short MA, Louca M. Sleep deprivation leads to mood deficits in healthy adolescents. *Sleep Med* 2015;16:987–93.
- [11] Gangwisch JE, Babiss LA, Malaspina D, et al. Earlier parental set bedtimes as a protective factor against depression and suicidal ideation. *Sleep* 2010;33:97–106.
- [12] Hysing M, Sivertsen B, Stormark KM, et al. Sleep problems and self-harm in adolescence. *Br J Psychiatry* 2015;207:306–12.
- [13] Clarke G, Harvey AG. The complex role of sleep in adolescent depression. *Child Adolesc Psychiatr Clin North Am* 2012. 21385–400.
- [14] Martiniuk AL, Senserrick T, Lo S, et al. Sleep-deprived young drivers and the risk for crash: the DRIVE prospective cohort study. *JAMA Pediatr* 2013;167:647–55.
- [15] Wong MM, Robertson GC, Dyson RB. Prospective relationship between poor sleep and substance-related problems in a national sample of adolescents. *Alcohol Clin Exp Res* 2015;39:355–62.
- [16] Terry-McElrath YM, Maslowsky J, O'Malley PM, et al. Sleep and substance use among US adolescents, 1991_2014. *Am J Health Behav* 2016;40:77–91.
- [17] Pasch KE, Latimer LA, Cance JD, et al. Longitudinal bi-directional relationships between sleep and youth substance use. *J Youth Adolesc* 2012;41:1184–96.
- [18] Stea TH, Knutsen T, Torstveit MK. Association between short time in bed, health-risk behaviors and poor academic achievement among Norwegian adolescents. *Sleep Med* 2014;15:666–71.
- [19] Hysing M, Harvey AG, Linto SJ, et al. Sleep and academic performance in later adolescence: Results from a large population-based study. *J Sleep Res* 2016;25(3):318–24.
- [20] Tonetti L, Natale V, Randler C. Association between circadian preference and academic achievement: a systematic review and meta-analysis. *Chronobiol Int* 2015;32:792–801.
- [21] Curcio G, Ferrara M, De Gennaro L. Sleep loss, learning capacity and academic performance. *Sleep Med Rev* 2006;10:323–37.
- [22] Hysing M, Haugland S, Stormark KM, et al. Sleep and school attendance in adolescence: Results from a large population-based study. *Scand J Public Health* 2015;43:2–9.
- [23] Felden ÉPG, Filipin D, Barbosa DG, et al. Factors associated with sleep deprivation in adolescents. *Revista Paulista de Pediatria (English Edition)* 2016;34(1):64–70.
- [24] Keyes KM, Maslowsky J, Hamilton A, et al. The great sleep recession: changes in sleep duration among US adolescents, 1991_2012. *Pediatrics* 2015;135:460–8.
- [25] Moore M, Meltzer LJ. The sleepy adolescent: causes and consequences of sleepiness in teens. *Paediatr Respir Rev* 2008;9:114–20. quiz 120–1.
- [26] Hale L, Guan S. Screen time and sleep among school-aged children and adolescents: a systematic literature review. *Sleep Med Rev* 2015;21:50–8.
- [27] Sanchez SE, Martinez C, Oriol RA, et al. Sleep quality, sleep patterns and consumption of energy drinks and other caffeinated beverages among Peruvian college students. *Health (Irvine Calif)* 2013;5:26–35.
- [28] Lemma S, Patel SV, Tarekegn YA, et al. The epidemiology of sleep quality, sleep patterns, consumption of caffeinated beverages, and khat use among Ethiopian college students. *Sleep Disord* 2012;2012:583510.
- [29] Wheaton AG, Chapman DP, Croft JB. School start times, sleep, behavioral, health, and academic outcomes: a review of the literature. *J Sch Health* 2016;86:363–81.
- [30] Bawazeer NM, Al-Daghri NM, Valsamakis G, et al. Sleep duration and quality associated with obesity among Arab children. *Obesity (Silver Spring)* 2009;17:2251–3.
- [31] Kilani H, Al-Hazzaa H, Waly, et al. Lifestyle habits: diet, physical activity and sleep duration among Omani adolescents. *Sultan Qaboos Univ Med J* 2013;13:510–9.
- [32] Al-Hazzaa HM, Musaiger AO, Abahussain NA, et al. Prevalence of sleep deprivation and its association with obesity among adolescents 15- to 19-year olds: a cross-sectional study from three major cities in Saudi Arabia. *Ann Thorac Med* 2012;7:133–9.
- [33] Al-Hazzaa HM, Musaiger AO, Abahussain NA, et al. Lifestyle correlates of self-reported sleep duration among Saudi adolescents: a multicentre school-based cross-sectional study. *Child Care Health Dev* 2014;40:533–42.
- [34] Merdad RA, Merdad LA, Nassif RA, et al. Sleep habits in adolescents of Saudi Arabia: distinct patterns and extreme sleep schedules. *Sleep Med* 2014;15:1370–8.

- [35] AlBuhairan FS, Tamim H, Al Dubayee M, et al. Time for an adolescent health surveillance system in Saudi Arabia: findings from "Jeeluna". *J Adolesc Health* 2015;57:263–9.
- [36] World Health Organization - WebPage. Global School-Based Student Health Survey (GSHS). Noncommunicable diseases and their risk factors. 2018 (03/01/2018). Available at: <http://www.who.int/ncds/surveillance/gshs/en/>. [Accessed 1 March 2018].
- [37] Centers for Disease Control and Prevention. YRBSS in Brief. Adolescent and School Health. 2016. Available at: <https://www.cdc.gov/healthyyouth/data/yrbs/index.htm>. [Accessed 1 March 2018].
- [38] Chen T, Wu Z, Shen Z, et al. Sleep duration in Chinese adolescents: biological, environmental, and behavioral predictors. *Sleep Med* 2014;15:1345–53.
- [39] Hirshkowitz M, Whiton K, Albert SM, et al. National Sleep Foundation's updated sleep duration recommendations: final report. *Sleep Health* 2015;1:233–43.
- [40] Ohida T, Osaki Y, Doi Y, et al. An epidemiologic study of self-reported sleep problems among Japanese adolescents. *Sleep* 2004;27:978–85.
- [41] Al-Haifi AA, AlMajed HT, Al-Hazzaa HM, et al. Relative contribution of obesity, sedentary behaviors and dietary habits to sleep duration among Kuwaiti adolescents. *Global J Health Sci* 2016;8:107–17.
- [42] Ahmed AE, Al-Jahdali F, AlAlwan A, et al. Prevalence of sleep duration among Saudi adults. *Saudi Med J* 2017;38:276–83.
- [43] Fuligni AJ, Tsai KM, Krull JL, et al. Daily concordance between parent and adolescent sleep habits. *J Adolesc Health* 2015;56:244–50.
- [44] National Adolescent and Young Adult Health Information Center. Sleep Deprivation in Adolescents and Young Adults. 2014. San Francisco: University of California, San Francisco. Available from: <http://nahic.ucsf.edu/wp-content/uploads/2014/08/Sleep-Brief-FINAL.pdf> [Accessed 9 Oct 2018].
- [45] Carskadon MA, Vieira C, Acebo C. Association between puberty and delayed phase preference. *Sleep* 1993;16:258–62.
- [46] Carskadon MA. Sleep in adolescents: the perfect storm. *Pediatr Clin North Am* 2011;58:637–47.
- [47] Vollmer C, Michael U, Randler C. Outdoor light at night (LAN) is correlated with eveningness in adolescents. *Chronobiol Int* 2012;4:502–8.
- [48] BaHammam AS. Sleep medicine in Saudi Arabia: current problems and future challenges. *Ann Thorac Med* 2011;6:3–10.
- [49] McDowall PS, Elder DE, Campbell AJ. Relationship between parent knowledge of child sleep, and child sleep practices and problems: a pilot study in a children's hospital cohort. *J Paediatr Child Health* 2017;53:788–93.
- [50] Adolescent Sleep Working Group, c.o.a. Council on School Health. American Academy of Pediatrics policy statement: school start times for adolescents. *Pediatrics* 2014;134:642.
- [51] Felden _EPG, et al. Factors associated with sleep deprivation in adolescents. *Revista Paulista de Pediatria (English Ed)* 2016;34:64–70.
- [52] Randler C, Bilger S. Associations among sleep, chronotype, parental monitoring, and pubertal development among German adolescents. *J Psychol* 2009;143:509–20.
- [53] Felden _EPG, et al. Sleep in adolescents of different socioeconomic status: a systematic review. *Revista Paulista de Pediatria* 2015;33:467–73.
- [54] Abdul Salam A, Elsegaey I, Khraif R, et al. Population distribution and household conditions in Saudi Arabia: reflections from the 2010 census. *Springer Plus* 2014;3:530.
- [55] Li S, Jin X, Yan C, et al. Factors associated with bed and room sharing in Chinese schooled children. *Child Care Health Dev* 2009;35:171–7.
- [56] Li S, Jin X, Yan C, et al. Bed- and room-sharing in Chinese school-aged children: prevalence and association with sleep behaviors. *Sleep Med* 2008;9:555–63.
- [57] Thorleifsdottir B, Bjornsson JK, Benediktsdottir B, et al. Sleep and sleep habits from childhood to young adulthood over a 10-year period. *J Psychosom Res* 2002;53:529–37.
- [58] Gradisar M, Wright H, Robinson J, et al. Adolescent napping behavior: comparisons of school week versus weekend sleep patterns. *Sleep Biol Rhythms* 2008;6:183–6.
- [59] Jakubowski KP, Hall MH, Lee L, et al. Temporal relationships between napping and nocturnal sleep in healthy adolescents. *Behav Sleep Med* 2017;15:257–69.
- [60] Malone SK, Zemel BS, Compher C, et al. Characteristics associated with sleep duration, chronotype, and social jet lag in adolescents. *J Sch Nurs* 2016;32:120–31.