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Association of Sunlight Exposure with Sleep Hours in Iranian Children and Adolescents: The CASPIAN-V Study

Sadegh Baradaran Mahdavi,[1,2,3] MD, Marjan Mansourian,[4] PHD, Elaheh Shams,[5] BSC, Mostafa Qorbani,[6] PHD, Ramin Heshmat,[7] PHD, Mohammad Esmaeil Motlagh,[8] MD, Hasan Ziaodini,[9] MD, Razieh Dashti,[10] MD, Majzoubeh Taheri,[10] MD *and* Roya Kelishadi,[2] MD

[1]Department of Physical Medicine and Rehabilitation School of Medicine, Isfahan University of Medical Sciences, Isfahan 8167636954, Iran
[2]Pediatrics Department, Child Growth and Development Research Center Research Institute for Primordial Prevention of Non-communicable Disease, Isfahan University of Medical Sciences, Isfahan 8167636954, Iran
[3]Student Research Committee, School of Medicine, Isfahan University of Medical Sciences, Isfahan 8167636954, Iran
[4]Department of Biostatistics and Epidemiology School of Health, Isfahan University of Medical Sciences, Isfahan 8167636954, Iran
[5]Department of Mathematical Sciences, Isfahan University of Technology, Isfahan 8415683111, Iran
[6]Department of Epidemiology, Non-communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj 3149779453, Iran
[7]Department of Epidemiology, Chronic Diseases Research Center Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran 1417653761, Iran
[8]Pediatrics Department, Ahvaz Jundishapur University of Medical Sciences, Ahvaz 6135715794, Iran
[9]Health Psychology Department, Research Center of Education Ministry Studies, Tehran 1997755611, Iran
[10]Bureau of Family, Population, Youth and School Health Ministry of Health and Medical Education, Tehran 1467664961, Iran
Correspondence: Roya Kelishadi, Department of Pediatrics, Child Growth and Development Research Center, Research Institute for Primordial Prevention of Non-communicable Disease, Hezarjerib Ave, Isfahan University of Medical Sciences, Isfahan 8167636954, Iran.
Tel: +983137923929. Fax: +983137923929. E-mail <kelishadi@med.mui.ac.ir>.

ABSTRACT

We aimed to assess the association of sunlight exposure with sleep duration and sleep onset time in children. Data were obtained from the fifth survey of a national school-based surveillance program in Iran. Sunlight exposure time, sleep duration, sleep onset time, physical activity time, mental health status and frequency of consuming coffee and tea were recorded. Overall, 14 274 students aged 7–18 years were recruited. Sleep duration was associated positively with sex, age, body mass index and physical activity, as well as with sunlight exposure and negatively with the consumption of coffee and tea. Higher physical activity, exposure to sunlight and mental status score in children exposed to sunlight via their face, hands, arms and feet, reduced the likelihood of sleep onset time after midnight (odds ratio (OR) = 0.909, 0.741 and 0.554 respectively). Daily exposure to sunlight may increase sleep duration and advance the sleep onset time in children and adolescents.

KEYWORDS: sunlight; physical activity; mental health; caffeine; sleep; children and adolescents

INTRODUCTION

Compared with adulthood, adolescence is characterized by delayed bedtimes and increased need for sleep due to various familial, social and biological determinants [1]. Chronic sleep deprivation in adolescents resulted from school schedules, contributes to sleepiness, tiredness, decreased alertness and impaired daytime functioning [2]. In this regard, sleep quality is in the category of main factors influencing mental health and well-being of children and adolescents [3].

Human sleep times, waking times and sleep duration which are mediated by sleep-wake cycle (SWC), may be influenced by exposure to natural or artificial light of different wavelengths, intensities and timings leading to bidirectional phase shifts [4]. Previous research revealed that each hour of exposure to morning sunlight associated with earlier sleep onset of 30 min and circadian rhythm advancement [5] whereas exposure to light in night revealed delays in sleep onset [6]. Light also has effects on sleep slow wave activity (SWA), sleep termination and duration of sleep rapid eye movement cycles [4].

Light is considered as the main factor or Zeitgeber (time giver) when it comes for synchronization of the human circadian clock with 24-h dark-night cycle derived from the constant external solar clock [7]. In normal conditions, this circadian rhythm entrainment is essential for regulating physiological and biological functions of humans including body temperature, heart rate, gene expression as well as sleep characteristics [8, 9]. In addition to the effects of light on sleep through indirect pathways mediated by circadian rhythm, there is also accumulating evidence indicating the direct influences of light on sleep, cognition and affect via the mechanisms remained to be more investigated [9].

Furthermore, sleep is influenced not only by light but also by other life behaviours such as physical activity [10] and drinking caffeinated beverages [11]. It has been documented that chronic vigorous exercise in athletes is associated with higher sleep quality, shorter sleep onset latency, increased concentration and lower depressive symptoms compared with control adolescents leading to better psychological functioning [12]. On the other hand, another study reported that after 7 days of performing morning exercise in sunlight in 160 students, there were no significant effects on sleep quality and SWC parameters [13].

Along with the increase in availability of caffeinated products, there is an elevated trend for consuming caffeinated drinks among children and adolescents to confront with sleepiness and fatigue during the day [11]. One study reported that regular consumption of caffeine in 10–16-year-old children was associated with lower sleep duration, later bedtimes and reduced SWA but not with morning tiredness [14].

Overall, the longer sleep duration in children and adolescents is associated with better academic achievement as well as better emotional, mental and physical health [15]. To our knowledge, there is no comprehensive research on the main determinants of sleep duration and sleep onset time among school-aged children and adolescents. Our primary objective was to determine the direction and strength of associations of sunlight exposure with sleep duration and sleep onset time in children and adolescents. However, the associations of physical activity, mental health and consumption of caffeinated drinks with children's sleep hours were also postulated to be investigated as some main confounder factors modulating the associations of sunlight exposure. Therefore in this research, we examined the relationship of sunlight exposure with sleep hours regard to the other potential factors among a representative sample of Iranian children and adolescents.

METHODS

Study population and sampling method

This study was conducted in 2014–15 as part of the fifth survey of a national school-based surveillance program entitled Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable disease (CASPIAN-V study). It was performed among 14 400 students aged 7–18 years living in urban and rural areas of 30 provinces in Iran. The study population was selected by multi-stage sampling approach consisting of cluster, stratified and random sampling method. The study protocol has been explained in details [16], and here it is presented in brief.

Study measurements

The questionnaire of this study was mainly based on the questionnaire of the World Health Organization Global School Health Survey [17], which was translated into Persian, and validated in the Iranian population. Content validity was affirmed by getting a score of more than 0.75. Cronbach's alpha coefficient of the questionnaire was 0.97 and Pearson's correlation coefficient was obtained 0.94 in test–retest phase, confirming the reliability of the questionnaire [16]. Trained health care providers completed the questionnaire by interviewing students and one of their parents. Children's anthropometric characteristics such as height and weight were measured through the physical examinations by trained staff. Then body mass index (BMI) was calculated as weight (kg)/height $(m)^2$. In addition to the WHO questionnaire, we asked questions regarding sun exposure by asking about the amount of exposure to outdoor sunlight in weekdays and weekends, and the parts of the body exposed to sunlight during this time, as well as the use of sunscreen creams [18]. The responses for body parts were categorized into the face and hands (Group 1) or face, hands, arms and feet (Group 2). Weekly hours spend for physical activity (performing exercises leading to an increase in heart rate or breathing) was recorded. The mental status was obtained from seven multiple choice Likert scale questions to access feeling worthless, confusion, nervousness, anxiety and having a poor sleep during 6 months ago as well as feeling depressed and worried during 12 months ago. The responses were converted into quantitative values, and the mental status score for each person was calculated as the sum of scores divided into seven afterwards. This score ranged from 1 to 4.71, and the higher score indicated better mental status. Total times spend for sleep over day and night was assessed concerning weekdays and weekends (hours/day). Bedtimes (times children usually went to bed at night) were also collected through the questionnaire. The children reported the consumption frequency of tea and coffee via a categorical question as daily, weekly, rarely or never as well. The mean amount of drinking coffee and tea were calculated using factor analysis as follows: (0.7 × drinking tea – 0.7 × drinking coffee).

Statistical analysis

Descriptive statistics and frequencies were determined for continuous and discrete variables, respectively. The Kolmogorov–Smirnov and Shapiro–Wilk tests were performed to assess the normal distribution of the data. Survey analyses for cross-sectional studies were used to investigate the relations between the variables. To examine the relationship between sunlight exposure time and sleep hours, three models of multiple linear regression analysis were performed (Stepwise analyses). Model 1 was considered a crude model. Model 2 was adjusted for sex and age and finally, Model 3 was adjusted for by sex, age, BMI, physical activity, drinking coffee and tea and mental status. For more precise results, the model was fit for two categories of people. The first category was for children whose only hands and faces were exposed to sunlight (Group 1), and the second one was for those who were exposed more to sunlight (Group 2). Then, the equation of linear regression line was obtained for these two groups separately as follows, in which the sunlight exposure time, sleep time, physical activity and the mental status score were represented by the symbols N, K, M and T, respectively:

$$K_i = \text{Sex}_i*\beta_1 + \text{Age}_i*\beta_2 + \text{BMI}_i*\beta_3 + N_i*\beta_4 + M_i*\beta_5 + F_i*\beta_6 + T_i*\beta_7 + \varepsilon_i;\ i = 1, \ldots, n.$$

To investigate the relationship between the sunlight exposure time with sleep onset times, binomial logistic regression models were retained in which the bedtime after 24 o'clock was considered as code 1 and the bedtime before 24 o'clock as code 2. Similar to the linear regression analysis, three types of models were performed as described earlier and the results were prepared for Groups 1 and 2 separately. p-value < 0.05 was considered statistically significant for all tests. Statistical analyses were conducted using IBM SPSS (IBM Crop. 2011. IBM SPSS Statistics for Windows, version 20.0. NY, EUA)

Ethical statement

Ethical protocols for this study were reviewed and approved by national and regional regulatory ethics committees. It was approved by the Ethics

Committee of Isfahan University of Medical Sciences (Project No. 194049). The study was performed after obtaining informed written consent from parents and oral assent from students based on providing sufficient information about the research.

RESULTS

The participation rate was 99%, 14 274 students (50.64% boys) completed the study. The mean age (SD) of children was 12.26 (3.15) years. After excluding the participants weighted more than 100 kg as outliers from the analyses, descriptive values were measured. Table 1 shows the frequency distribution of sunlight exposure times divided by weekday and weekend among study participants. In weekends, 52.3% of children were exposed to sunlight more than 30 min a day while in the weekdays, 41.2% of them were exposed considering the same duration. There were 10 493 children (74.1%) who had exposures to sunlight solely with their face and hands (Group 1). Also, there were 3431 (24.2%) children who had exposures to sunlight with their face, hands, arms and feet (Group 2).

Furthermore, as Table 2 illustrates, in the participants, the mean of sleep duration (SD) was 8.99 (1.18) hours/day, and this duration ranged from 4.00 to 15.00 hours/day. Children' mean time (SD) for beginning sleep was 22: 59 (63.6 min) o'clock ranged from 18: 50 to 02: 00. The means (SD) of physical activity, BMI and mental status score were 19.18 (7.73) hours/week, 18.42 (4.29) kg/m^2 and 3.97 (0.71), respectively.

Concerning the consumption of tea and coffee, Table 3 represents that overall 87% and 55.7% of Iranian children and adolescents consume tea and coffee, respectively.

Models of linear regression tests for Group 1 and 2 separately, showed the variables which were significantly correlated to sleep duration among participants: sex, age, BMI, physical activity, sunlight exposure time, drinking coffee and tea and mental status score (Table 4). Therefore, the linear regression equations were obtained as following:

- Group 1: Sleep duration = (0.935 × mental status score) + (0.625 × sex) + (0.444 × sunlight exposure duration) – (0.314 × drinking amounts of coffee and tea) + (0.068 × physical activity) + (0.064 × BMI) + (0.058 × age)
- Group 2: Sleep duration = (1.112 × mental status score) + (0.651 × sex) + (0.342 × sunlight exposure duration) – (0.211 × drinking amounts of coffee and tea) + (0.081 × age) + (0.061 × BMI) + (0.035 × physical activity)

According to analysis code 2 for girls and 1 for boys, these equations show that sleep duration is higher in girls in comparison with boys.

In addition, Table 5 illustrates the results of logistic regression tests to find the probability of sleep onset after 24: 00 o'clock rather than before 24: 00 o'clock considering other variables for two mentioned groups. In Group 2, higher exposure rates to sunlight were associated with a decreased likelihood

TABLE 1. Distribution frequency of sunlight exposure durations among children: the CASPIAN-V study

	Weekday						Weekend					
	Boys		Girls		Total		Boys		Girls		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
< 5 min	1014	14.28	1118	16.08	2132	15.1	1253	17.65	1321	19.02	2574	18.2
5–30 min	3102	43.69	2980	42.86	6082	42.9	2002	28.21	2051	29.54	4053	28.6
30 min	2983	42.02	2854	41.05	5837	41.2	3841	54.12	3570	51.42	7411	52.3
Sum	7099	99.99	6952	99.99	14 051	99.2	7096	99.98	6942	99.98	14 038	99.1

Table 2. Demographic characteristics of study participants: the CASPIAN-V study

	Total				Boys				Girls				
	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	*p*-value[a]
Age (years)	7.00	18.00	12.27	3.15	7.00	18.00	12.36	3.13	7.00	18.00	12.17	3.17	**< 0.001**[b]
Physical activity per week (hours)	7.00	35.00	19.18	7.73	7.00	35.00	19.43	7.82	7.00	35.00	18.92	7.64	**< 0.001**
BMI (kg/m^2)	4.96	105.47	18.42	4.29	7.68	105.47	18.34	4.24	4.96	50.94	18.51	4.35	**0.018**
Sleep duration per day (hours)	4.00	15.00	8.99	1.18	4.00	15.00	8.97	1.17	4.50	15.00	9.01	1.19	**0.040**
Sleep beginning time (/24 h clock)	18: 50	02: 00	22: 59	1.06	19: 50	02: 00	22: 58	1.07	18: 50	02: 00	22: 59	1.06	0.460
Mental status score	1.00	4.71	3.97	0.71	1.14	4.71	4.00	0.70	1.00	4.71	3.95	0.72	**< 0.001**

[a]Obtained from Independent *t*-test.
[b]Significant *p*-values are **bolded** for emphasis.

of sleeping after 24 o'clock. (OR = 0.741, 95% CI = 0.571–0.960, *p*-value = 0.024). The same status could be mentioned for physical activity and mental status score among these children (OR = 0.909 and 0.554, respectively, 95% CI = 0.883–0.935 and 0.456–0.673, respectively, *p*-values < 0.001). These results indicated the association of studied variables with sleep phase shift to be stronger for mental status, sunlight exposure and physical activity respectively. In Group 1, increasing BMI, age and consuming tea/coffee were associated with an increased likelihood of sleeping after 24 o'clock (OR = 1.029 and 95% CI = 1.008–1.052 and *p*-value = 0.008, OR = 1.062 and 95% CI = 1.028–1.097 and *p*-value < 0.001, OR = 1.348 and 95% CI = 1.192–1.524 and *p*-value < 0.001, respectively). In both groups physical activity was related to only a minor change in sleep phase (OR = 0.955, 95% CI = 0.942–0.968, *p*-value < 0.001 for Group 1 and OR = 0.909, 95% CI = 0.883–0.935, *p*-value < 0.001 for Group 2) (Table 5).

DISCUSSION

Children's sleep as a complex behaviour is influenced by the interaction between culture and biology [19]. Present study enlightened the association of sunlight exposure with sleep hours among a large sample of children and adolescents. Although the associations of some more factors with children's sleep beside the sunlight exposure were investigated as well. i.e. we found that sleep duration increased by increasing sunlight exposure duration as well as mental status score, age, BMI, physical activity and being female, while decreased by higher amounts of drinking coffee and tea. Moreover, for children who exposed to sunlight via their face and hands (Group 1 in the analyses), factors such as increased age, BMI and consumption of coffee and tea were associated with delayed sleep onset time, while increments in physical activity and mental status score were associated with advanced sleep onset time. Furthermore, for children who exposed to sunlight via their face, hands, arms and feet (Group 2 in the analyses) similar relationships were obtained except for sunlight exposure that found to advance the sleep onset time and age and BMI that revealed no significant effects on sleep onset time.

Table 3. Distribution frequency of tea and coffee consumption among children: the CASPIAN-V study

	Drinking tea						Drinking coffee					
	Boys		Girls		Total		Boys		Girls		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Daily	3655	51.2	3602	51.7	7257	51.5	407	5.7	422	6.0	829	5.9
Weekly	1700	23.8	1547	22.2	3247	23.0	790	11.1	833	11.9	16.23	11.5
rarely	877	12.3	892	12.8	17.69	12.5	2750	38.5	2663	38.0	5413	38.3
Never	903	12.7	928	13.3	18.31	13.0	3200	44.8	3085	44.1	62.85	44.4
Sum	7135	100	6969	100	14 104	100	7147	100	7003	100	14 150	100

Table 4. Association of sunlight exposure time and sleep duration via multiple linear regression models: the CASPIAN-V study

	Variable	Group[d]	Unstandardized coefficient		*p*-value	Adjusted *R* square
			B	Standard error		
Model 1[a]	Sunlight exposure time	1	3.715	0.011	< 0.001	0.914
		2	3.437	0.018	< 0.001	0.915
Model 2[b]	Sunlight exposure time	1	1.353	0.024	< 0.001	• 0.958 for Group 1
		2	1.321	0.041	< 0.001	
	Sex	1	1.524	0.032	< 0.001	• 0.956 for Group 2
		2	1.516	0.057	< 0.001	
	Age	1	0.281	0.005	< 0.001	
		2	0.264	0.008	< 0.001	
Model 3[c]	Sunlight exposure time	1	0.444	0.038	< 0.001	• 0.976 for Group 1
		2	0.342	0.021	< 0.001	
	Sex	1	0.625	0.049	< 0.001	• 0.979 for Group 2
		2	0.651	0.027	< 0.001	
	Age	1	0.058	0.009	< 0.001	
		2	0.081	0.005	< 0.001	
	BMI	1	0.064	0.007	< 0.001	
		2	0.061	0.004	< 0.001	
	Physical activity	1	0.068	0.004	< 0.001	
		2	0.035	0.002	< 0.001	
	Amount of drinking coffee and tea[e]	1	−0.314	0.027	< 0.001	
		2	−0.211	0.015	< 0.001	
	Mental status score	1	0.935	0.029	< 0.001	
		2	1.112	0.016	< 0.001	

[a]Crude model.
[b]Model adjusted by sex and age.
[c]Model adjusted by sex, age, BMI, physical activity, drinking coffee and tea and mental status.
[d]Group 1 refers to children who were exposed to sunlight merely via their face and hands. Group 2 applies to children who were exposed to sunlight via their face, hands, arms and feet.
[e]Mean amount of drinking coffee and tea were calculated using factor analysis as follows: (0.7 × drinking tea – 0.7 × drinking coffee).

TABLE 5. Associations of sunlight exposure time and sleep onset time via logistic regression models: the CASPIAN-V study

	Variable	Group[d]	Odds ratio	95% Confidence interval for the odds ratio	*p*-value
Model 1[a]	Sunlight exposure time	1	0.237	0.226–0.248	**< 0.001**
		2	0.261	0.241–0.282	**< 0.001**
Model 2[b]	Sunlight exposure time	1	0.483	0.429–0.545	**< 0.001**
		2	0.454	0.374–0.552	**< 0.001**
	Sex	1	0.540	0.458–0.636	**< 0.001**
		2	0.583	0.438–0.777	**< 0.001**
	Age	1	0.951	0.930–0.972	**< 0.001**
		2	0.962	0.925–1.000	**0.048**
Model 3[c]	Sunlight exposure time	1	0.976	0.838–1.136	0.750
		2	0.741	0.571–0.960	**0.024**
	Sex	1	1.053	0.873–1.271	0.587
		2	1.038	0.739–1.459	0.828
	Age	1	1.062	1.028–1.097	**< 0.001**
		2	1.062	1.000–1.127	0.050
	BMI	1	1.029	1.008–1.052	**0.008**
		2	1.034	0.988–1.081	0.148
	Physical activity	1	0.955	0.942–0.968	**< 0.001**
		2	0.909	0.883–0.935	**< 0.001**
	Amount of drinking coffee and tea[e]	1	1.348	1.192–1.524	**< 0.001**
		2	1.173	0.952–1.446	0.134
	Mental status score	1	0.372	0.335–0.413	**< 0.001**
		2	0.554	0.456–0.673	**< 0.001**

[a]Crude model.
[b]Crude model adjusted by sex and age.
[c]Crude model adjusted by sex, age, BMI, physical activity, drinking coffee and tea and mental status.
[d]Group 1 refers to children who were exposed to sunlight merely via their face and hands. Group 2 applies to children who were exposed to sunlight via their face, hands, arms and feet.
[e]Mean amount of drinking coffee and tea were calculated using factor analysis as follows: (0.7 × drinking tea – 0.7 × drinking coffee).
Significant *p*-values are **bolded** for emphasis.

Sleep and light exposure

For many years it has been documented that environmental light plays an essential role in human image-forming visual tasks through the function of retinal photoreceptors in detecting light photons and retinal ganglion cells in transferring the messages into the associated brain structures. However, the human visual system is also considered necessary for non-image forming functions through which the circadian system alters due to environmental dark-light cycle [9]. Pathological alterations in this entrainment result in circadian rhythm sleep disorders such as those found in jet lag and among night shift workers [20]. Circadian rhythm entrainment to light-dark cycle occurs through the neural and hormonal mechanisms in which, the melatonin released by the pineal glands plays an essential role and proceeds the sleep [21, 22].

Furthermore, exposure to light has revealed positive effects on the treatment of seasonal affective disorder or sleepiness and tiredness during the day [23]. It is about the timing of the exposure (e.g. morning or evening), dose/intensity of light and duration of being exposed [6]. It is proposed that morning exposure to light significantly advances the circadian pacemaker whereas early night exposure has phase-delaying effects [24]. The central part of light-induced circadian rhythm change results from shorter light wavelengths (i.e. blue light) [25]. The red light may not interfere with melatonin secretion and in turn, to sleep disorders [26]. We found that increased daily light exposure is associated with higher sleep duration as well as with earlier sleep onset times.

Moreover, we found that increased physical activity and better mental status are linked with sleep time advancement. It is of clinical importance when the sleep delaying effects of increased BMI, age and consumption of caffeinated drinks are considered in our study. It has been shown that sleep problems among adolescents associate with depressive syndromes and cigarette smoking and affect health and neurocognitive performance [2, 27]. Educational programs have been examined in the school setting to aware children about the detrimental effects of sleep problems [28, 29].

Sleep and physical activity

In our study increased physical activity associated with increased sleep time and earlier sleep onset time. Moreover, BMI with a small positive coefficient associated with longer sleep duration. Also increased BMI associated with delayed sleep onset. In one study on 2241 children, sleep duration and physical activity did not show any association [30], whereas in another study higher rates of physical activity were associated with shorter sleep latency [31]. Even there is research indicating the adverse effect of high-intensity physical activity on the sleep [32]. A cohort study on 1231 children aged 6–10 years in which sleep and physical activity were measured via accelerometry during 7 days reported that intensive physical activity increased the sleep efficiently the following night. In the mentioned study sleep duration was not affected. Also, shorter sleep duration was found in children with high BMI [33] as seen in other researches as well [34, 35]. Cultural differences have been proposed to modify the association of sleep duration and obesity in children [36]. Also, whether the physical activity is performed indoor or outdoor may affect sleep in different directions [37]. Thus the results from studies should be compared and interpreted with cautions due to remarkable differences in the definition of physical activity, study designs, study measurement tools and duration of studies as well as study participants.

Sleep and caffeinated drinks

Caffeine is a competitive antagonist of adenosine receptors. The potential effects of caffeine on sleep have been investigated in the adults [38, 39] more extensive than in the children. The caffeinated drinks may be consumed to increase the alertness, performance and energy level [11]. Consistent with our study results, caffeine consumption is associated with later bedtime and shorter time in bed in children and adolescents [14]. It is worthwhile to note that habitual caffeine consumption may merely restore the performance decreased by sleepiness rather than increasing performance. This sleepiness may be attributed to chronic sleep deprivation among this age group [40]. It should be considered of main concerns, as the consumption rates of caffeine are increasing worldwide along with the increase in the availability of caffeinated products. Also, children and adolescents are less likely to be provided with sufficient information about the detrimental effects of excessive consumptions [41]. For instance, the behaviour may be influenced by sleep problems due to caffeine consumption [42]. On the other hand, there is evidence proposing the possible effects of extensive use on brain development, and it has remained to be further investigated [14, 43].

Sleep and mental status

Sleep problems are associated with mental health in children and adolescents. For instance, studies revealed the links between insomnia and depression, anxiety and aggression [44]. A survey of 174 children reported that sleep problems were common in children with psychiatric symptoms. In this study, there were also correlations between the severity of psychiatric symptoms and sleep problems such as short sleep duration and long sleep latencies [45]. Another cross-sectional study in new school entrants in Melbourne, Australia demonstrated that sleep problems were associated with both child and parent's mental health as well as with child's health-related quality of life [46]. Also, treatment of sleep difficulties should be addressed in youth with psychiatric symptoms to reduce subsequent emotional and behavioural problems. In our study, better mental/psychological status was associated with longer sleep duration and advanced sleep onset time. It is in agreement with previous research in which a bidirectional relationship was proposed between mental health status and sleep [47].

Thus, there is a need to provide general behaviour change techniques in the development of sleep educational programs in the school setting to emphasize the main potential factors influencing the children' sleep [48].

Strengths and limitations

We conducted a large cross-sectional study among Iranian children and adolescents and determined the contributors to sleep hours quantitatively. Our study may provide important clues for future longitudinal studies as the evidence in this age group is scarce. However, this design of the research does not guarantee the cause and effect relationships. Also, our questionnaire as the principle measurement tool relied on self-assessed questions about light exposure, physical activity, mental health and sleep hours led to decrements in measurement accuracy [33]. Thus, further objective-based longitudinal studies are recommended.

Moreover, it appears that the type of light source including natural or artificial and the timing of exposure to light, e.g. in the morning or evening, may have different effects on children's sleep. One study showed that exposure to artificial light in the morning did not affect children's bedtime [2]. Also as implicated from a recent review article, there are studies indicated the negative effects of artificial light at night on sleep duration, sleep timing and sleep composition while some studies did not report such relationships [49]. Also, exposure to artificial light in the evening has been linked to delayed sleep onset [50]. Thus, the effects of artificial light on children's sleep remain to be better investigated in future research. It can be considered as a limitation to our study since we investigated the effects of daytime exposure to sunlight and not any artificial light whether in the morning or evening/night.

CONCLUSIONS

In brief, the findings showed that children with higher BMI and older children as well as those with higher consumption of caffeinated drinks are more likely to go to sleep later (after 24 o'clock) and experiencing sleep phase delays. On the other hand, increased physical activity and better mental status are related to sleep phase advancement. Finally, the phase advancement was found in children who reported more body parts exposed to sunlight.

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CONFLICT OF INTEREST

No conflict of interest and none to declare.

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