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The IDEFICS/I.Family Cohort

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Associations of Sleep Duration and Screen Time with Incidence of Overweight in European Children: The IDEFICS/I.Family Cohort

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Keywords

Sleep time · Screen duration · Overweight · Obesity · Children

Abstract

Introduction: Over the past decades, children have been increasingly using screen devices, while at the same time their sleep duration has decreased. Both behaviors have been associated with excess weight, and it is possible they act as mutually reinforcing behaviors for weight gain. The aim of the study was to explore independent, prospective associations of screen time and sleep duration with incident overweight in a sample of European children. **Methods:** Data from 4,285 children of the IDEFICS/I.Family cohort who were followed up from 2009/2010 to 2013/2014 were analyzed. Hours per day of screen time and of sleep duration were reported by parents at baseline. Logistic regression analyses were carried out in separate and mutually adjusted models

controlled for sex, age, European country region, parental level of education, and baseline BMI z-scores. **Results:** Among normal weight children at baseline ($N = 3,734$), separate models suggest that every hour increase in screen time and every hour decrease in sleep duration were associated with higher odds of the child becoming overweight or obese at follow-up (OR = 1.16, 95% CI: 1.02–1.32 and OR = 1.23, 95% CI: 1.05–1.43, respectively). In the mutually adjusted model, both associations were attenuated slightly (screen time OR = 1.13, 95% CI: 0.99–1.28; sleep duration OR = 1.20, 95% CI: 1.03–1.40), being consistently somewhat stronger for sleep duration. **Discussion/Conclusion:** Both screen time and sleep duration increased the incidence of overweight or obesity by 13–20%. Interventions that include an emphasis on adequate sleep and minimal screen time are needed to establish their causal role in the prevention of overweight and obesity among European children.

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Introduction

Although there is some evidence that children overweight prevalence has stabilized in certain countries such as the USA, Australia, and Sweden, it has done so at high levels ranging from 19 to 33% [1, 2]. Trends indicate that a high proportion of children who are overweight or obese maintain the excess weight into adolescence and adulthood [3, 4], which is accompanied by an increased risk of noncommunicable diseases, such as type 2 diabetes, hypertension, stroke, and certain types of cancer, such as endometrial, liver, and gastric cancer [5–7]. Moreover, consequences of overweight and obesity that were thought to be applicable only to adults are more frequently being found in children [8–11].

The mechanisms underlying the development of overweight and obesity in children are complex [12, 13]. While some factors related to excess weight in the young population are derived from the individual's biology such as genetic factors, other predictors can be traced back to an obesogenic environment and its influence on lifestyle determinants such as diet and physical activity [12, 14]. Thus, excess weight can be considered as a result from interactions between nonmodifiable and modifiable risk factors [15–17]. Gaining a deeper understanding of the modifiable risk factors associated with excess weight in children is of great importance to identify opportunities for prevention and public health interventions [18].

Previous studies have indicated that excessive screen time and short sleep duration might lead to overweight through several mechanisms [19–22]. For instance, by reducing opportunities for physical activity and increasing opportunities for food consumption [20, 23]. However, despite public health recommendations, children and adolescents are increasingly using screen devices, and their sleep duration has been steadily decreasing [24–28]. Furthermore, it has been previously suggested that prolonged screen time and short sleep duration may be mutually reinforcing behaviors that result in weight gain [21, 22, 29]. Our study aims to add evidence of the relationship between the time spent using screens and sleeping, and how these habits may interact to influence changes in weight status among European children.

Methods

The data used in this study are part of the IDEFICS cohort data collected in 2009/2010 and its extension, the I.Family data collected in 2013/2014. Comprehensive information about the cohort design has been published elsewhere [30, 31].

Screen time and sleep duration calculations were derived from parental reports of their children's time spent watching TV/video/DVD/PC/game consoles (answer options from 0 to >3 h per day) and time spent sleeping over 24 h, on both weekdays and weekends (open-ended answer). Additional categorical variables identified compliance with the screen time recommendations of ≤ 2 h per day as suggested by the American Academy of Pediatrics [25] and those for adequate sleep duration suggested by the National Sleep Foundation [24]. Ten hours of sleep per day was considered as the cutpoint according to the average sleep duration recommended for the age groups represented in our sample.

Weight was measured to the nearest 0.1 kg with a Tanita BC 420 SMA scale, and height was measured to the nearest 0.1 cm by using a SECA 225 Stadiometer [30]. Age-specific and sex-specific BMI and BMI z-scores were calculated. The latest was used for model adjustment, while a binary variable was created to categorize children as normal weight (including thin) or overweight (including obese) utilizing the cutpoints for children and adolescents developed by the International Obesity Task Force (IOTF) [32].

Data on covariates were obtained through the parental questionnaire. Since previous studies have demonstrated sleep duration, screen time, and overweight differ between European regions [33–35], we grouped participants according to their country location in South-Central Europe (Cyprus, Hungary, Italy, and Spain) and North-Western Europe (Belgium, Estonia, Germany, and Sweden).

Statistical Analysis

Figure 1 shows a flowchart of the population sample included in this study. Participants with missing data on variables of interest were excluded from analysis. The study population comprised 4,825 individuals aged between 2 and 11 years old in 2009/2010. χ^2 tests were carried out to determine differences in the participant's characteristics with respect to compliance with recommendations for screen time and sleep duration. Logistic regression was used to estimate the odds ratio (OR) corresponding to the risk of incident overweight associated with 1-h less sleep and 1 additional hour watching screens. Furthermore, categorical screen time and sleep duration variables defined by compliance with recommendations were analyzed. To determine the effect estimate change due to mutual adjustment, we calculated the difference within the resulting OR for screen and sleep variables in separate and mutually adjusted models. All models were controlled for categorical country region, sex, and parental level of education and continuous age and baseline BMI z-scores. Moderation was tested in the mutually adjusted model by adding an interaction term of sleep and screen times. Data analyses were performed using SPSS 24.0 (2016).

Results

A negative correlation was observed between screen and sleep times (Spearman's $\rho = -0.226$, $p < 0.001$). In the overall sample, baseline BMI z-score was the most significant predictor for becoming overweight or obese at follow-up (OR = 12.1 per SD of BMI z-score, 95% CI: 10.3–14.1). Therefore, further analysis was performed on

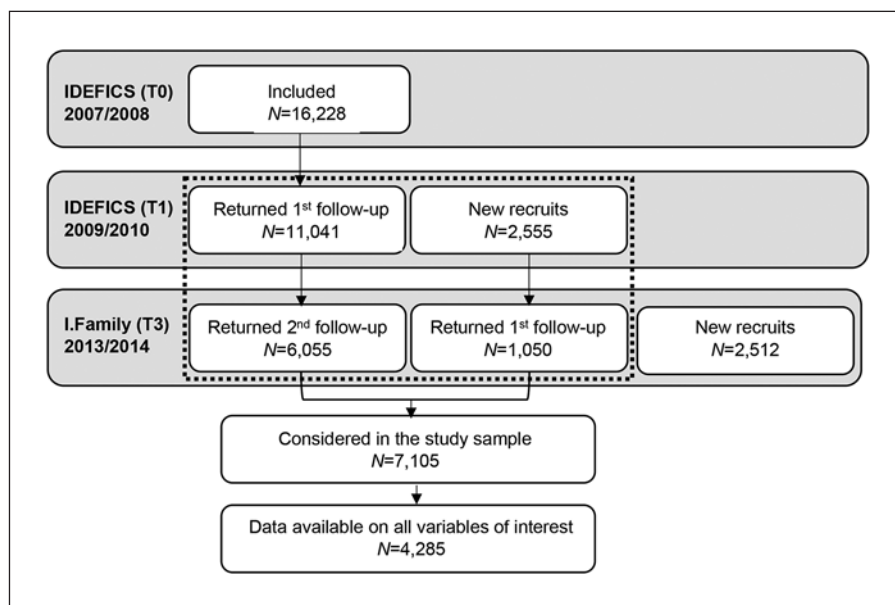


Fig. 1. Flowchart of study participants.

Table 1. Sociodemographic characteristics and compliance with screen time and sleep duration recommendations in the nonoverweight population at baseline ($N = 3,734$)

	N (%)	Not meeting screen time* recommendations, $N = 1,477$		χ^2	Not meeting sleep duration** recommendations, $N = 1,921$		χ^2
		N (%)	p value		N (%)	p value	
Age group							
2–5 years old	907 (24.3)	235 (25.9)		<0.001	358 (39.5)		<0.001
6–12 years old	2,827 (75.7)	1,242 (43.9)			1,563 (55.3)		
European country region							
North	1,990 (53.3)	809 (40.7)		0.1	878 (44.1)		<0.001
South	1,744 (46.7)	668 (38.3)			1,043 (59.8)		
Sex							
Female	1,853 (49.6)	638 (34.4)		<0.001	925 (49.9)		0.064
Male	1,881 (50.4)	839 (44.6)			996 (53)		
Parental level of education							
Low-medium	1,554 (41.6)	703 (45.2)		<0.001	841 (54.1)		<0.05
High	2,180 (58.4)	774 (35.5)			1,080 (49.5)		
Not meeting screen time recommendations*	1,477 (39.5)	~		~	920 (62.3)		<0.001
Not meeting sleep duration recommendations**	1,921 (51.4)	920 (47.9)		<0.001	~		~

North countries: Sweden, Belgium, Estonia, and Germany; south countries: Italy, Spain, Hungary, and Cyprus. * Not meeting recommendations was considered as screen time >2 h per day. ** Not meeting recommendations was considered as sleep duration <10 h per day.

samples stratified by weight status at baseline. Among those overweight or obese at baseline ($N = 1,091$), 228 participants (21%) became normal or underweight. Of those normal or underweight at baseline ($N = 3,734$), 387 participants (8%) gained weight and became overweight or obese. Analysis of the overweight and obese partici-

pants at baseline showed no significant associations of screen time and sleep duration with the odds of remaining overweight or obese in either the separate or mutually adjusted models (results not shown). Subsequent analysis focuses on the group that was not overweight or obese at baseline.

Table 2. Non-OWOB participant prospective associations of screen time and sleep duration with the odds of becoming OWOB at follow-up ($N = 3,734$)

Model	Variable	Units or categories	Overweight OR (95% CI)
1.a	Total screen time	(+1 h)	1.156** (1.015–1.316)
1.b	Total sleep duration	(–1 h)	1.226* (1.053–1.428)
2	Total screen time	(+1 h)	1.125 (0.986–1.284)
	Total sleep duration	(–1 h)	1.198** (1.026–1.398)
3.a	Total screen time	Meeting recommendations (reference)/not meeting recommendations [^]	1.245 (0.970–1.598)
3.b	Total sleep duration		1.286* (1.006–1.645)
4	Total screen time		1.216 (0.946–1.564)
	Total sleep duration		1.262 (0.986–1.617)

Test of interaction between screen and sleep time was nonsignificant. Models 1 and 3: separate; models 2 and 4: mutually adjusted. All models controlled for country region, sex, parental level of education, BMI z-scores, and age. OWOB, overweight/obese; OR, odds ratio; CI, confidence intervals. * $p < 0.01$. ** $p < 0.05$. [^] Not meeting screen time recommendations: >2 h per day; not meeting sleep duration recommendations <10 h per day.

The distribution of normal and underweight participants according to their baseline characteristics and compliance with screen and sleep time recommendations is summarized in Table 1. The percentage of children not meeting either of the recommendations was 24.6%. Screen time recommendations were not met by 39.5% of this sample, with significantly higher noncompliance among children in the older age group, boys, and low-medium parental education group. Around half of the participants did not meet sleep duration recommendations, with a mean sleeping time of 9.88 h. The proportion of noncompliance with sleep duration recommendations was significantly higher among older children, those living in Southern-Central European countries, and children from parents with low-medium level of education.

Results from the analysis of associations between screen time and sleep duration with incidence of overweight and obesity are shown in Table 2. The separate models utilizing continuous predictor variables indicate that a 1-h increase of screen time and a 1-h decrease of sleep duration were associated with higher odds of the child becoming overweight or obese at follow-up (OR = 1.156, 95% CI: 1.015–1.316 and OR = 1.226, 95% CI: 1.053–1.428, respectively). In the mutually adjusted model, both the screen time and the sleep duration association were attenuated. The degrees of attenuation were similar in magnitude (effect estimate change = 0.031 for sleep duration and 0.028 for screen time), although only sleep duration remained statistically significant after adjustment.

The analysis of the association between incident overweight and compliance with recommendations was only significant for those not meeting sleep recommendations in the separate model. However, we observed the same directions of association as with the continuous variables.

We carried out 2 sensitivity analyses using alternative variables: continuous BMI z-score instead of incident overweight or obese and the number of screen devices in the bedroom instead of hours/day of screen time. Models were adjusted for the same confounders described previously. Setting BMI z-scores as the outcome, the separate model indicated 1-h increase in screen time was related to relative adiposity gain ($b = 0.019$, 95% CI: 0.001–0.036), while 1-h increase in sleep duration was related to relative adiposity loss ($b = -0.037$, 95% CI: -0.062 to -0.012). In the mutually adjusted models, screen time became nonsignificant, but sleep duration remained statistically significant (results not shown). Meanwhile, the sum of screen devices in the bedroom was only significant in unadjusted models, and sleep duration was slightly attenuated through mutual adjustment, but remained statistically significant (results not shown).

Discussion

We observed a high prevalence of noncompliance with screen time and sleep duration recommendations in European children, together with statistically significant prediction of incident overweight by the amount of screen

time and sleep duration at baseline. The results also confirm that the strongest predictor of weight status in children is previous BMI *z*-scores, indicating a persistence of the condition and suggesting that efforts should focus on the earliest possible prevention of overweight. However, these efforts should be reinforced with interventions that focus on contributing factors to overweight incidence [18].

Our findings were consistent with those of previous research that suggests there is an association between shorter sleep duration and overweight [36] and longer screen time and overweight [19]. The association with screen time became nonsignificant when including sleep duration in the analysis, which may imply some residual confounding as screen time and sleep duration are correlated or a mediation effect of sleep duration in the associations between screen time and overweight. Further mediation analyses with longer observed exposure times are suggested to better understand this dynamic association.

A particular strength of our longitudinal design is that it allows for establishment of temporality in the observed associations. However, since the population included in the IDEFICS/I.Family studies is not nationally representative, generalization of the reported prevalence values requires some caution, particularly since previous evidence from the IDEFICS Swedish sample found underrepresentation of families with low education, low socioeconomic income, and foreign backgrounds [37]. Thus, the associations found in this study could particularly differ in participants with less advantageous socioeconomic status or from diverse ethnic backgrounds.

We acknowledge as a limitation that sleep duration and screen time were obtained by parental report, which could have led to nondifferential misclassification [38, 39]. However, although parental observations can vary according to the punctuality of parents and the lifestyle of the family, they are considered as a suitable method for screening large populations [40, 41].

Other dimensions of sleep quality and screen use other than duration and time of exposure may have a significant role on incident overweight and obesity and are not been considered in the present study. Objective tools for sleep assessment, such as actigraphy, could provide nuanced and complementary descriptions of sleep patterns that may influence weight trajectories and should be considered in future studies. Moreover, we recommend further studies to include information on additional screen devices that are currently widely used by children, such as tablets and smartphones. Evidence suggests that

children may interact with some of these devices in different ways from traditional screen technology such as TV, PC, and videogames, due, for instance, to combinations of multiple new functionalities, as well as an increased freedom to choose the content they want to watch or who to interact with [28, 42]. Moreover, it would also be necessary to explore if the simultaneous use of multiple screen devices may lead to unique weight outcomes.

Conclusion

Our study adds to the evidence calling for a holistic and integrated approach to prevent overweight from early age and with a life course perspective. According to our findings, strategies for overweight prevention in children may benefit from interventions that include emphasizing adequate screen time and sleep duration.

Acknowledgments

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Statement of Ethics

The research was conducted in accordance with the World Medical Association Declaration of Helsinki. Ethical approval was obtained from the responsible committees in each of the 8 participating countries given as follows: (1) Belgium: Ethics Committee of the Gent University Hospital, 15 October 2007, Ref. No. EC UZG 2007/243 and 19 February 2013, No. B670201316342; (2) Cyprus: Cyprus National Bioethics Committee, 12 July 2007, Ref. No. EEBK/EM/2007/16 and 21 February 2013, No. EEBK/ETI/2012/33; (3) Estonia: Tallinn Medical Research Ethics Committee (TM-REC), 14 June 2007, Ref. No. 1093 and 17 January 2013, No. 128; (4) Germany: Ethics Commission of the University of Bremen, 16 January 2007 and 11 December 2012; (5) Hungary: Medical Research Council, 21 June 2007, Ref. 22-156/2007-1018EKU and 18 December 2012, 4536/2013/EKU; (6) Italy: Ethics Committee of the Local Health Authority (ASL) in Avellino, 19 June 2007, Ref. No. 2/CE and 18 September 2012, No. 12/12; (7) Spain: Ethics Committee for Clinical Research of Aragon (CEICA), 20 June 2007, Ref. No. PI07/13 and 13 February 2013, No. PI13/0012; and (8) Sweden: Regional Ethics Research Board in Gothenburg, 30 July 2007, Ref. No. 264-07 and 10 January 2013, No. 927-12. Written informed consent to participate was obtained from children and their caregivers [31]. Children <12 years gave their verbal assent. All study nurses and examination staff received central or local training; all the examinations and quality control adhered to the standard operation procedures. The Pan-European IDEFICS/I.Family children cohort has been registered at the ISRCTN clinical trials registry (ISRCTN62310987).

Conflict of Interest Statement

The authors declare no conflicts of interest.

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Author Contributions

V.G., L.L., L.A., and M.H. contributed to conceptualization; L.L., L.A., and M.H. contributed to methodology; V.G. contributed to formal analysis; V.G. contributed to investigation; L.L.,

A.H., A.S., F.L., J.K., L.A.R., L.M., R.F., S.H., T.V., and W.A. contributed to data acquisition; V.G., L.A., and M.H. contributed to data curation; V.G. contributed to writing – original draft preparation; L.L., L.A., A.H., A.S., F.L., J.K., L.A.R., L.M., R.F., S.H., T.V., W.A., and M.H. contributed to writing – review and editing. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data that support the findings of this study are not publicly available because they contain information that could compromise the quality of the study, but the data sharing committee is willing to receive requests. Interested researchers can contact the IDEFICS and I.Family consortia (<http://www.ideficsstudy.eu/Idefics/andhttp://www.ifamilystudy.eu/>) to discuss the possibilities for data access. Clinical Trial Registry: Pan-European IDEFICS/I.Family children cohort; ISRCTN62310987; <https://doi.org/10.1186/ISRCTN62310987>.

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