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Do sleeping habits mediate the association between time spent on digital devices and school problems in adolescence?

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Background: This study examined the associations of Internet and computer screen time with school difficulties and the role of sleep quality and soft and energy drinks consumption. **Methods:** We used data from the cross-sectional Health Behaviour in School-aged Children study collected in 2014 among Slovak adolescents (aged 11.0–15.9 years, $N=7595$, 48.1% boys). We examined the inter-relations between time spent with on digital devices (time spent playing digital games or Internet use), sleeping quality (sleeping shortage, sleeping difficulties), soft/energy drinks consumption and school problems (low academic achievement, disliking school, being pressured by schoolwork and truancy), using structural equation modeling. **Results:** Results showed that the more time adolescents spent on digital devices during leisure time, the more school problems they had. This association was mediated by a higher consumption of soft or energy drinks and a lower quality of sleeping. The direct effect of time spent on digital devices on school problems and its indirect effect via sleeping quality were relatively small (–0.26 and –0.30, respectively, standardized solution), compared with the indirect effect of time spent on digital devices via soft/energy drinks consumption as well as sleeping quality (0.65, standardized solution). **Conclusions:** Time spent on digital devices is associated with school problems, with sleeping and soft/energy drinks consumption playing a substantial role in this association.

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Introduction

Electronic media have become a fully integrated part of the lives of children and adolescents and a very important factor in their everyday lives. According to the EU Kids Online project, European adolescents spend almost 2 hours a day online.¹ Time spent online has been constantly growing during the last few years thanks to the widespread use of smartphones and mobile Internet.² Adolescents are involved daily in a wide range of online activities, especially in online games and online communication tools like chat and social networking

sites, which might also be associated with negative aspects, such as excessive or addictive Internet use.^{3,4} From a health perspective, the key criterion is whether such excessive use contributes to individual distress in a child's life. In the case of children or adolescents, such distress could be particularly visible in the form of problems at school, in terms of worse academic performance, negative attitudes to school or an increase in maladaptive behavior.^{5,6} These problems have negative consequences for their health and well-being.^{7,8}

Time spent with electronic media might influence school difficulties via deteriorating sleeping quality. Digital game play has

been shown to have a significant impact on sleep patterns and consequent verbal memory performance.⁹ Sleep laboratory study, by Wolfe et al.,¹⁰ found that video gaming was associated with sustained attention, mediated by sleep duration. Similarly, a small study by Dimitriou et al.¹¹ indicated that negative sleep patterns are related to decreased school performance. This association was affected by media use and caffeine drinks consumption before sleep. Screen time has been proven to be negatively associated with sleep patterns—either by displacing time for sleep,¹² physiologically arousing the users through exciting content,¹³ or by suppressing the level of the sleep hormone melatonin through prolonged exposure to screen light.¹⁴ Moreover, it has been found that the mere presence of electronic media in the bedroom of children can lead to decreased sleep time. Insufficient quality and quantity of sleep and overall sleepiness have been repeatedly shown as being associated with decreased school performance.¹⁵

Screen-based activities also have various effects on dietary habits, e.g. frequent screen-based behavior was associated with high sweetened beverages consumption¹⁶ and high-fat and high-sugar foods intake.¹⁷ Recent research suggests that a high consumption of caffeinated sugar-containing drinks is related to physical complaints (headaches, stomach aches, sleeping problems and low appetite) among children, and a stronger effect is observed for energy drinks compared with cola drinks.¹⁸ Moreover, this relationship might also be partially mediated by late bedtime.¹⁹ High consumption of sugar- and caffeine-containing drinks may also be associated with health complaints, for instance, anxiety, depression, tense, sleepiness or hyperactivity.^{20,21} In addition, children who daily consume soft drinks are more vulnerable to suffering from nervousness and irritability. That may in turn result in aggressive behavior, such as bullying or physical fighting,²² which has become a serious issue in schools.

In summary, associations have been found between screen-based activities, well-being, sleeping and eating habits and school performance.^{9–17} However, the mechanism behind school problems and the route to them via excessive screen time has still not been fully understood. We aimed to assess the associations of time spent with digital game play and use of the Internet for communication and entertainment with school difficulties, and whether these associations are mediated by poor sleep quality and quantity, and by a higher consumption of drinks rich in caffeine and/or sugar.

Methods

Sample and procedure

We used data from the Health Behaviour in School-aged Children study conducted in 2014 in Slovakia. To obtain a representative sample, we used a two-step sampling. In the first step, 151 larger and smaller elementary schools located in rural as well as urban areas from all regions of Slovakia were asked to participate. These were randomly selected from a list of all eligible schools in Slovakia obtained from the Slovak Institute of Information and Prognosis for Education. In the end, 130 schools agreed to participate in our survey (response rate: 86.1%). In the second step, we obtained data from 10 179 adolescents from the fifth to the ninth grades (response rate: 78.8%). Non-responses were caused mainly by school absence due to illness or other reasons and the refusal of parents or adolescent to be involved in this study. Respondents younger than 11 years and older than 15.9 years (929 respondents) and respondents with missing responses were excluded (1655 respondents), leading to a final sample of 7595 adolescents (mean age: 13.53 years; 48.1% boys). Non-response per item varied between 0.5% and 9.7% and was highest for time spent on digital games, probably due to these questions being at the end of the questionnaire; the cumulative item non-response was 17.9%. Non-response analyses revealed that boys, younger adolescents, those who drink soft and energy drinks more often and those who have worse self-rated health were excluded due to item non-response more

frequently. Responding and non-responding respondents did not differ in time spent with playing computer games or on Internet, and in truancy. The study was approved by the Ethics Committee of the Medical Faculty at the Pavol Jozef Safarik University in Kosice (No: 9/2012). Parents were informed about the study via the school administration and could opt out if they disagreed with their child's participation. Participation in the study was fully voluntary and anonymous, with no explicit incentives provided for participation. Questionnaires were administered by trained research assistants in the absence of a teacher during regular class time.

Measures

Time spent on digital devices regarded computer gaming and Internet use. Computer gaming was measured by asking: 'How many hours a day, in your free time, do you usually spend playing games on a computer, a gaming console, a tablet (like an iPad), a smartphone or other electronic devices (not including moving or fitness games)?' Responses could range from 'None at all' to '9 hours per day'.²³ Use of the Internet was measured by the question: 'How many hours a day, in your free time, do you usually spend using electronic devices such as computers, tablets (like an iPad) or smartphones, regarding for example, doing homework, e-mailing, tweeting, using facebook, chatting, and surfing the Internet'.

Soft and energy drinks consumption was assessed by asking children two questions, e.g. how many times a week they usually drank coke or other soft drinks that contain sugar, as well as how many times a week they usually drank energy drinks, e.g. Red Bull. Possible responses were: 'never', 'less than once a week', 'once a week', '2–4 days a week', '5–6 days a week', 'once a day, every day', 'every day, more than once'.

Sleeping quality was measured by asking about the duration of sleep and sleeping difficulties. Length of sleep was calculated from adolescents' reports of bedtimes and wake-up times on school days. Bedtimes were asked as follows: 'When do you usually go to bed if the next morning is a school day?' Answers ranged in half-hour intervals from 'at latest 9pm' to '2 am or later'. Wake-up times were assessed with the question: 'When do you usually wake-up on school mornings?' Response categories ranged from '5 am at the latest' to '8 am or later', in half-hour intervals. We then calculated sleep duration using the following formula: 24 – bedtime + wake-up time.²⁴ Moreover, children were asked to indicate how frequently during the last 6 months they had difficulties in getting to sleep. Responses for frequency were on a 5-point scale: rarely or never, about every month, about every week, more than once a week and about every day.

School problems regarded academic achievement, liking school and being pressured by the schoolwork and truancy; they were measured by four separate questions. Liking school was measured by an item asking children how they feel about school at the present, with 5 response categories ranging from 'I like it a lot' to 'I do not like it at all'. Children's academic achievement was measured by the question: 'In your opinion, what does your class teacher(s) think about your school performance compared to your classmates?' with the response alternatives: 'very good', 'good', 'average' and 'below average'.²³ Perceived schoolwork pressure was measured by a single item on the global feeling of being pressured by the demands of schoolwork, including work at school and homework. Possible answers were: 'Not at all', 'A little', 'Some' and 'A lot'. Finally, children were asked if they had skipped school without a proper excuse for at least one whole day in the last 12 months. Answers ranged from 'never' to 'three or more times'.

Statistical analysis

First, we assessed the Pearson correlations between all variables. Then we used structural equation modeling (SEM) to analyze the direct and indirect effects of time spent on digital devices, soft/

energy drinks consumption and sleeping quality on school problems. We constructed latent variables for these concepts as follows: time spent on digital devices was estimated from working with a computer and playing digital games, the soft/energy drinks consumption, sleeping quality from sleeping difficulties and length of sleep and finally school problems from liking school, academic achievement, being pressured by the schoolwork and truancy. Robust maximum likelihood was used for the estimates. Regarding to the concept of soft/energy drinks consumption, we assessed the associations of these two independent variables separately. First, using a linear regression model, we assessed the effect of soft drinks on sleep difficulties, and next of adding energy drinks in a second step. This modeling showed that consumption of soft drinks in itself is significantly associated with sleeping problems and adding energy drinks consumption to the model decreased this association, but did not explain it fully (not shown). Analyses were performed using LISREL software.²⁵

Results

Table 1 provides the description of the sample. Table 2 shows the correlations of the examined variables. The strongest correlation was found between digital games and Internet use ($r = 0.43$), followed by the correlation between soft and energy drinks ($r = 0.38$). A relatively weak correlation was found between duration of sleep and sleeping difficulties ($r = -0.14$) and between School problems variables, with

Table 1 Description of variables ($n = 7595$, Slovak adolescents aged 11–15 years, data collected in 2014)

		N (%)
Time spent on digital devices		
Playing digital games	More than 2 h a day	3543 (46.6)
Internet use	More than 2 h a day	4260 (56.1)
Soft/Energy drinks consumption		
Consumption of soft drinks	At least once a day	5760 (75.8)
Consumption of energy drinks	At least once a day	1488 (19.6)
Sleeping quality		
Duration of sleep	Less than 8 h	2367 (31.2)
Sleeping difficulties	At least every week	1841 (24.2)
School problems		
Academic achievement	Good or very good	5694 (75.0)
Liking school	Liking it a lot	1393 (18.3)
Being pressured by the school	A bit or a lot	1633 (21.5)
Truancy	One day or more	1238 (16.3)

Note: In the analyses, we used only the latent variables.

the strongest correlation between liking school and academic achievement ($r = 0.28$) and the weakest one between being pressured and truancy ($r = 0.04$).

Figure 1 describes the resulting structural equation model with four latent variables, each composed of several constituting variables. Time spent on digital devices was associated with school problems directly, as well as indirectly via soft/energy drinks consumption and lower sleeping quality. The more time adolescents spent playing digital games or using the Internet, the higher the probability of their consumption of soft or energy drinks. Moreover, time spent on digital devices was associated with shorter duration of sleep and a higher prevalence of sleeping problems. Higher consumption of soft or energy drinks was also associated with lower quality of sleeping, and lower quality of sleeping was associated with more school problems, e.g. with a less positive attitude towards school, worse academic achievement and higher experienced pressure by schoolwork and truancy.

The standardized direct effect of time spent on digital devices on school problems (-0.26) and the standardized indirect effect of time spent on digital devices on school problems via sleeping quality (-0.30) were relatively low. However, the standardized indirect effect of time spent on digital devices on sleep quality via soft/energy drinks consumption (0.65) as well as the standardized indirect effect of soft/energy drinks consumption on school difficulties via sleeping quality (0.55) was relatively high.

Acceptable values for goodness-of-fit indices were obtained ($\chi^2 = 56.28$; $df = 30$; $\chi^2/df = 1.87$; $P = 0.0025$, RMSEA = 0.011). The relations between the latent variables indicate high cohesion. The resulting regression parameters were relatively high, but the model explained a relatively small amount of the variability of the latent variables—the residual variances of endogenous variables were relatively high (>0.7). All regression weights were satisfactory (≥ 0.15).

Discussion

Time spent on digital devices was associated with school problems directly and also indirectly via high consumption of soft and energy drinks and lower sleeping quality and quantity. The more time adolescents spent online, the higher their consumption of soft or energy drinks was. Higher consumption of soft or energy drinks was associated with lower quality of sleeping as well, and lower quality of sleeping was associated with more school problems, e.g. with a less positive attitude towards school, worse academic achievement, higher experienced pressure from schoolwork and truancy. The direct effect of time spent on digital devices on school problems

Table 2 Correlation matrix of variables (Pearson correlation coefficients)

	Time spent on electronic devices		Soft/Energy drinks consumption		Sleeping quality		School problems			
	Digital games	Internet use	Soft drinks	Energy drinks	Duration of sleep	Sleeping difficulties	Academic achievement	Liking school	Being pressured	Truancy
Time spent on electronic devices										
Digital games										
Internet use	0.43									
Soft/Energy drinks consumption										
Soft drinks	0.22	0.23								
Energy drinks	0.24	0.24	0.38							
Sleeping quality										
Duration of sleep	-0.15	-0.28	-0.16	-0.29						
Sleeping difficulties	0.06	0.10	0.06	0.12	-0.14					
School problems										
Academic achievement	0.12	0.12	0.16	0.23	-0.12	0.12				
Liking school	0.17	0.17	0.15	0.26	-0.19	0.11	0.28			
Being pressured	0.04	0.08	0.05	0.07	-0.07	0.15	0.14	0.19		
Truancy	0.05	0.12	0.10	0.21	-0.18	0.08	0.16	0.16	0.04	

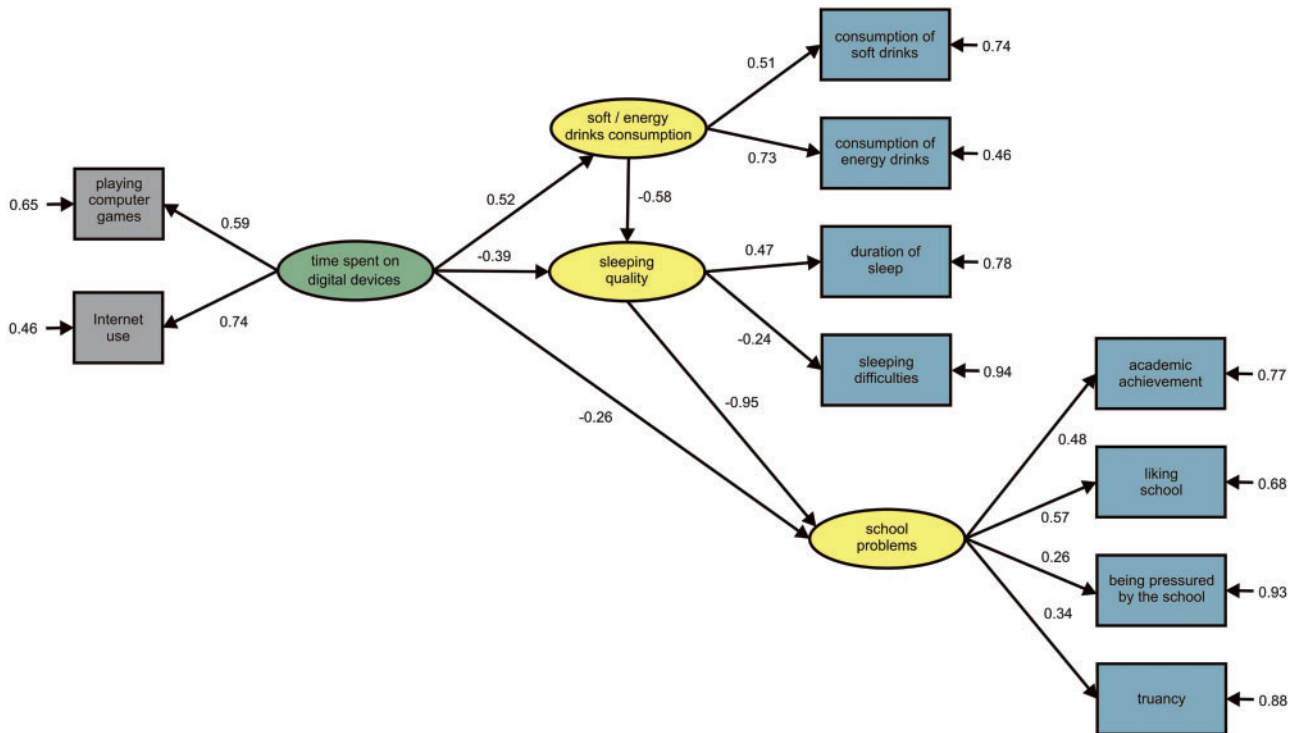


Figure 1 The association of time spent on digital devices with school problems mediated by soft/energy drinks consumption and sleeping quality: a structural equation model

was relatively small in comparison with the indirect effect via soft/energy drinks consumption and sleeping problems.

Our study indicates a relatively weak direct association between time spent on digital devices and school problems; such a direct association is assumed by the displacement hypothesis.²⁶ Evidence indicates that computer gaming and the mere presence of a computer in an adolescent's bedroom has a negative association with school performance.²⁷ Such findings are mostly explained by the displacement hypothesis stating that the time spent online is at the expense of time otherwise used for preparation for school or doing schoolwork. However, computers and the Internet may be used and often are used by children as an educational resource—for information, schoolwork, etc.²⁸ In line with this hypothesis, there are studies showing no or even a positive association of computer use with children's school results.^{29,30} From this perspective, the negative effect of media consumption on academic performance is mostly a matter of how such media are being used and not necessarily of how much they are being used. Some studies have shown that while excessive time with traditional media (television) is reflected in poor academic achievement, high time with new media (computer, Internet) does not.³⁰

Our model indicates that regarding adolescents' eating habits, the daily consumption of soft and energy drinks and impaired sleeping quality significantly contributed to the association between excessive time spent on digital devices and school problems. Calamaro³¹ showed that the use of computers late into the night and subsequently consuming of beverages containing caffeine or sugar are related to the adolescent's ability to stay alert and fully functional throughout the day are the main components of energy drinks and partially also of soft drinks, such as caffeine, taurine, guarana and other stimulating ingredients, have a stimulation effect³² and might disrupt the sleep.³³ Moreover, high caffeine consumption during the previous evening is positively associated with adolescents' daytime sleepiness the next day.³⁴ Problems with sleeping in terms of short sleep duration, daytime sleepiness or poor sleeping quality are frequent among adolescents;³⁵ however, sleep seems to be crucial for them especially in the school context.

One study suggests that sleep quality and quantity is closely related to children's learning capacity and learning memory processes, which are important factors in school performance.³⁶ Moreover, short sleep represents a large risk for school problems, in terms of poor academic functioning.³⁷ Deficits in sleep might lead to tiredness and daytime sleepiness during the class time which in turn might have negative effect on adolescents' attention. In addition, better adolescents' sleep patterns, including increased sleep efficiency, less daytime dysfunction and sleep latency within the normal range, are associated with better academic performance as these positively influence the mental functioning and learning skills of these adolescents.³⁸

The mediating role of sleeping quality and quantity has a crucial mediation role in the association between time spent on digital devices and school problems. Our findings are in line with recent experimental¹⁰ and diary-based¹¹ studies suggesting that media use is negatively affecting cognitive and school performance only to the extent that it affects sleep.

On the basis of this, we may tentatively expect that the more adolescents stay online later in the night, which thus limits their quantity of sleep, and the more they consume drinks that further worsen the quality of sleep, then this in turn causes school problems. However, the opposite causality is also possible. According to the mood modification hypothesis of media use, media entertainment is often used as a tool for regulating stressful and otherwise unpleasant feelings.³⁹ Adolescents may thus turn especially to media entertainment to regulate their school problems. And this may lead to a vicious circle: the higher time on the Internet may then cause lower sleep and further worsen school problems. Moreover, with the increasing use of smartphones among adolescents, future research should be focused not only on measuring actual screen time but also on frequency of checking.

Strengths and limitations

This study's most important strength is the representativeness and large size of the sample of adolescents. Another one is the high response rate. However, some limitations need to be considered

too. First, the number of adolescents with missing the responses in at least one item of each latent variable was relatively high (17.9%). However, differences in item-non-response by the various independent variables were generally rather small though sometimes statistically significant because of the large sample. The relatively small size of the differences limits the likelihood of systematic bias. Second, due to study's cross-sectional design, we are unable to further explore the direction of the relationships than we did with the application of SEM. Second, a relatively high proportion of the variance of the explored variables was not covered by the latent variables. This suggests that latent variables may also have been affected by other characteristics than those measured. This would then lead to additional random error in these variables and thus to some underestimation of the relations within the model. Nevertheless, the overall goodness-of-fit was acceptable, suggesting a good specification of the model even if such added error occurred. Finally, only self-reported data were used, which regard children's subjective perception of overall screen time. An alternative might be to measure actual screen time on the device and frequency of checking. However, previous research supports the validity of self-reported measurement of screen-based behavior in adolescents.⁴⁰

Conclusion

To conclude, the association of the time spent on digital devices with school problems was mostly mediated through increased soft/energy drink consumption and poor sleep quality. Therefore, the focus of intervention strategies should be on improved health education connected to prevention of negative consequences of excessive screen time. Moreover, future research should also address the opposite pathway, i.e. whether school problems might contribute to excessive time spent on digital devices.

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Conflicts of interest: None declared.

Key points

- Partial associations between time spent on digital devices and sleeping as well as soft/energy drinks consumption and school problems are known; however, the mechanism behind school problems via screen time is still not fully understood.
- Time spent on digital devices was associated with school problems directly and also indirectly via high consumption of soft and energy drinks and lower sleeping quality and quantity.
- The focus of health promotion strategies should be on maintaining healthy eating habits and sleeping habits.
- The resulting interventions may highly add to adolescents' health and to their future position on the labor market.

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Association between physical exercise and psychosocial problems in 96 617 Dutch adolescents in secondary education: a cross-sectional study

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Background: Psychosocial problems negatively affect school performance, social skills and mental development. In recent years, researchers have investigated the relationship between physical activity and psychological health. With this large school-based study, we examined whether physically inactive adolescents and slightly active adolescents experience more psychosocial problems compared with active adolescents. **Methods:** This study is based on the Dutch National Youth Health Monitor. This monitor uses a, school-based, cross-sectional questionnaire conducted among 96 617 adolescents in 2015. To examine the association between physical exercise and psychosocial problems, multi-level linear regression was carried out. **Results:** The weighted average Strengths and Difficulties Questionnaire score of active adolescents was lower than that of inactive adolescents. Adolescents who are inactive had 12% ($\beta=1.12$; 95% CI: 1.10–1.14; $P<0.001$) more psychosocial problems compared with active adolescents. Further, inactive adolescents had a higher score on the subscales emotional problems ($\beta=1.19$; 95% CI: 1.17–1.22; $P<0.001$) and problems with peers ($\beta=1.16$; 95% CI: 1.14–1.19; $P<0.001$). There was no statistical significant difference in total score of the Strengths and Difficulties Questionnaire between active and slightly active adolescents. **Conclusion:** Physically active adolescents have fewer psychosocial problems compared with physically inactive adolescents. Not only is this association significant, but there is an indication that it is also of clinical relevance.

Introduction

According to the population-based studies, 20% of the Dutch adolescents have some degree of psychosocial problems.^{1,2} Psychosocial problems can be a psychological problem as well as a social problem. These adolescents may have anxious feelings and thoughts and also may have problems in social interaction with others.³ Psychosocial problems among adolescents negatively affect school performance, social skills and mental development.

Moreover, they lead to high social costs and are a major cause of increased health care use in later life.^{4–7}

Researchers have investigated the relationship between physical activity and psychological health. Several cross-sectional studies have shown that regular exercise is associated with a lower risk of psychosocial problems in adults and children.^{8–16} In a large-scale population study, however, no positive association was found between physical exercise and psychological health after controlling for several confounders.¹⁷ Various longitudinal studies have shown