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SCIENTIFIC INVESTIGATIONS

Insufficient Sleep Duration Is Associated With Dietary Habits, Screen Time, and Obesity in Children

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Study Objectives: To examine sleep duration and the association between insufficient sleep duration and life- style factors in a representative sample of Greek children and adolescents.

Methods: Population data derived from a school-based health survey carried out in spring 2015 on 177,091 children (51% male) aged 8 to 17 years (participation rate was approximately 40% of the total population). Dietary habits, sleeping hours (weekdays and weekend), physical activity status, and sedentary activities were assessed through electronic questionnaires completed at school with assistance of teachers. Anthropometric and physical fitness measurements were obtained by physical education teachers.

Results: A greater proportion of males than females (42.3% versus 37.3%, $P < .001$) and of children compared with adolescents (42.1% versus 32.8%, $P < .001$) reported insufficient sleep duration. Insufficient sleep duration was associated with unhealthy dietary habits such as skipping breakfast (odds ratio [OR] 1.30, 95% confidence interval [CI] 1.25–1.35), fast-food consumption (OR 1.35, 95% CI 1.29–1.41), and consuming sweets regularly (OR 1.32, 95% CI 1.25–1.39). Insufficient sleep duration was found to be associated with insufficient dietary habits (OR 0.59, 95% CI 0.54–0.64), increased screen time (OR 1.26, 95% CI 1.21–1.31), and being overweight/obese (OR 1.21, 95% CI 1.17–1.25), after adjusting for several covariates.

Conclusions: Insufficient sleep duration was associated with an unhealthy lifestyle profile among children and adolescents in this study. Results support the development of interventions to help students improve sleep duration.

Keywords: adolescents, children, dietary habits, overweight, sleeping duration

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BRIEF SUMMARY

Current Knowledge/Study Rationale: This study investigated the influence of a wide range of lifestyle characteristics on sleep duration in a large representative cohort of children and adolescents. Also, it is the first one conducted among Greek children and adolescents.

Study Impact: Insufficient sleep duration among children potentially constitutes an understated health issue in westernized societies. Taking into consideration these epidemiologic findings, the authorities should promote strategies emphasizing improved sleep duration.

INTRODUCTION

The American Academy of Sleep Medicine recommends that the duration of sleep must be at least 9 hours for children and 8 hours for adolescents; those who sleep fewer than the recommended hours were classified as having insufficient sleep duration.[1] Insufficient sleep duration is common among schoolchildren because it is considered that almost 69% and 58% of United States children and adolescents, respectively, sleep the optimal time (at least 8 or 9 h/d) on school nights.[2] A review of studies that included data from 20 countries showed that in the past century sleep duration was reduced by more than 1 hour among children and adolescents.[3] Sufficient sleep duration is a significant factor that contributes to the regulation of hormonal and metabolic procedures in children.[4] Insufficient sleep is connected with adverse outcomes in several aspects of adolescents' health, including physical and mental health and academic success.[5,6] Also, insufficient sleep duration is linked with several cardiometabolic risk factors in children and adolescents such as dyslipidemia, glucose homeostasis, and increased blood pressure.[7–9] Over the past half century the prevalence of childhood obesity reached alarming levels and it is considered that it was increased in parallel with a chronic partial sleep deprivation.[10] Three recent review studies and meta-analyses concluded that short sleep duration is associated with increased risk of obesity, in children and adolescents.[11–13] Moreover, a study among 10- to 12-year-old Greek participants has shown that children's body composition was partly mediated by consumption of sugary drinks, physical activity and sleep duration.[14] Screen time was considered to be related to shorter sleep duration.[15] It seems that declines in the sleep duration of children and adolescents over the past century may be partially attributed to increases in total screen time.[3] Eating behavior is a crucial behavioral pathway that may increase obesity risk and potentially be influenced by sleep duration.[4] It has been proposed that insufficient sleep duration was associated

with unhealthy eating behaviors.[16] According to the literature, endocrinological mechanisms including hormones such as cortisol, insulin, ghrelin, and leptin have been proposed to explain the connection between insufficient sleep duration and food consumption, appetite, satiety, and energy balance.[17] In conclusion, there are insufficient data on the effect of lifestyle characteristics of children's sleep duration.

Therefore, the objectives of the current study were (1) to examine the prevalence of insufficient sleep duration and (2) to investigate the association between insufficient sleep levels and several lifestyle factors, in schoolchildren aged 8 to 17 years. We hypothesized that insufficient sleep duration would have a negative effect on life- style factors.

METHODS

Participants

Based on population, representative data were derived from a nationwide school health survey under the auspices of the Ministry of Education. Specifically, data on anthropometrics, nutrition, physical activity (PA), sleep, sedentary habits, and physical fitness (PF) along with information on age and sex were collected from March 2015 to May 2015. In total, 177,091 children (51% male and 49% female) aged 8 to 17 years old from elementary (8 to 12 years) and middle (13 to 17 years) public and private schools agreed to participate in the study (participation rate was almost 40% of the total population). Parents were informed in writing for the purposes of this school health survey.

Assessment of Demographic and Anthropometric Measurements

Demographic information of students (eg, school, class, sex, and date of birth) was obtained from each school headmaster. Children's height, weight, and waist circumference were measured in the morning, using a standardized procedure. Body mass index (BMI) status was classified using the International Obesity Task Force age- and sex-specific BMI cutoff criteria, as the most proper for epidemiologic studies.[18] All anthropometric measurements were performed by trained teachers of physical education (PE). Verbally informed consent for the child to participate in the measurements was obtained from PE teachers. As the measurements were included in an obligatory school curriculum, verbal informed consent was considered sufficient.

Assessment of Physical Fitness Levels

The Euro-fit PF test battery was used to evaluate children's PF levels.[19] The battery consists of 5 tests, ie, (1) a multistage 20-meter shuttle run test (20-meter SRT), to estimate aerobic performance; (2) a maximum 10- × 5- meter shuttle run test (10- × 5- meter SRT) to evaluate speed and agility; (3) a sit-ups test in 30 seconds (SUs), to measure the endurance of the abdominal and hip flexor muscles; (4) a standing long jump (SLJ), to evaluate lower body explosive power; and (5) a sit and reach (SR) test to measure flexibility. All five fitness tests were administered during the PE class by PE professionals, who were instructed via a detailed manual of operations and followed a standardized procedure of measurements in order to minimize the interrate variability among schools.

Assessment of Dietary Habits

Participating children's dietary, PA, and sedentary habits were recorded via the use of an electronic questionnaire that was completed at school with the presence and assistance of their teachers and/or information technology professors. Regarding students' dietary habits, these were assessed through the KIDMED (Mediterranean Diet Quality Index for children and adolescents).[20] The index comprised 16 yes or no questions, including dietary habits that were in accordance with the principles of the Mediterranean diet (MD) dietary pattern and the general dietary guidelines for youth, and other habits that undermined them. Questions denoting a negative connotation with respect to a high-quality diet were assigned a value of −1, whereas those with a positive aspect were assigned a value of +1. Thus, the total KIDMED score ranged from 0–12 and was classified into 3 levels: ≥ 8, suggesting an optimal adherence to the MD (sufficient dietary habits); 4–7, suggesting an average adherence to the MD and an improvement needed to adjust dietary intake to guidelines (relatively sufficient dietary habits); and ≤ 3, suggesting a low adherence to the MD and generally a low diet quality (insufficient dietary habits).

Assessment of Self-Reported Physical Activity and Sedentary Time

With regard to PA habits, patterns of PA were also self-reported. The questionnaire applied had been previously used in children in other large-scale epidemiological studies,[21] and included simple closed-type questions regarding children's frequency, time, and intensity of participation in (1) school-related PA (including activity during physical education classes; (2) organized sports activities; and (3) PA during leisure time. The frequency of all reported activities was multiplied by the minutes of moderate to vigorous physical activities (MVPA) and then divided by seven to obtain the average daily time children engaged in MVPA. MVPA refers to activities that produced increase in breathing or heart rate, such as brisk walking, bicycling, jogging, aerobic activity, etc. Children who participated in MVPA for at least 60 min/d were considered as meeting the recommendations for PA. Daily time spent in sedentary activities (eg, television viewing, use of Internet for nonstudy reasons, playing with computer and/or console games) was also calculated for each student (by multiplying the weekly frequency of participation with the duration per bout of participation in sedentary activities, and then dividing by seven). Using the threshold of 2 h/day proposed by current scientific evidence and guidelines,[22] students were classified as sedentary or not, that is, exceeding (> 2 h/d) or not exceeding (≤ 2 h/d) the recommended daily time spent in sedentary activities.

Main Outcome Variable

Daily reported total sleep time was assessed through self-reported recordings as follows: "During week days how many hours (and minutes) do you usually sleep?"; and "During weekend days how many hours (and minutes) do you usually sleep?"

Table 1—Baseline characteristics of participants in the EYZHN program age 8 to 17 years.

	Total (n = 177,091)	Male (n = 87,803)	Female (n = 89,288)	*P**
Age (years)	9.88 (2.8)	9.91 (2.8)	9.84 (2.8)	< .001
Children 8 to 12 years, n (%)	12,8134	65,161 (50.9)	62,973 (49.1)	< .001
Adolescents 13 to 17 years, n (%)	48,975	25,660 (52.5)	23,315 (47.5)	< .001
BMI (kg/m^2)	19.7 (3.8)	19.8 (3.8)	19.5 (3.7)	< .001
Waist circumference, (cm)	70.4 (10.7)	71.6 (11.1)	69.2 (10.2)	< .001
Sleeping time weekdays, (h/d)	8.6 (1.6)	8.6 (1.6)	8.7 (1.6)	< .001
Sleeping time weekend, (h/d)	9.7 (1.8)	9.6 (1.9)	9.8 (1.8)	< .001
KIDMED score (0–12)	6.7 (2.4)	6.7 (2.4)	6.8 (2.4)	< .001
Physical activity (h/wk)	9.4 (5.5)	10.4 (5.9)	8.4 (5.2)	< .001
Screen time (h/wk)	8.6 (8.5)	9.3 (8.8)	7.8 (7.7)	< .001
20-meter shuttle run (laps)	31.1 (18.6)	36.2 (20.6)	25.4 (13.9)	< .001
Standing long jump (cm)	117 (55.7)	124 (59.3)	110 (50.5)	< .001
Sit and reach (cm)	15.4 (8.3)	13.2 (7.6)	17.7 (8.3)	< .001
Sit-ups in 30 seconds (n)	19.7 (5.7)	20.6 (5.8)	18.7 (5.3)	< .001
10- × 5-meter shuttle run (seconds)	21.5 (3.4)	21.0 (3.4)	22.1 (3.3)	< .001

Values are presented as mean (standard deviation). * = *P* values for differences between boys and girls. BMI = body mass index, KIDMED = Mediterranean Diet Quality Index for children and adolescents.

A total weekly sleep score was calculated as: ([minutes weekdays × 5] + [minutes weekend days × 2] / 7). Based on the Consensus Statement of the American Academy of Sleep Medicine, children (aged 6 to 12 years) who were sleeping at least 9 h/d and adolescents (aged 13 to 17 years) who were sleeping at least 8 h/d, were classified as meeting the recommendations of sufficient sleep duration. Children and adolescents sleeping fewer than the number of recommended hours per day were classified as having insufficient sleep.[1]

Ethical Approval

Ethical approval for the health survey was graded by the Ethical Review Board of the Ministry of Education and the Ethical Committee of Harokopio University.

Data Analysis

Descriptive statistics are presented as mean ± standard deviation or frequencies (percentages). The chi-square test evaluated associations between the categorical variables and the *t* test was applied to evaluate differences in mean values of normally distributed variables. To assess the potential effect of several dietary habits on the sufficient versus insufficient sleep duration, binary logistic regression analysis was implemented and odds ratios (OR) with the corresponding 95% confidence intervals (CI) were calculated, adjusted for confounders. Furthermore, aiming to assess the potential effect of several demographic and lifestyle factors on the sleep duration levels, hierarchical binary logistic regression analysis was implemented and OR with the corresponding 95% CI were calculated to obtain adjusted association of covariates while controlling for confounding. The Hosmer and Lemeshow goodness-of-fit test was calculated in order to evaluate the model's goodness-of-fit and residual analysis was implicated using the dbeta, the leverage, and Cook distance D statistics in order to identify outliers and influential observations. Finally, discriminant analysis was used to explore the strength of each component in relation to the outcome. All statistical analyses were performed using the SPSS version 23.0 software for Windows (SPSS Inc., Chicago, Illinois, United States). Statistical significance level from two-sided hypotheses was set at $P < .05$.

RESULTS

In the current study, data were analyzed for 177,091 children and adolescents aged 8 to 17 years. Basic descriptive statistics of the total sample by sex of participants in the EYZHN program are presented in **Table 1**. Percentages of 42.5% among males and 37.3% among females were classified as having insufficient sleep duration ($P < .001$). Also, more children (42.1%) than adolescents (31.8%) reported insufficient sleeping hours ($P < .001$). Females reported increased sleep time on weekdays and weekends as compared to males (*P* values < .001). Females who were considered overweight (9.0 ± 1.5 h/d) and having obesity (8.9 ± 1.6 h/d) reported reduced sleeping hours as compared to females who were of normal weight (9.2 ± 1.4 h/d) (all $P < .05$). Similarly, males classified as having normal weight indicated to sleep more hours (8.9 ± 1.5 h/d) than males who were considered overweight (8.7 ± 1.5 h/d) and having obesity (8.6 ± 1.6 h/d) (all $P < .05$). **Table 2** presents a description of the study participants having sufficient or insufficient sleep duration, in children and adolescents, by sex. Participants from both age range and sex who were classified as having insufficient sleep duration recorded increased BMI, poorer dietary habits, increased screen time, and lower aerobic fitness and physical activity (only in adolescents) in comparison with those with sufficient sleeping hours from the same age range and sex (all $P < .05$).

In unadjusted multivariate binary logistic regression, consuming fast food frequently, skipping breakfast, and eating sweets/candy several times per day increased odds of having

Table 2—Anthropometric and behavioral characteristics according to daily sleep levels, in Greek boys and girls (age 8 to 17 years) of the EYZHN study.

	Insufficient Sleep		Sufficient Sleep	
Children	**Male**	**Female**	**Male**	**Female**
Age (years)	10.3 (1.2)	10.3 (1.2)	10.2 (1.3)*	10.1 (1.3)*
BMI (kg/m^2)	19.3 (3.6)	19.2 (3.6)	18.9 (3.5)*	18.8 (3.5) *
Waist circumference (cm)	70.0 (10.4)	68.4 (10.2)	68.8 (9.9)*	67.6 (9.9)*
KIDMED score	6.6 (2.4)	6.7 (2.3)	7.0 (2.4)*	7.2 (2.2)*
Physical activity (h/wk)	10.6 (5.9)	8.9 (5.3)	10.5 (5.9)	8.8 (5.1)
Screen time (h/wk)	9.3 (8.8)	7.5 (7.9)	8.0 (7.8)*	6.4 (6.7)*
Sleeping time (h/day)	7.4 (1.4)	7.6 (1.4)	9.9 (0.9)*	9.9 (0.8)*
20-meter SRT (laps)	32.6 (18.3)	24.7 (13.5)	33.3 (18.2)*	24.7 (13.6)
Standing long jump (cm)	119 (51.0)	119 (47.0)	119 (51.9)	119 (45.8)
Sit and reach (cm)	12.9 (7.1)	17.0 (7.8)	12.7 (7.2)*	17.0 (7.9)
Sit-ups in 30 seconds (n)	19.6 (5.7)	18.3 (5.3)	19.6 (5.5)	18.3 (5.5)
10- × 5-meter shuttle run (seconds)	21.4 (3.2)	22.3 (3.2)	21.3 (3.6)	22.2 (3.2)
Adolescents				
Age (years)	14.8 (1.3)	14.9 (1.3)	14.5 (1.2)*	14.2 (1.3)*
BMI (kg/m^2)	22.1 (4.0)	20.5 (3.3)	21.3 (3.8)*	20.1 (3.3)*
Waist circumference (cm)	79.3 (11.2)	72.2 (9.2)	77.3 (10.6)*	71.5 (8.8)
KIDMED score	5.6 (2.5)	6.5 (2.0)	6.5 (2.4)*	7.2 (2.0)*
Physical activity (h/wk)	9.5 (5.9)	7.8 (5.1)	10.3 (5.9)*	8.4 (4.8)*
Screen time (h/wk)	12.9 (9.1)	11.9 (9.1)	10.9 (9.2)*	9.7 (7.9)*
Sleeping time (h/day)	7.0 (1.1)	7.3 (1.1)	9.2 (1.0) *	9.1 (0.8)*
20 meter SRT (laps)	47.7 (24.4)	29.2 (16.4)	50.4 (24.0)*	31.2 (15.6)*
Standing long jump (cm)	140 (74.7)	117 (60.1)	140 (75.0)	117 (60.0)
Sit and reach (cm)	14.3 (8.6)	19.7 (9.0)	14.2 (8.5)	20.1 (8.9)
Sit-ups in 30 seconds (n)	23.4 (5.6)	19.8 (5.4)	23.3 (5.7)	20.6 (5.0)*
10- × 5-meter shuttle run (seconds)	19.7 (3.2)	21.1 (3.3)	20.1 (3.5)	21.1 (3.1)

Values are presented as mean (standard deviation). * = *P* values < .01 for differences between insufficient sleep (children < 9 h/d, adolescents < 8 h/d) and sufficient sleep, from the same sex. BMI = body mass index, KIDMED = Mediterranean Diet Quality Index for children and adolescents, SRT = shuttle run test.

insufficient sleep duration in both sexes, while eating fruits and vegetables every day, eating pulses and fish regularly, using olive oil and intaking dairy products daily was associated with lower odds of being a frequent consumer of fast food (**Table 3,** Model 1). After adjusting for several covariates (eg, age, BMI, waist circumference, and physical activity), the food habits previously presented remained significantly associated with insufficient sleep duration in both sexes (**Table 3**, Model 2). Further adjustment for screen time holds the same results (**Table 3**, Model 3).

Taking into consideration that participants with insufficient sleep duration had a worse lifestyle profile as compared to those with sufficient sleep, stepwise logistic regression analyses (Model 4) in both sexes was applied to examine the potential associations of several covariates on sleep duration (sufficient versus insufficient). The initial analysis (Model 1) revealed that increase in age (per 1 year) decreased odds of sleeping insufficient hours by almost 3% but only in boys, whereas g overweight/obesity increased odds of having insufficient sleep duration by 25% and 16%, in males and females, respectively (**Table 4**). When KIDMED index and PA levels were added in the analysis (**Table 4**, Model 2), results related to the effect of age and obesity status did not change, whereas sufficient dietary habits decreased children's odds of having insufficient sleep duration. After further adjustment for screen time (Model 3), the results revealed an unfavorable influence of increased sedentary activities on sleeping status. Finally, when PF measurements were included in the analysis (Model 4), the influence of previous factors did not change significantly, whereas improved performances in aerobic fitness were related to lower probabilities of insufficient sleep.

Discriminant analysis by sex was applied to assess whether the predictors could better distinguish those with insufficient from those with sufficient sleep duration. Standardized function coefficients suggest that dietary habits (0.7), screen time (0.7), and BMI status (0.5) contributes more to distinguishing the aforementioned groups, in both sexes. The classification results revealed that the model correctly predicts 73% and 68% of participants having sufficient and insufficient sleeping duration, respectively.

DISCUSSION

This is the first study among Greek children and adolescents examining the association between sleep duration and lifestyle

Table 3—Results from logistic regression models that used to evaluate the association of children's (age 8 to 17 years) dietary habits with sleep levels (sufficient versus insufficient).

Predictors	Model 1	Model 2	Model 3
Male			
Skips breakfast (no versus yes)	1.271 (1.208–1.337)	1.249 (1.187–1.314)	1.226 (1.165–1.291)
Consumes fast food more than once weekly (no versus yes)	1.274 (1.212–1.339)	1.317 (1.252–1.386)	1.278 (1.214–1.346)
Takes sweets and candy several times every day (no versus yes)	1.247 (1.183–1.315)	1.287 (1.220–1.359)	1.236 (1.170–1.306)
Has a second fruit every day (no versus yes)	0.909 (0.871–0.948)	0.814 (0.767–0.864)	0.834 (0.785–0.885)
Has fresh or cooked vegetables more than once a day (no versus yes)	0.912 (0.868–0.959)	0.898 (0.854–0.945)	0.905 (0.860–0.952)
Consumes fish regularly (at least 2 to 3×/wk) (no versus yes)	0.895 (0.858–0.934)	0.892 (0.855–0.931)	0.908 (0.870–0.949)
Eats pulses > 1×/wk (no versus yes)	0.803 (0.767–0.841)	0.807 (0.770–0.845)	0.820 (0.783–0.860)
Eats pasta or rice almost every day (no versus yes)	0.978 (0.936–1.020)	0.992 (0.950–1.036)	0.989 (0.947–1.034)
Consumes nuts regularly (at least 2 to 3×/wk) (no versus yes)	0.963 (0.923–1.005)	0.965 (0.924–1.007)	0.967 (0.926–1.010)
Uses olive oil at home (no versus yes)	0.817 (0.731–0.912)	0.828 (0.740–0.926)	0.824 (0.736–0.923)
Consumes two yogurts and/or some cheese (40 g/d) (no versus yes)	0.854 (0.809–0.901)	0.861 (0.815–0.909)	0.869 (0.823–0.918)
Female			
Skips breakfast (no versus yes)	1.336 (1.259–1.419)	1.338 (1.259–1.422)	1.326 (1.247–1.410)
Consumes fast food more than once weekly (no versus yes)	1.384 (1.292–1.482)	1.383 (1.290–1.482)	1.339 (1.248–1.437)
Consumes sweets and candy several times every day (no versus yes)	1.358 (1.270–1.451)	1.359 (1.270–1.454)	1.298 (1.210–1.389)
Has a second fruit every day (no versus yes)	0.893 (0.850–0.938)	0.771 (0.717–0.829)	0.797 (0.740–0.857)
Has fresh or cooked vegetables more than once a day (no versus yes)	0.878 (0.830–0.928)	0.873 (0.825–0.923)	0.879 (0.831–0.930)
Consumes fish regularly (at least 2 to 3×/wk) (no versus yes)	0.892 (0.850–0.937)	0.893 (0.850–0.938)	0.914 (0.869–0.960)
Eats pulses > 1×/wk (no versus yes)	0.779 (0.739–0.821)	0.772 (0.732–0.814)	0.781 (0.740–0.824)
Eats pasta or rice almost every day (no versus yes)	1.020 (0.978–1.061)	1.012 (0.984–1.041)	1.007 (0.977–1.037)
Consumes nuts regularly (at least 2 to 3×/wk) (no versus yes)	0.913 (0.870–0.959)	0.915 (0.870–0.961)	0.925 (0.880–0.963)
Uses olive oil at home (no versus yes)	0.857 (0.741–0.991)	0.868 (0.790–0.947)	0.865 (0.787–0.951)
Consumes two yogurts and/or some cheese (40 g/d) (no versus yes)	0.790 (0.742–0.842)	0.790 (0.741–0.842)	0.794 (0.744–0.847)

Values are presented as odds ratio (95% confidence interval). Insufficient sleep (children < 9 h/d, adolescents < 8 h/d), sufficient sleep (children ≥ 9 h/d, adolescents ≥ 8 h/d). Model 1 is unadjusted. Model 2 is adjusted for age, body mass index, waist circumference and physical activity levels. Model 3 is adjusted the same as Model 2 with the addition of screen time.

characteristics. The data were derived from 177,091 schoolchildren (aged 8 to 17 years) of primary and secondary education in Greece. The main aims of the program were to investigate obesity, PF, PA, and lifestyle factors (eg, eating habits, sleeping levels and screen time). Reliable, standardized, and comparable findings came as an outcome of the way the study was designed. Also, the monitoring in the school setting had a favorable role in the development and evaluation of the efficiency of public health intervention programs. The main findings of this study highlighted that: (1) approximately 40% of schoolchildren had insufficient sleep duration, (2) participants from both sexes with insufficient sleeping hours had a worse lifestyle profile, and (3) sleeping levels were associated with poor dietary habits, increased screen time, and overweight/obesity, in both sexes.

In the current study, approximately 40% among the surveyed population sleep insufficient hours. Recent data from the United States have showed that approximately 35% of children and adolescents had insufficient sleep duration (at least 8 or 9 h/d) on school nights.[2] Accordingly, a study in adolescents from 10 European cities has found that almost 34% of participants were insufficient sleepers.[23] Females compared to males (9.1 ± 1.5 versus 8.9 ± 1.4 h/d, $P < .001$) and children compared to adolescents (9.1 ± 1.5 versus 8.5 ± 1.4 h/d, $P < .001$) reported slightly increased time of sleeping hours. In line with the current study, a report of United States National Sleep Foundation in 2014 highlighted that shorter sleep was more common in adolescents than children (8.0 versus 8.9 h/d).[24] Also, findings from the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study in European adolescents have speculated that the average duration of daily sleep was 8.0 hours.[23]

Overweight status in Greek schoolchildren population is of great concern.[25] Insufficient sleep duration among children and adolescents of the current study is associated with increased odds of overweight/obesity by 20%. This adverse association has been reported by several studies. Three recent review studies and meta-analyses have concluded that short sleep duration among children and adolescents is associated with increased risk of obesity.[11–13] Specifically, the proposed pooled ORs ranged from 1.30 to 1.71 for the association between short sleep and obesity with a high heterogeneity of effect among studies.[11–13] Among potential explanations for the conflicting results being reported, differences in cutoff of insufficient sleep duration, geographical location, cohort, and definition of overweight may be included.

Our results indicated that dietary habits, screen time, and aerobic fitness were significantly associated with insufficient

Table 4—Results from logistic regression models used to evaluate the association of children's (age 8 to 17 years) characteristics with sleep levels (sufficient versus insufficient).

Predictors	Model 1	Model 2	Model 3	Model 4
Male				
Age (per 1 year)	0.967 (0.958–0.976)	0.964 (0.954–0.973)	0.959 (0.960–0.974)	0.968 (0.954–0.982)
BMI group (normal weight versus overweight/obese)	1.250 (1.152–1.361)	1.205 (1.150–1.260)	1.203 (1.150–1.259)	1.190 (1.112–1.271)
KIDMED index (relatively/sufficient versus insufficient)		0.580 (0.634–0.730)	0.600 (0.630–0.770)	0.624 (0.671–0.775)
Physical activity (adequate versus inadequate)		0.979 (0.936–1.024)	0.968 (0.925–1.013)	0.975 (0.923–1.030)
Screen time (acceptable versus increased)			1.227 (1.167–1.289)	1.210 (1.138–1.284)
20-meter shuttle run (per 1 lap)				0.998 (0.996–0.999)
Standing long jump (per 1 cm)				1.000 (1.000–1.001)
Sit and reach (per 1 cm)				0.998 (0.995–1.002)
Sit-ups in 30 seconds (per 1 repetition)				1.004 (0.998–1.009)
10- × 5-meter shuttle run (per 1 second)				1.003 (0.994–1.012)
Female				
Age (per 1 year)	1.005 (0.989–1.022)	1.008 (0.991–1.025)	1.006 (0.989–1.023)	1.032 (0.999–1.066)
BMI group (normal weight versus overweight/obese)	1.155 (1.101–1.112)	1.150 (1.090–1.210)	1.101 (1.034–1.167)	1.095 (1.029–1.162)
KIDMED index (relatively/sufficient versus insufficient)		0.562 (0.603–0.726)	0.596 (0.633–0.765)	0.574 (0.602–0.755)
Physical activity (adequate versus inadequate)		1.029 (0.980–1.081)	1.015 (0.965–1.066)	1.029 (0.970–1.092)
Screen time (acceptable versus increased)			1.293 (1.212–1.380)	1.234 (1.143–1.333)
20-meter shuttle run (per 1 lap)				0.998 (0.997–0.999)
Standing long jump (per 1 cm)				1.000 (0.999–1.001)
Sit and reach (per 1 cm)				0.997 (0.993–1.001)
Sit-ups in 30 seconds (per 1 repetition)				0.997 (0.990–1.004)
10- × 5-meter shuttle run (per 1 second)				1.008 (0.998–1.019)

Values are presented as odds ratio (95% confidence interval). Model 1 includes the age and BMI groups. Model 2 includes Model 1 and KIDMED index and physical activity levels. Model 3 includes Model 2 and screen time. Model 4 includes Model 3 and physical fitness measurements. BMI = body mass index, KIDMED = Mediterranean Diet Quality Index for children and adolescents.

sleep duration. According to several studies, sufficient sleep duration is associated with healthier dietary habits, whereas breakfast, fast food, and sweets/candy were more frequently consumed by "insufficient" sleepers.[16,26,27] Also, review of studies in the general population have shown a constant relationship between insufficient sleep duration and lower intakes of healthy foods and diet quality.[28]

Our findings have revealed that insufficient sleep duration was associated with increased screen time consumption, in both sexes. Reduction in sleep duration and increase in screen time among schoolchildren may intercorrelate.[3] Studies among German children and adolescents have shown that participants with short sleep incorporated significantly increased screen time than those with long sleep duration, with the was evidence in HELENA study among adolescents from 10 European cities.[23,26] Moreover, results in children aged 4 to 13 years indicated that TV viewing and computer use were connected to short sleep duration.[15] Summarized evidence from 67 studies in schoolchildren proposed that screen time is negatively associated with shortened sleep duration in 90% of studies.[29]

Physical activity was not associated with sleeping levels after adjustment for potential covariates. In concordance with previous findings, the HELENA study among adolescents (aged 12.5 to 17.5 years) from 11 countries did not observe significant associations between sleep duration and PA.[23] Moreover, a study in a sample of 1,586 adolescents in Italy (11 to 14 years) revealed that total sleep time, and sleep time on weekdays and on weekend days did not relate to PA levels.[16] Furthermore, recent studies in Australian, Croatian, Slovenian, and US schoolchildren have found no associations between objectively measured physical activity and sleep duration.[30,31]

Finally, the current study has highlighted that as performances of aerobic fitness were improved, odds of having insufficient sleep were declined. In line with current findings, a study among Canadian schoolchildren aged 6 to 17 years has concluded that participants with low aerobic fitness measurements sleep for less time than the sample average.[32] Similarly, research in which 1,726 Portuguese females aged 10 to 18 years participated reported that poor sleep quality was associated with lower aerobic fitness.[33] A recent review in interventional studies proposed that exercise improved sleep duration or quality.[34] Potentially, improved aerobic fitness contribute to a healthy lifestyle and these children were more likely to sleep sufficiently.

The study has several strengths. Firstly, it was performed in a wide range of children and adolescents and investigated several covariates. In Greece, primary and secondary education is compulsory and, as a result, we had the chance to study a large number of schoolchildren aged 8 to 17 years. Based on the standardized, reliable, and comparable results extraction of the comparison with the data from similar studies is obtainable.

Limitations of the current study include methodological issues (the cross-sectional design of this study cannot present

causal relationships, other than hypotheses for additional research), and the fact that potential confounding factors, such as socioeconomic status and sleep quality, have not been evaluated. With respect to the original design (school-based health survey), disorders such as sleep-related breathing or delayed sleep phase syndrome, etc. have not been evaluated. Specifically, because of the large scale of the cohort and the "sensitive" population that was examined, it was practically impossible to include the assessment of such special examinations. Moreover, the record of PA, dietary habits, sleeping time, and sedentary time were self-reported, which may potentially be subject to desirable reporting bias. However, with reference to the main outcome, it is considered that self-reported sleep duration is highly correlated with polysomnography-derived measurements of sleep duration in a general population.[35] Furthermore, participant responses were anonymous; as a consequence, they had no reason to misreport or dissemble their answers. Finally, because of the large sample size, statistical significance can easily be achieved.

CONCLUSIONS

To summarize, the current study has proposed that a significant proportion of Greek children and adolescents are insufficient sleepers. Sleep duration is significantly associated with unhealthy dietary habits, screen time, overweight status, and aerobic fitness. Urgent actions are needed to support strategies emphasizing on improved sleep duration.

ABBREVIATIONS

BMI, body mass index
CI, confidence interval
KIDMED, Mediterranean Diet Quality Index for children and adolescents
MD, Mediterranean diet
MVPA, moderate to vigorous physical activity
OR, odds ratio
PA, physical activity
PE, physical education
PF, physical fitness

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