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The Associations Between Screen Time, Sleep Duration, and Body Mass Index (BMI) in Under Five-Year-Old Children

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Abstract

Background: Today, due to recent developments in technology, children devote plenty of time to screen viewing. However, its harmful effects are not yet clear.
Objectives: The purpose of the present study was to examine the associations between screen viewing, sleep duration, and body mass index (BMI) in under-five-year-old children.
Methods: This cross-sectional study was conducted on 322 under-five healthy children that were selected using a multistage stratified cluster sampling method in 2017. The data gathered by the time-use diary method were analyzed using the Kolmogorov-Smirnov test, Spearman Correlation test, Multiple Linear Regression Analysis, one-way ANCOVA, and two-way ANCOVA.
Results: There was a negative correlation between screen time and sleep duration ($P < 0.001$), a positive correlation between screen time and BMI ($P < 0.001$), and a negative correlation between sleep duration and BMI ($P < 0.001$). Screen viewing was a predictive factor for both sleep duration ($P < 0.001$) and BMI ($P < 0.001$). Screen viewing had a significant impact on sleep duration ($P = 0.001$) and BMI ($P = 0.298$).
Conclusions: The results of this study indicate that screen viewing is related to sleep duration and BMI in under-five-year-old children. Furthermore, screen time has an impact on sleep duration and BMI of children.

Keywords: Screen Time, Sleep Duration, Body Mass Index (BMI), Time Use

1. Background

In the shadow of the dramatic technological advances, the diversity and availability of media and their impacts on the lives of children are expanding (1-3). Furthermore, the electronic screen use including media use and exposure has increased markedly amongst infants and young children despite the recommendations of the American Academy of Pediatrics for children under 18 months (3-5). The existing data suggest that early and excessive media exposure and use is associated with sleep problems (6), overweight and obesity (7), and child developmental delay (8-10).

Sleep is an active neurophysiological process and the preliminary function of the developing nervous system (11, 12). Research widely indicates that sleep is crucial for optimal cognitive performance, physiological processes, emotional regulation, and quality of life (11, 13). Shorter sleep duration is related to a broad range of harmful health and educational outcomes (11, 14-16).

According to the World Health Organization (WHO), "overweight and obesity are defined as abnormal or excessive fat accumulation that may affect health" (17). Childhood overweight/obesity prevalence appears to be rising rapidly in developing countries. In particular, in the past three decades, obesity prevalence among Iranian children has more than doubled (18, 19). Obesity and overweight in childhood have a considerable impact on either physical or

psychological health (18, 20). Furthermore, in the future, they will often become obese and overweight adolescents and adults (18).

There is limited evidence on the relationship between media use/exposure and sleep duration in under-five-year-old children (6, 21). In the same way, while various analytical studies have shown associations between screen time and BMI in late childhood (22-27), evidence about infants, young children, and preschool children is not conclusive (28, 29).

Moreover, although some studies indicate that the duration of media use is associated with sleep duration and BMI, most researchers have concentrated on particular types of the screen viewing devices such as TV and portable video device (29-31). This is while children in real life are in touch with a variety of screen viewing devices. Therefore, in this study, screen-viewing time was investigated based on all media devices. Regarding the fact that lifestyle-related variables are usually culture-dependent (32), research in the field of screen viewing, sleep, and BMI should be conducted separately for each community. Nonetheless, to the best of our knowledge, no other study investigated the relationship between screen time, sleep duration, and BMI in under five-year-old Iranian children residing in provinces and counties.

2. Objectives

The main objectives of the present study were: To explore the associations between screen viewing and sleep duration, screen viewing and BMI, and sleep duration and BMI in under-five year old children, to examine whether screen viewing can predict sleep duration and BMI and whether sleep duration can predict BMI among under-five-year-old Iranian children, to explore the difference in sleep duration by screen time levels after being adjusting for age categories and finally, to inquire the interaction of screen viewing levels and sleep duration levels with BMI of participants adjusted by age.

3. Methods

3.1. Study Type, Population, and Sampling Method

The present cross-sectional study was conducted in Takestan County, an area in Qazvin province of Iran, from May to December 2017.

Using multistage stratified cluster sampling, 322 under-five-year-old healthy children were enrolled in the study, while children with severe mental or physical illness that needed hostel special care services in institutes were excluded from the research process.

Participants were selected from all cities and villages of the county. In the first stage of sampling, from similar socio-economic regions of urban and rural areas, representative areas were selected. In the next stage, seven rural health centers and three urban health centers were selected from among 16 rural health centers and eight urban health centers. Subsequently, the equal numbers of girls and boys were selected from various health houses of rural centers and various health posts of urban centers based on the population load of children under five years of age and proportional to the number of children in every seven age groups (under one month, 2 - 3 months, 4 - 6 months, 7 - 12 months, 1 - 2 years, and 3 - 5 years).

We obtained written informed consent from parents before participation and an approval for the study was obtained from the Social Welfare and Rehabilitation Sciences University.

3.2. Instrument and Procedures

The version of the time-use diary that was applied to this research had four main open-ended questions that asked the primary activity, when it began and ended, whether any other activities took place, and where and with whom that activity took place.

The time-use diary, which was either interviewer-administered or self-reported, asked about the child's flow of activities over a 24-hour period of a weekday. The time-use diary in the present study was designed as open-response category and open interval formats via per three hours. Yesterday or tomorrow methods of time use diaries were utilized in line with the desire and conditions of the participants. In the "tomorrow" diary method, the interviewer left the time-use diaries behind for the participant to be completed after an initial face-to-face interview, on the following day(s) (33-35) while in the "yesterday" diary method, the respondent was required to recall recent events and record activities performed over a specified recall period, which is usually yesterday, during an interview. In other words, the respondent recalls the activities of the past 24-hours (36, 37).

All data were gathered by three professionally trained staff that had participated in workshops about the time-use methodology, time-use diary administration, and interview method of assessment.

3.2.1. Screen Time

Screen viewing time was calculated based on the sum of media use as either a primary or a secondary activity on the weekday, including time-use estimates (minutes) of TV viewing, video games, and the use of the personal computer, laptop, or tablet that were measured by yesterday and tomorrow time-use diaries.

3.2.2. Sleep Duration

Total sleep duration was calculated by the summation of daytime sleep and nighttime sleep estimates that were measured by yesterday or tomorrow time-use diaries.

3.2.3. BMI

Anthropometric data including height and weight were measured according to a standard program using calibrated devices by a trained staff of health-care systems (38, 39). Overweight and obesity status was determined based on BMI z-scores that were calculated by using the World Health Organization gender-specific BMI-for-age growth charts (17).

3.3. Analysis

3.3.1. Qualitative Analysis

Unlike previous time-use studies, this study investigated the estimates of time use based on eight areas of occupations, which were classified according to the third version of occupational therapy practice framework, domain and process (OTPF3) (40). The interpretation of the diary was done in several steps. In the first stage, verbatim was extracted and the number and duration of each of them were determined. In the next step, the frequency and duration of the tasks, activities, and occupations of daily life were determined according to the OTPF3, and in the final stage, the time allocated to each of the areas of occupations was determined based on the OFPF3.

3.3.2. Statistical Analysis

Statistical analyses were performed by using IBM SPSS and the level of significance was set at $P < 0.05$.

The data were analyzed using Kolmogorov-Smirnov test for normality testing. Spearman Rho Correlation tests were employed for the analysis of relationships and the Multiple Linear Regression Analyses were used to evaluate the impacts of selected predictor variables (screen time, sleep duration, and age) on sleep duration and BMI as dependent variables. The first regression analysis included the duration of screen time adjusted for age categories predicting sleep duration, and the second regression analysis included the duration of screen time adjusted for sleep duration levels and age categories for predicting BMI. One-way Analyses of Covariance (ANCOVA) were used to examine how screen time was related to five categories of sleep duration with a covariate of age, and the differences in BMI scores were assessed by two-way ANCOVA (5 screen time × 5 sleep duration) with adjustment for the covariate of age.

3.4. Ethics Approval

This study was approved by the Ethics Committee of the University of Social Welfare and Rehabilitation Sciences on 3 October 2016 under the ethics code IR.USWR.REC.1395.193.

4. Results

Table 1 presents descriptive statistics including the mean and standard deviation of screen time, sleep duration, and BMI by age categories and gender. In general, the mean screen time, sleep duration, and BMI were 97.75 min/day, 668.35 min/day, and 16.58 among our participants. It is noteworthy that there was no significant difference in any of the variables between girls and boys.

As presented in Table 2, approximately 63.9 percent of the participants spent excessive screen time according to the American Academy of Pediatrics, 12.4 percent of the participants had short sleep duration, and 14.1 percent of the children were overweight or obese.

Table 3 shows the results of the Spearman's Rho Correlation test carried out to examine the association between screen time, sleep duration, BMI, and age. Screen time was positively significantly correlated with BMI ($r_s = 0.38$, $P < 0.001$) and age ($r_s = 0.60$, $P < 0.001$), while it was negatively significantly correlated with sleep duration ($r_s = -0.42$, $P < 0.001$). Sleep duration was negatively significantly correlated with BMI ($r_s = -0.22$, $P < 0.001$) and age ($r_s = -0.40$, $P < 0.001$) and BMI was positively significantly correlated with age ($r_s = 0.133$, $p < 0.001$).

The screen time ($\beta = -0.26$, $P < 0.001$) and age ($\beta = -0.20$, $P < 0.001$) were significant predictors of sleep duration (Table 4).

As shown in Table 5, the multiple linear regression model shows a direct association between BMI and screen time ($\beta = 0.44$, $P < 0.001$) and age ($\beta = -0.17$, $P < 0.001$), indicating screen time had more contribution to BMI. However, sleep duration ($\beta = -0.09$, $P = 0.12$) was not a significant predictor of BMI (Table 6). The Multiple Regression presented in Table 7 indicated the significant predictive role of sleep duration in BMI scores.

The one-way ANCOVA (screen time categories x sleep duration with age as a covariate) indicated the significant impact of screen time ($F(4, 314) = 5.02$, $P < 0.001$) on the sleep duration (Table 8).

Two-way ANCOVA with factors of screen time (five categories) and sleep duration (five categories) and age as a covariate found no significant interaction between screen time and sleep duration categories ($F(4, 314) = 1.16$, $P = 0.298$) while it found a significant main effect for the screen

Table 1. Descriptive Statistics of Screen Time, Sleep Duration, and BMI by Age Categories and Gender

Variable	Screen Time, Mean (SD)	Sleep Duration, Mean (SD)	BMI, Mean (SD)	N
Age categories (mo)				
0 - 1	13.33 (23.01)	759.72 (143.94)	13.95 (1.05)	18
2 - 3	20.75 (27.83)	806.75 (135.23)	16.22 (1.49)	20
4 - 6	34.25 (60.88)	722.75 (98.82)	16.76 (2.00)	20
7 - 12	59.16 (66.85)	691.86 (86.73)	16.97 (1.94)	43
13 - 24	82.36 (73.74)	643.48 (106.2)	17.01 (1.89)	69
25 - 60	144.13 (96.56)	636.17 (96.56)	16.61 (1.77)	149
Gender				
Girl	98.69 (84.30)	675.31 (102.91)	16.50 (1.89)	160
Boy	97.75 (92.76)	661.44 (124.83)	16.66 (1.92)	159
Total	97.75 (92.76)	668.35 (114.39)	16.58 (1.90)	319

Table 2. The Frequencies and Percentages of Participants with Excessive Screen Time, Short Sleep, Overweight, and Obesity by Age Groups

Variable	Age Categories (mo)						Total
	0 - 1	2 - 3	4 - 6	7 - 12	13 - 24	25 - 60	
Excessive screen time, No. (%)	5 (27.78)	8 (40.00)	10 (50.00)	26 (59.09)	51 (73.91)	104 (69.80)	204 (63.95)
Short sleep, No. (%)	2 (11.11)	2 (10.00)	2 (10.00)	6 (13.64)	13 (18.57)	15 (10.00)	40 (12.42)
Overweight, No. (%)	0 (0.00)	0 (0.00)	3 (15.00)	4 (9.30)	5 (7.25)	11 (7.38)	23 (7.21)
Obesity, No. (%)	0 (0.00)	0 (0.00)	0 (0.00)	1 (2.33)	8 (11.59)	13 (8.72)	22 (6.90)

Table 3. The Association Between Screen Time, Sleep Duration, BMI, and Age

Variable	Screen Time		Sleep Duration		BMI		Age	
	r_s	P	r_s	P	r_s	P	r_s	P
Screen time	1	< 0.001	- 0.417	< 0.001	0.380	< 0.001	0.597	< 0.001
Sleep duration	- 0.417	< 0.001	1	-	- 0.218	< 0.001	- 0.397	< 0.001
BMI	- 0.218	< 0.001	0.380	< 0.001	1	-	0.133	< 0.001
Age	0.597	< 0.001	- 0.397	< 0.001	0.133	< 0.001	1	-

Table 4. Multiple-Linear Regression Model Examining the Association of Screen Time and Age with Sleep Duration

Variable	Sleep Duration					
	B	SE	β	R^2	Adjusted R^2	P
Screen time	- 0.317	0.076	- 0.257	0.189	0.184	< 0.001
Age	- 1.551	0.41	- 0.234			< 0.001

Table 5. Multiple-Linear Regression Model Examining the Association of BMI with Screen Time, Sleep Duration, and Age

Variable	BMI					
	B	SE	B	R^2	Adjusted R^2	P
Screen time	0.009	0.001	0.440	0.164	0.156	< 0.001
Sleep duration	- 0.002	0.001	- 0.09			0.117
Age	- 0.019	0.007	- 0.170			< 0.001

Table 6. Multiple-Linear Regression Model Examining the Association of Sleep Duration and Age with BMI

Variable	BMI					
	B	SE	B	R^2	Adjusted R^2	P
Sleep duration	- 0.003	0.001	- 0.183	0.042	0.0360	0.002
Age	0.005	0.007	0.049			0.415

Table 7. A Summary of Covariance Analysis to Evaluate the Effect of Screen Time on Sleep Duration (Covariate: Age)

Source of Variation	Sum-of-Squares	Df	Mean Square	F	P
Age	131151.761	1	131151.761	12.273	0.001
Screen time	214390.353	4	53597.588	5.015	0.001
Error	3344889.927	313	10686.549	-	-

time categories ($F(4, 314) = 9.25$, $P < 0.001$) and sleep duration categories ($F(4, 314) = 4.18$, $P < 0.001$), as summarized in Table 8.

5. Discussion

The purpose of the present study was to investigate the relationships between screen time, sleep duration, and BMI among under-five-year-old children.

We found that children who had more screen time had less sleep duration. In other words, screen time as a predictor had a significant impact on sleep duration. The findings of the present study are consistent with the American Academy of Pediatrics that recommends appropriate limitations for screen time for under-five-year-old children (3, 4). This finding is consistent with some previous studies that found screen time is adversely associated with sleep outcomes. For instance, the findings of a cohort study on Australian children (4 - 5 years of age at baseline) showed that the total media use at four years of age was significantly associated with sleep duration at six years of age (41). In most studies, the relationship between time spent on watching TV, using computers or other screen devices, and sleep-related variables including sleep duration has also been evaluated separately (42). Mak et al. in their baseline survey study on adolescents in Hong Kong obtained heterogeneous results and indicated that Television and computer viewing was not correlated with sleep duration while mobile phone viewing was correlated with sleep duration (43). It is noteworthy that the content type (6) and temporal and physical locations of screen viewing (6, 44) are two compelling factors influencing sleep duration.

The findings of the present study showed that the BMI scores of under-five children were positively associated with screen viewing time and negatively associated with sleep duration. In addition, the results of this study indicate that screen time could predict BMI scores although sleep duration could not predict the BMI of under-five children in the presence of screen time as an independent variable. Furthermore, both screen time and sleep duration had an impact on under-five children's BMI scores. The results of our study could be supported by the unconscious eating mechanism implying when children eat during TV viewing, they will be unaware of the amount of food they eat (45, 46). Moreover, the more screen time is associated with more sedentary behavior time and less physical activity, which in turn can lead to overweight or obesity (47, 48).

Our findings are in good agreement with some previous research findings suggesting the relationship between screen viewing aspects and BMI, overweight, or obesity. Kuriyan et al. identified TV viewing as one of the significant factors contributing to overweight in 6 - 16-year-old children (49).

The findings of this study are not consistent with a meta-analysis of prospective studies published in 2018 that revealed shorter sleep duration is a risk factor for obesity in infants, children, and adolescents (50). The disparity of the findings may be attributed to the role of screen time as an independent variable in such a way that irrespective of screen time as an independent variable, sleep duration could predict BMI, as shown in Table 7.

The main limitation of this research was related to its participants as it was conducted on a relatively limited geographical area with a small sample size. Future research on this topic could address the limitations of this study by expanding the geographical coverage and enrolling a larger sample size.

The strengths of this study were its sampling strategy and its attempt to control extraneous variables, especially age, gender, and the socioeconomic status of the households.

Table 8. A Summary of Two-Way ANCOVA to Evaluate the Effect of Screen Time and Sleep Duration on BMI (Covariate: Age)

Source of Variation	Sum-of-Squares	Df	Mean Square	F	P
Age	17.474	1	17.47	5.799	0.017
Screen time	111.507	4	27.877	9.252	< 0.001
Sleep duration	50.334	4	12.583	4.176	0.003
Screen*sleep	56.011	16	3.501	1.162	0.298
Error	879.816	292	3.013	-	-

5.1. Conclusion

In summary, the findings of the present study suggest that screen viewing is associated with sleep duration and BMI in under-five children. Moreover, screen time is a predictive factor of sleep duration and BMI scores of children. Our findings suggest that sleep duration is negatively related to BMI in under-five-year-old children.

Footnotes

Authors' Contribution: Hossein Sourtiji, Seyed Ali Hosseini, and Mehdi Rassafiani were principal investigators of this research project and contributed to the conceptualization and designing the research, implementation of the study, development of the questionnaire, analyzing data and writing-original draft of the manuscript. Mehdi Noroozi and Mohammad Esmaeil Motlagh were contributed to the development of study design, and Amir Kohan was contributed to editing manuscript

Ethical Considerations: This study was approved by the Ethics Committee of the University of Social Welfare and Rehabilitation Sciences on 3 October 2016 under the ethics code IR.USWR.REC.1395.193.

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