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Concurrent associations between sleep duration and screen time with childhood obesity

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A B S T R A C T

Objectives: Obesity is a multifactorial condition showing a rapid rise worldwide, especially in children and adolescents. The present study aims to investigate the impact of sleep duration, TV watching, and dietary intake on the risk of childhood obesity.

Subjects and methods: A cross-sectional study was undertaken among 270 primary school children in Tehran, Iran. Sleep duration was measured using an ActiGraph device worn on the wrist. Using a questionnaire completed by parents, screen time (TV, video games, etc.) was estimated. Also, weight, height, and body mass index (BMI) were obtained. Data were analyzed with SPSS software (version 18, IBM Corporation).

Results: Lower BMI and longer sleep duration were associated with less screen time ($p < 0.01$). Higher daily energy (1673.4 ± 405.3 kcal), total fat (55.3 ± 19.3 g), carbohydrate (238.5 ± 67.1 g), sugars (114.3 ± 34.9 g), and snack (37.4 ± 19.3 g) consumption as well as lower daily fiber (7.9 ± 3.7 g) and vegetable and fruit (2.6 ± 1.3 servings) intakes were significantly correlated with longer screen time in children ($p < 0.05$). Lower fiber (8.1 ± 4.2 g) as well as fruit and vegetable (2.6 ± 1.4 servings) consumption were related to longer sleep duration (≥ 540 min/day) ($p < 0.01$).

Conclusion: Screen time is significantly associated with BMI, diet, and sleep in Iranian school children. Further studies are required to elaborate these associations.

Introduction

Obesity is increasing at an alarming rate and is considered a public health issue among children and adolescents [1]. It is estimated that 170 million children aged less than 18 years are overweight or obese, and, by the year 2030, about 30% of all children will be affected by this prominent nutritional and metabolic disorder [2]. There is evidence for a pronounced increase in obesity prevalence among children and adolescents in developing countries in recent years [3].

Obesity and overweight are conditions associated with fat accumulation in adipocytes and occur as a result of an imbalance between food intake and

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body's metabolic requirements for growth, development and physical activities [4]. The immense effect of childhood obesity and its huge burden on health systems have been reported. Overweight and obese children and adolescents often become obese adults. Obese individuals are at increased risk for comorbidities of type 2 diabetes, hypertension, stroke, certain cancers, infertility, and other conditions [4]. In addition, obese children are also at an increased risk of experiencing several psychological problems including attention-deficit hyperactivity disorder and sleep problems [5].

Sleep duration, screen time (ST; i.e., television/ video games), and physical activity are modifiable lifestyle risk factors for childhood obesity [6]. According to a meta-analysis [7], high television watching time is positively associated with childhood obesity, and this association is suggested to be due to the displacement of moderate to vigorous physical activity by increased television viewing [8].

There is another potential contributor to the association between television viewing and obesity, i.e., food intake. Television viewing is associated with an overconsumption of food in the current obesogenic environment [9]. Specifically, televisions watching time has been reported to be negatively associated with fruit and vegetable intake, and positively associated with total energy intake and consumption of fast food and other energy-dense snacks and drinks [10].

In an attempt to determine to what extent factors impact obesity risk, several studies have been undertaken so far. Our previous work found that preschool children who spent more time watching TV tended to be fatter and less active, and we suggested a relation between TV viewing and obesity that is more likely to be driven by an effect on food intake [11].

However, further research is critical to determine the interactions between the variables affecting childhood obesity. Therefore, this study was designed to examine the association of watching TV with sleep, BMI, and dietary intake in children.

Material and methods

A cross-sectional study was conducted to assess the association of childhood obesity with sleep duration and screen time and to identify relevant dietary factors.

Participants

For sample size determination, the following equation was used. We reached the sample size of 256 participants. The final sample size was increased by 14 to be able to make up for possible attrition. Total sample size: 256 + 14 = 270

$$N - 3 = \left[\frac{Z1\text{-}\alpha/2 + Z1\text{-}\beta}{W - Wo} \right]^2 = 256 \qquad N = 256$$

$$Z1\text{-}\alpha/_2 = 1/96$$

$$Z1\text{-}\beta = 0/85$$

$$W = 1/2 \ln \frac{1 + r}{1 - r}$$

$$r = 0/15 \qquad W = 0/15$$

Two hundred seventy healthy children (119 boys and 151 girls) aged 6 to 9 years were recruited through cluster sampling method. From among 22 districts of Tehran, 10 were selected randomly, of which two schools (a boys' and a girls' school) were eventually selected for data collection. Data collection started in November 2012 and extended till February 2013.

The approval for the study was obtained from the Tehran University of Medical Sciences Ethics Committee (No. 6092-31-03-86). Inclusion criteria were being healthy (both physically and mentally) and having the parents' written informed consent.

Measures

Anthropometric measurements

Trained nutritionists collected anthropometric data during school hours. Height was measured to the nearest 0.1 cm using a seca® portable stadiometer. Weight was measured in light clothing using a seca® scale to the nearest 0.1 kg. The growth charts of the Centers for Disease Control and Prevention [12] were used to determine the subjects' BMI percentiles. Children were grouped according to BMI percentile as follows: normal weight (BMI percentile < 85), overweight (85th to 94th percentile), and obese (≥ 95th percentile).

Screen time

Screen (TV, Video games, etc.) time was measured using a previously validated questionnaire described elsewhere [13]. The self-administered questionnaire was completed by parents.

Sleep duration

Sleep time was measured with a wrist-worn ActiGraph (Pensacola, Florida, USA). The participants were asked to wear the device on their wrist over a week. This small device weighs 27 grams, warranting weekly compliance. ActiGraph is a triaxial accelerometer able to estimate sleep-wake cycles from differences activity levels [14], thus providing highly valid and reliable data regarding

sleep and physical activity [15].

Diet and nutrients

Dietary intakes were assessed by 3-day 24-hour dietary records. Parents were asked to help verify the children's food intakes. Food data were analyzed using Nutritionist IV (version 3.5.2; 1994, N-Squared Computing, San Bruno, CA).

Statistical analyses

Data were analyzed using SPSS version 16.0 (SPSS, Inc., Chicago, IL, USA). Descriptive results are presented as mean ± SD. The student's t-test, chi-square, Fisher's exact test, and Mann-Whitney U test were used when applicable. To adjust for the effects of potential confounders, correlation or partial correlations were used. All significant tests were 2-tailed, and a p value of less than .05 was considered statistically significant.

Spearman's rho was used to identify potential relationships among the risk factors, BMI percentile, screen time, and sleep duration.

Results

General characteristics of the participants are shown in Table 1. The mean ± SD age was 8.15 ± 0.93 years. Of 270 children under study, 166 (61.5%) were identified as short sleepers, with a sleep duration lower than recommended levels. The majority of the children (81.5%) had a screen time of more than 2 hours a day.

Table 1. General characteristics of the participants, aged 5-11 years

Variables	Mean ± SD*
Age, year	8.15 ± 0.93
Gender, number (%)	
Male	119 (44.1%)
Female	151 (55.9%)
Weight, kg	29.54 ± 9.19
Height, cm	128.67 ± 8.57
BMI, kg/m2	17.51 ± 3.44
BMI percentile	58.14 ± 31.89
Sleep duration, min/24h	524.54 ± 44.71
Sufficient sleep, number (%)	104 (38.5%0)
Insufficient sleep, number (%)	166 (61.5%)
Screen time, hours per day	4.17 ± 2.06
Less than 2 hours per day, number (%)	50 (18.5%)
More than 2 hours per day, number (%)	220 (81.5%)

**Values are reported as mean ± SD, unless otherwise indicated.*

Table 2. Characteristics and dietary intake of the subjects by screen time

Variables	Low screen time[a] (n = 50)	High screen time[a] (n = 220)	p value
Age, year	7.9 ± 0.90[b]	8.2 ± 0.93	0.1
Number of girls (%)	35 (70)	116 (52)	0.03*
BMI (kg/m^2)	16.1 ± 2.3	17.8 ± 3.6	0.002*
Overweight/obese, number (%)	6 (12)	77 (35)	0.001*
BMI percentile	47.1 ± 28.8	60.6 ± 32.1	0.01*
Birth weight, g	3251.6 ± 607.7	3118.7 ± 587.7	0.2
Sleep duration, min/24h	543.2 ± 40.0	520.3 ± 44.7	0.002*
Ghrelin (pg/mL)	1015.7 ± 598.4	1049.3 ± 499.7	0.6
Leptin(ng/mL)	6.9 ± 7.6	8.9 ± 9.8	0.3
	Parents		
Mothers' BMI, kg/m^2	25.2 ± 3.7	25.6 ± 3.8	0.5
Fathers' BMI, kg/m^2	25.8 ± 4.4	26.3 ± 3.8	0.2
Parents holding a university degree,number (%)	24 (48)	116 (52)	0.6
	Children's dietary intake		
Energy, kcal	1548.6 ± 332.1	1673.4 ± 405.3	0.04*
Total fat, g	48.3 ± 13.2	55.3 ± 19.3	0.007*
Total carbohydrate, g	215.7 ± 55.5	238.5 ± 67.1	0.02*
Total protein, g	68.3 ± 19.3	64.7 ± 18.8	0.8
Fiber, g	11.5 ± 4.5	7.9 ± 3.7	< 0001*
Vegetables and fruit, serving per day	3.7 ± 1.7	2.6 ± 1.3	< 0.002*
Sugars, g	99.9 ± 29.1	114.3 ± 34.9	0.01*
Snack	29.3 ± 16.1	37.4 ± 19.3	0.03*

[a] Screen time was categorized as low (< 2 h/d) and high (≥ 2 h/d); [b] mean ± SD;
** Statistically significant*

General characteristics and dietary intakes of the children as well as their parents were analyzed separately by screen time (Table 2).

No statistically significant difference was observed in age, birth weight, ghrelin, and leptin between the groups. The percentage of girls was significantly higher in the low (< 2 h) compared with the high (≥ 2 h) screen time group. The mean BMI and BMI percentile were significantly higher for the high screen time group. Children in the low screen time group had significantly longer sleep duration. Furthermore, children in the high screen time group were significantly overweight.

No statistically significant difference was noted in the parents' education level and BMI. Statistically significant differences were observed in all dietary components between the groups except for total protein.

Table 3. Characteristics and dietary intake of the subjects by sleep duration

Variables	Sleep duration (n = 104) < 540 min/d	sleep duration ≥ 540 min/d(n = 166)	p value
Age, year	7.9 ± 1.0a	8.2 ± 0.9	0.02*
Number of girls (%)	55 (52)	96 (57)	0.451
Children's BMI, kg/m^2	17.3 ± 3.4	17.6 ± 3.2	0.3
Overweight/obese, number (%)	30 (28.9)	53 (32)	0.6
Birth weight, g	3100.6 ± 631.5	3166.7 ± 593.7	0.3
Ghrelin (pg/mL)	1081.4 ± 605.1	1020.4 ± 462.7	0.9
Leptin (ng/mL)	8.61 ± 9.1	8.7 ± 9.8	0.6
BMI percentile	55.2 ± 32.6	59.8 ± 31.9	0.5
Screen time, h/d	4.0 ± 2.2	4.3 ± 2.0	0.07*
	Parents		
Mothers' BMI, kg/m^2	25.9 ± 4.1	25.7 ± 3.5	0.2
Fathers' BMI, kg/m^2	26.8 ± 4.7	25.9 ± 3.5	0.4
Parent holding a university degree, number (%)	51 (49)	89 (53)	0.5
	Children's dietary intake		
Energy, kcal	1652.4 ± 422.4	1641.4 ± 380.8	0.9
Total fat, g	52.6 ± 17.8	54.9 ± 19.3	0.4
Total carbohydrate, g	239.8 ± 69.4	230.3 ± 61.4	0.3
Total protein, g	64.3 ± 18.5	64.5 ± 17.6	0.8
Fiber, g	9.0 ± 4.0	8.1 ± 4.2	0.008*
Vegetables and fruit, serving per day	3.1 ± 1.4	2.6 ± 1.4	0.001*
Sugars, g	112.5 ± 34.1	110.5 ± 34.7	0.3
Snack	35.9 ± 19.8	35.5 ± 18.9	0.5

[a] *mean ± SD*
** Statistically significant (p < 0.05).*

Table 4. Correlations between body mass index percentile and lifestyle behavioral risk factors

Variables	BMI percentile	Sleep duration	Screen time
BMI percentile	.	NS	.
Correlation coefficient (r)	….		0.087
p value			0.04*
Sleep duration		….	
Correlation coefficient (r)	NS		-0.174
p value			0.004*
Screen time			
Correlation coefficient (r)	0.11	-0.174	……
p value	0.05*	0.004*	
Age	NS	-0.163*	0.226*
Leptin (ng/mL)	0.165*	0.011	-0.006
Ghrelin (pg/mL)	-0.124 (0.06)	0.018	0.00
Birth weight	NS	-0.053	-0.078
Mother's BMI	0.253**	-0.026**	0.048
Father's BMI	0.220**	0.016	0.081
Energy intake	0.423*	-0.022	0.195*
Total carbohydrate	0.374*	0.015	0.164*
Total fat	0.319*	-0.054	0.197*
Total protein	0.321*	-0.055	0.021
Fiber	-0.041	0.132*	-0.066
Vegetables and fruit, serving per day	-0.039	0.172**	-0.032
Sugars	0.149*	0.064	0.061
snack	-0.007	0.007	0.027

**Correlation is significant at the 0.05 level.*
*** Correlation is significant at the 0.01 level.*

Additionally, obese or overweight children consumed snacks and sugars more frequently than the normal-weight children. Finally, lower intakes of fruits and vegetables and fiber were observed in these children.

The association between screen time and children's dietary intake

The present study found that more television viewing and video gaming among children is significantly associated with increased intakes of energy, fat, and carbohydrates. These findings are supported by the previous studies reporting the association of high screen times with consumption of unhealthy foods, including fast foods. Boyland and colleagues showed that the greater amounts of televisual media use increased the preference for high-carbohydrate and high-fat foods in children [23].

Additionally, there is evidence that higher exposure to TV food advertisement can produce an obesogenic food preference response in normal-weight children that is typically found in overweight and obese children [24].

Regarding the correlation of BMI percentile with sleep duration, we found no statistically significant association. Additionally, the duration of sleep was not different between children with normal BMI and overweight/obese individuals. These findings are not consistent with previous studies [8, 25]. According to the displacement hypothesis of television viewing and obesity, higher television viewing time is associated with reduced available time for physical activity in children, which has a potential impact on energy balance [8] and, consequently, on weight. However, these results might be explainable by the finding that the majority of participants in our study had short sleep duration. In fact, none of the school children's sleep duration exceeded the recommended amount; thus, we were unable to discover an association, if any, between sleep duration and BMI in those with sleep duration higher than recommended levels.

However, as awake time increases, the intake of energy and energy-dense foods might increase, affecting energy balance and, consequently, weight [26]. Moreover, children getting insufficient sleep are more likely to be less active due to tiredness and fatigue, and thus spend more time on sedentary activities such as watching television and playing video games, which is also likely to be associated with a high energy intake (e.g., from snacks) [27]. In this regard, a negative association has been found between sleep duration and consumption of energy-dense foods [28, 29]. There is evidence that sleep restriction is associated with increased intakes of total kilocalories, sugar, carbohydrate and fat, and overconsumption of highly palatable "comfort foods" [30, 31].

Additionally, our results demonstrated that shorter sleep was associated with lower intakes of healthy foods including fiber as well as fruits and vegetables. Such food choices may promote weight gain over time and be a potential mechanism mediating the effects of sleep restriction on childhood obesity [31]. Dietary intake and anthropometric indices of children in relation to sleep deserve more research.

Consistent with recent evidence, the current study revealed that parental obesity is associated with children's overweight and obesity, indicating the multifactorial nature of childhood obesity.

There is evidence that children with overweight/obese parents have an increased likelihood of being overweight/obese [32]. A family history of overweight or obesity is an important indicator of genetic risk for being overweight in childhood.

However, in addition to genetic predisposition to obesity, parental overweight is also a proxy for shaping children's eating and activity environment [33, 34]. In most cases, overweight parents create and sustain an obesogenic environment (that is, high-energy diet and physical inactivity) not only for themselves, but also for their children [35].

Thus, important risk factors for childhood overweight and obesity need to be identified, and it might be beyond positive energy balance.

Conclusion

The present study reveals significant associations among BMI, screen time and sleep duration in Iranian children. Furthermore, significant differences in children's dietary intake were observed by screen time and sleep duration. The modifiable factors identified as related to childhood obesity in this study may inform future research aimed at prevention of obesity.

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Conflict of interest

None of the authors have conflict of interest.

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