Factors that Influence Weekday Sleep Duration in European Children

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Study Objectives: To compare nocturnal sleep duration in children from 8 European countries and identify its determinants.
Design: Cross-sectional.
Setting: Primary schools and preschools participating in the IDEFICS study.
Participants: 8,542 children aged 2 to 9 years from 8 European countries with complete information on nocturnal sleep duration.
Interventions: Not applicable.
Measurements: Nocturnal sleep duration was assessed by means of a computer based parental 24-h recall. Data on personal, social, environmental, and behavioral factors were collected by means of standardized parental questionnaire. Physical activity was surveyed with accelerometers.
Results: Nocturnal sleep duration in the participating countries ranged from 9.5 h (SD 0.8) in Estonia to 11.2 h (SD 0.7) in Belgium and differed significantly between countries ($P < 0.001$) in univariate as well as in multivariate analyses, with children from northern countries sleeping the longest. Sleep duration decreased by about 6 min with each year of age over all countries. No effect of season, daylight duration, overweight, parental education level, or lifestyle factors could be seen.
Conclusion: Sleep duration differs significantly between countries. Our findings allow for the conclusion that regional affiliation, including culture and environmental characteristics, seems to overlay individual determinants of sleep duration.
Keywords: Epidemiological study, lifestyle, sleep, school children, pre-school children
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INTRODUCTION

The effect of sleep duration on diverse health outcomes seems undisputable, and an adequate amount of sleep is believed to be important for optimal health and functioning throughout life.[1] National US surveys have shown a reduction of 1.5 to 2 hours in self-reported sleep duration over the last 50 years.[2] Moreover, associations between reduced sleep duration and cognitive deficits or mood disturbances have been found in adults, and evidence for similar effects in children is increasing.[1,3] For example, behavioral problems of attention deficit hyperactivity disorder appear to be associated with sleep curtailment in the young.[4] Concurrent with the decrease in sleep duration, a worldwide increase of overweight and obesity has been reported and mounting evidence in the recent past has identified sleep duration as a new risk factor for overweight and obesity already in childhood.[1,2,5-11] Likewise, an association between reduced sleep duration and metabolic dysfunction has been discussed.[12-14] Therefore, sleep appears to be an issue of public health interest as a potential new risk factor that needs to be further examined, especially in children.

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Information on average sleep duration has been published for different age groups from several countries[1,15-17] but comparability of those results is limited by reasons of different study designs and methods. In particular, sleep assessment methods differed. For example, some studies assessed sleep duration by means of structured interviews, asking parents questions on habitual bedtime and wake up time of their children, while other studies applied diaries to assess nocturnal sleep duration. Against the background of a previous study that has reported unsatisfactory agreement rates between questionnaires and diaries to assess sleep duration in children,[18] this heterogeneity hampers comparability of study results from different studies, while uniform methods and the high degree of standardization of data collection in a multicenter study allows for comparability of data.

Previous studies have reported several determinants of sleep duration in children. One of the main factors in this context is age, which has been shown to be negatively associated with sleep duration.[17,19] Physical activity has also been suggested to influence sleep duration, but no significant correlation between physical activity and sleep in children has been found.[1] A slightly different picture can be drawn for sociodemographic factors. For example, a study from New Zealand did not find any effect of gender, socioeconomic status, or maternal education on children's sleep duration,[1] while others observed associations between sociodemographic variables and sleep.[19,20] Another aspect that has been discussed to influence sleep duration in children is the time spent in front of the TV. Studies have shown adverse effects of TV time on sleep duration, though the findings were not always statistically significant.[1,21] It has also been suggested that season may play a role on sleep duration: a previous survey reported longer sleep duration in fall, winter, and spring than in summer.[1] Another factor that has been discussed intensely in the past years in association with sleep duration is overweight. The association is well known in adults, and evidence for the relationship is growing also in children.[2,10] The respective research has mainly focused on overweight as the outcome variable, but the direction of this association is not yet entirely clear, and the published data allow only limited conclusions on causality, especially in children. Furthermore, studies have shown that sleep duration is probably influenced by cultural and environmental factors and differs between countries.[16,22] To the authors' knowledge, no study that has simultaneously investigated the effect of regional or country-specific aspects and individual determinants of sleep duration has been done. Against this background it is of interest if regional aspects, for example, geographic (e.g., daylight duration) or other differences between European countries affect sleep duration in children, and how their impact on sleep duration relates to the above-mentioned individual determinants of sleep duration. To answer this question, internationally comparable data from a population based study of sufficient sample size are necessary.

We present here data from diverse European countries and multiple age groups which were collected within the "identification and prevention of dietary- and lifestyle-induced health effect in children and infants" (IDEFICS) project, an international collaborative study involving 8 European countries.[23,24] The present study compared nocturnal sleep duration assessed in a consistent and standardized manner in the participating countries to find out whether sleep duration differs between European countries independent of individual determinants of sleep duration. This study offered a unique opportunity to describe the distribution of sleep duration by age in European children based on epidemiological data.

METHODS

The IDEFICS project is a population based multicenter study which includes children aged 2 to 9 years from 8 European countries. Between September 2007 and June 2008, a total of 31,543 children from primary schools and preschools in selected regions in Italy, Estonia, Cyprus, Belgium, Sweden, Hungary, Germany, and Spain were invited to participate in the baseline survey (T0), with an adhesion rate of 53.4%. Examination period was the same in all countries. A total of 16,223 (96.2%) fulfilled the inclusion criteria and gave full information on sex, height, and weight. Sample size across countries ranged from 1,507 children in Spain to 2,567 in Hungary. In each country, the participating centers obtained ethical approval by their responsible authority. Parents or legal guardians provided written informed consent for all examinations and/or the collection of samples, subsequent analysis, and storage of personal data and collected samples. Before the start of the study, all instruments were pre-tested. The final instruments were introduced through a central training by the coordinating center and by subsequent local trainings of the field staff in each recruitment center. All data were collected according to standard operating procedures and adherence to the protocol was assured by quality control site visits in all study centers conducted by the coordinating center (Bremen Institute for Prevention Research and Social Medicine). Questionnaires were translated in the national languages and then retranslated into English by the respective study centers to ensure compatibility of translations with the English original. More detailed information on the study procedures can be obtained from previous reports.[23-25]

Sleep Duration

Information on sleep duration was collected in the context of a standardized 24-h recall (SACINA) that was developed to be used in children, based on an instrument previously used in adolescents.[26] The SACINA is a computer-based instrument filled out by parents or guardian of each participating child and contained questions on the time at which the child got up in the morning and went to bed on the previous day. Nocturnal sleep duration was calculated as the difference between bedtime and get-up time in the SACINA interview. Data were collected on all days of the week, including weekends. However, preliminary analyses of variance showed no significant sleep duration differences from Monday to Thursday, while there were significant differences ($P < 0.001$) between Fridays, Saturdays, and Sundays. This may be due to the fact, that in some countries only very few or no data were available for weekend days. Therefore, we decided to include only nocturnal sleep duration data from Monday to Thursday for the present analysis. Parents had the possibility to fill out the 24-h recall on more than one day, if they wanted to. However, if information on sleep duration was given for more than one night, the first weekday night was included in the analysis to avoid differences in variability of the data.

Anthropometry

Anthropometric measurements were done according to a standardized manual in all centers. Body height was measured without shoes by trained staff using a portable stadiometer (SECA 225). Weight was measured by means of an adapted version of electronic scale (TANITA BC 420 SMA), with subjects wearing only underwear. Body mass index (BMI) was calculated and then categorized referring to cutoff points according to the criteria of International Obesity Task Force.[27] Our category "overweight" included overweight and obese children, while the reference category included normal and underweight children.

Personal and Environmental Factors

Sex, age, country, season, daylight duration, parental education level, overweight, time spent in front of a TV or PC, weekly hours spent in a sports club, time playing outside, and physical activity according to accelerometer measurements were considered potential determinants of sleep duration. Data on personal, social, environmental and behavioral factors were collected by means of a standardized parental questionnaire, while children's physical activity was surveyed with accelerometers (Actigraph GT1M and ActiTrainer) with cutoffs for moderate to vigorous activity according to Sirard et al.,[28] resulting in a continuous variable of daily minutes spent in moderate to vigorous physical activity. Accelerometers were worn around the waist for 3 consecutive days and had to be taken off for swimming, showering or bathing, and during sleep. The parents were asked

Table 1—Characteristics of study samples and distribution of covariates, by country

Variable	Estonia (n = 1331)	Italy (n = 1643)	Hungary (n = 902)	Cyprus (n = 953)	Spain (n = 504)	Sweden (n = 1215)	Germany (n = 1586)	Belgium (n = 408)	All (n = 8542)
Age (Mean)	5.8	6.2	6.7	6.3	5.5	5.7	6.1	5.5	6.0
Boys (%)	48.9	52.0	49.2	49.4	42.4	51.7	51.5	52.5	50.8
Fall/Winter (%)	37.0	79.1	75.8	78.9	95.4	66.9	72.6	61.5	64.0
Overweight (%)	13.8	40.8	17.3	24.0	17.9	9.8	15.8	6.6	20.2
Education level									
High (%)	9.6	13.2	38.4	34.1	48.6	56.6	9.7	53.4	14.5
Medium (%)	83.1	57.0	55.0	43.4	25.4	35.8	54.5	38.2	53.1
Low (%)	3.9	27.4	4.2	5.5	16.3	4.9	30.6	4.4	27.2
Screen time									
Not at all (%)	0.6	2.1	3.6	1.6	5.6	0.9	4.0	1.7	2.3
≤ 0.5 h (%)	5.5	8.2	15.3	7.5	22.2	7.4	12.2	13.0	10.1
≥ 0.5 h to < 1 h (%)	18.6	19.8	26.8	19.9	28.0	22.2	26.4	32.1	23.0
≥ 1 h to < 2 h (%)	23.5	27.1	24.8	32.0	25.6	32.3	26.4	27.5	27.4
≥ 2 h to < 3 h (%)	17.7	19.0	15.0	16.7	11.5	19.5	14.1	14.5	16.6
≥ 3 h (%)	32.1	23.6	12.1	12.0	6.2	15.4	12.9	11.0	17.6
Play outside (%)	94.1	85.6	95.0	81.0	95.8	93.2	85.2	91.7	98.0
Time spent in sports club									
< 1 h (%)	1.7	0.2	0.4	5.1	2.4	1.2	0.5	0.3	0.8
≥ 1 h to < 4 h (%)	29.7	24.5	16.3	0.9	24.4	14.7	25.5	24.0	21.1
≥ 4 h (%)	14.3	4.7	4.3	-	6.0	0.9	2.5	2.5	4.8

to keep records of each time the device was taken off in an accelerometer diary. Education level categorized according to the International Standard Classification of Education (ISCED)[29] was used as a surrogate measurement for socioeconomic status. Three levels of education (low, medium, high) of the 6 ISCED levels were created, with ISCED levels 0, 1, and 2 indicating low education; 3 and 4 indicating medium education, and ≥ 5 indicating high education. Information on daylight duration was obtained from astronomical tables available at www.timeanddate.com. Daylight duration is given in decimal hours.

Non-Responder Analysis

Non-responder analysis by sex, age, and parental education level was performed in each country for children whose parents did not answer the SACINA interview and for those providing sleep data only for weekend days. These analyses showed no differences for sex, while there were some significant differences for age and parental education level in some countries. In Estonia, Belgium, Germany, and Spain, nonparticipants were slightly older than participants, while in Cyprus and Hungary nonparticipants were younger. In Hungary nonparticipants had a slightly lower education than participants.

Statistical Analysis

Preliminary analyses revealed that sleep duration was normally distributed in all countries. Therefore, we applied parametric tests in our statistical analyses. Differences in continuously distributed variables were compared using the Student *t*-statistics while the χ^2 statistic was used for the comparison of categorical variables. Percentile curves of sleep duration based on cubic interpolation of age-specific percentiles have been developed to model the distribution of sleep duration by age. For some analysis two age groups were created, with one group including children aged 2 to < 6 years (preschool children) and the other group including children aged 6 to 9 years (primary school children).

Analysis of variance was used to compare means of unadjusted values by categorical variables. To estimate the mean sleep duration in each country sample, controlling for confounding factors, we fit multivariate linear regression models and calculated adjusted mean values using minutes of sleep as the effect measure. Model 1 included only non-modifiable factors such as country, season, daylight duration, age, and parental education level. Model 2 included the same variables as Model 1 plus modifiable variables such as overweight, time spent playing outside, weekly time spent in a sports club, and daily time spent in front of a TV or PC screen. A test for interaction between age group and country was conducted. Models were constructed using the SAS procedure PROC GLM and including only variables that were found to be significantly related to sleep duration in univariate analysis. Because of the large sample size, a more stringent criterion for statistical significance was chosen, with $\alpha = 0.01$. Statistical analyses were done with SAS Version 8.2 (SAS Institute, Cary, NC, USA).

RESULTS

Data on nocturnal sleep duration were available for 10,613 (65.4%) of 16,223 children. After exclusion of children reporting only sleep duration for weekend days, data from 8,542 (52.6%) children were used for the present analysis. The mean age ranged from 5.5 in Spain (SD 1.9) and Belgium (SD 1.5) to 6.7 (SD 1.8) in Hungary. The frequency of boys and girls was very similar in each of the country samples. A more detailed description of the study sample can be found in Table 1, which

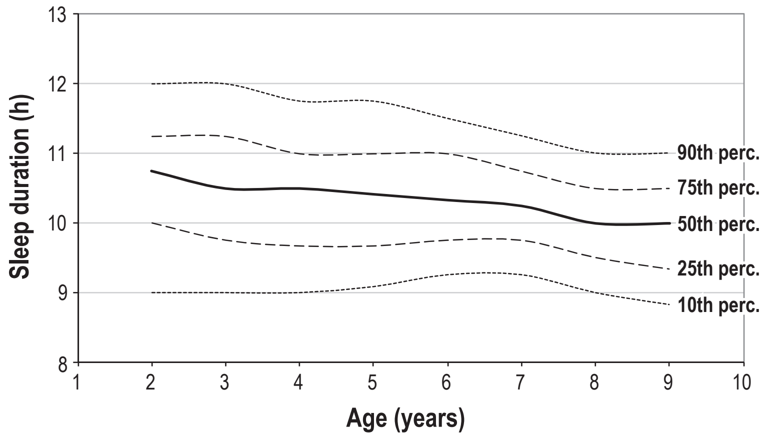

Figure 1—Percentile curves of sleep duration by age in all countries.

also gives an overview of the distribution of possible determinants of sleep duration within the sample.

Sleep duration showed a significant decline with age ($P < 0.001$). Comparing sleep duration between age groups, significant differences between preschool and school children could be seen in all countries except for Hungary and Cyprus (data not shown). To give an impression of the distribution of sleep duration by age in the overall sample, we present percentile curves of sleep duration based on cubic interpolation of age-specific percentiles in Figure 1.

Unadjusted nocturnal sleep duration differed significantly between countries ($P < 0.001$), with children from northern Europe (Sweden, Germany, Belgium) showing longer sleep duration than children in southern (Italy, Spain, Cyprus) or eastern (Estonia, Hungary) Europe. Mean sleep duration ranged from 9.5 (SD 0.8) h in Estonia to 11.2 (SD 0.7) h in Belgium. There were also some differences of within-sample variability of sleep duration, which was highest in the German and lowest in the Cypriote sample (Figure 2).

Results of univariate and multivariate analyses are shown in Table 2. Based on Model 1, sleep duration generally decreases by about 5.5 min per year of age increase. Adjusted (Model 1) sleep duration differed significantly between countries ($P < 0.001$), largely confirming the differences already observed in the unadjusted analysis. Thus, Swedish children (reference group) slept > 1 h more than children in Estonia and Italy. Shorter sleep durations in Hungary, Cyprus, and Spain were less pronounced but still significant, while children in Germany and Belgium slept even longer than the Swedish reference group. With regard to seasonal influences and daylight duration, no effect on sleep duration could be found. Parental education level showed no association with sleep duration. Unexpectedly, none of the additionally included variables in Model 2 accounted for significant changes in sleep duration. Since inclusion of the variable "weekly time spent in a sports club" led to a substantial reduction in sample size (n = 2,269) and the variable showed no effect on sleep duration ($P = 0.442$) in the multivariate analysis, we conducted sensitivity analyses excluding this variable. Exclusion did not account for relevant changes in the estimates of the remaining variables and therefore we decided to drop the variable in Model 2. Also in this model, main effects were revealed in association with age and country. These results remained strongly significant, although to a lower extent than in the first model. Generally, the biggest effect was observed for country, with an $r^2 = 0.36$ already in the univariate analysis. The multivariate analyses showed that most of the univariate associations did not persist after controlling for covariates, indicating independent effects on sleep duration only for a few factors.

To account for the striking differences between age groups, we present adjusted mean values of sleep duration from Model 2, for preschool and primary school children by country in Figure 3. As expected, the adjusted sleep duration confirmed the trend observed for unadjusted sleep duration shown in Figure 2. However, tests for an interaction between country and age group showed no significant results. Of note, sex of the child and physical activity measured by means of accelerometry were not associated with sleep duration in the univariate analysis and were therefore not included in any of the models.

DISCUSSION

The present study investigated nocturnal sleep duration in children aged 2 to 9 years from 8 European countries participating in the IDEFICS project. Adjusted as well as unadjusted mean sleep duration differed up to 1.7 hours in the participating countries, and disparities between northern, southern, and eastern Europe were striking. Age accounted for less difference, but still had a significant effect in all models. Season, daylight duration, overweight, behavioral factors, and parental education level were not found to be associated with sleep duration in the multivariate analysis.Mean values and percentiles of sleep duration in children have been reported in studies from different countries.[17,30,31] Additionally, attempts to define a "normal" sleep duration and develop reference values have been made.[6,17] Our study demonstrates that sleep duration differs significantly between countries within Europe. This is in line with previous reports that have compared sleep duration between countries and cultures. However, no other study has presented data that has been collected within large-scale studies including several countries to systematically compare results and test effects within and between European countries.

In our study children from southern and eastern European countries sleep less than children in northern countries. In fact, differences in bedtime routines have been shown in a study that compared infant care practices in the Boston area and a small town close to Rome, Italy.[32] Italian parents were less concerned about their children's sleep habits than parents of American children. In Italy, the integration of children in the adults' evening social activities and letting them fall asleep before going to bed is a common feature. Such unstructured and flexible bedtime habits escape our observation since they were not assessed in the present study and seem to result in later bedtimes in comparison to children from other industrialized countries. These results from Italy are paralleled by similar patterns reported from other southern European countries such as Spain and Greece.[32] Such cultural diversity needs to be kept in mind when developing recommendations or reference

Table 2—Associations between various factors and nocturnal sleep duration. Results are expressed as effect size in minutes (99% CI)

Variable	Univariate analysis		Model 1* (r² = 0.39)		Model 2** (r² = 0.47)	
	ß (99%CI)	P†	ß (99%CI)	P†	ß (99%CI)	P†
Male sex	-0.9 (-4.1; 2.4)	0.493				
Age	-6.0 (-6.9; -5.1)	< 0.001	-5.5 (-6.2; -4.8)	< 0.001	-6.0 (-7.7; -4.2)	< 0.001
Education level		< 0.001		0.453		0.247
High	ref.		ref.		ref.	
Medium	-14.9 (-18.7; 11.0)		0.7 (-2.6; 4.0)		-4.6 (-11.0; 1.7)	
Low	-7.5 (-12.8; 2.2)		-2.8 (-7.4; 1.7)		-3.3 (-13.2; 6.5)	
Country		< 0.001		< 0.001		< 0.001
Estonia	-74.9 (-79.7; -70.1)		-72.5 (-78.0; -67.9)		-59.5 (-70.4; -48.6)	
Italy	-66.5 (-71.1; -62.0)		-64.5 (-69.6; -60.0)		-49.7 (-60.5; -38.9)	
Hungary	-44.8 (-50.1; -39.6)		-39.9 (-45.4; -34.8)		-30.6 (-42.5; -18.8)	
Cyprus	-35.6 (-40.8; -30.4)		-35.5 (-41.4; -30.5)		-21.3 (-39.9; -2.8)	
Spain	-31.7 (-38.1; -25.4)		-29.8 (-36.4; -22.9)		-23.7 (-37.0; -10.3)	
Sweden	ref.		ref.		ref.	
Germany	14.8 (10.3; 19.4)		17.5 (12.5; 22.2)		28.6 (18.2; 38.9)	
Belgium	24.9 (18.0; 31.7)		24.6 (17.6; 31.3)		30.0 (15.6; 44.5)	
Fall/winter vs. spring/summer	10.5 (7.1; 13.9)	< 0.001	4.0 (-1.0; 9.0)	< 0.041	3.8 (-6.3; 13.8)	0.331
Daylight hours	-3.1 (-3.7; -2.5)	< 0.001	-0.4 (-1.3; 0.5)	< 0.232	-0.3 (-2.0; 1.4)	0.655
Normal weight vs. overweight	20.6 (17.6; 23.7)	< 0.001			5.4 (-1.1; 11.7)	0.034
Screen time		< 0.001				0.043
Not at all	ref.				ref.	
< 30 min	0.5 (-8.3; 9.4)				-3.5 (-22.3; 15.3)	
< 1 h	-6.5 (-14.9; 1.9)				-9.8 (-27.8; 8.1)	
> 1 h and < 2 h	-14.3 (-22.6; -5.9)				-10.8 (-28.7; 7.1)	
> 2 h and < 3 h	-21.7 (-30.2; -13.1)				-14.6 (-32.8; 3.6)	
> 3 h	-34.6 (-43.1; -26.1)				-13.2 (-31.5; 5.0)	
Play outdoors	4.4 (3.6; 5.5)	< 0.001			0.9 (-1.3; 3.1)	0.301
Time spent in sports club		< 0.001				
< 1 h	21.1 (6.0; 36.3)					
≥ 1 h and < 4 h	23.0 (16.8; 29.3)					
≥ 4 h	ref.					
Mean (min) of moderate to vigorous activity	-0.1 (-0.3; 0.1)	0.134				

*Including age, parental education level, country, season, daylight hours; n = 8093. **Model 1 + modifiable variables (overweight, screen time, and time playing outside); n = 8093. †P-values of multivariate analyses of variance.

values of "normal" sleep duration in children. Another factor that should be taken into account is the season in which the survey takes place. Our data did not confirm the findings of another study[1] that showed differences in sleep duration due to seasonality. Another aspect that we hypothesized to have an effect on sleep duration, and which may partly explain the effect of season that has been found previously, was daylight duration. However, we could not support this hypothesis with our data. Since daylight duration is determined by season, we conducted sensitivity analysis excluding daylight duration from the multivariate model to avoid over-adjustment, but this did not result in relevant changes in the estimate for season.

Sleep needs change with age, especially in childhood. Our data were in line with other studies reporting significant changes in sleep duration in children of different age groups.[16,17] Due to the elevated sample size and the multicenter study design, our data offered the unique possibility to develop percentile curves for sleep duration of European children. A previous study presenting such curves was based on a much smaller sample size drawn from only one country (Switzerland).[17] However, our data show a more moderate decline of sleep duration by age in the European sample than the report from Switzerland. It can be assumed that the transition from preschool to primary school involves a change in sleep duration, if only due the modified daily routine.[33] To account for this difference, we conducted an age-stratified analysis with our final model and presented adjusted mean values for each country by age group.

Several studies have indicated an effect of sleep duration on overweight in children.[1,2,5-11] However, the direction and causality of this association is not yet clear, since very few longitudinal studies are available, and to the authors' knowledge, no data have been published on the effect that overweight may have on sleep duration in healthy children. Anyway, our results do not support the hypothesis that overweight influences sleep duration, and further studies are necessary in order to investigate on this aspect.

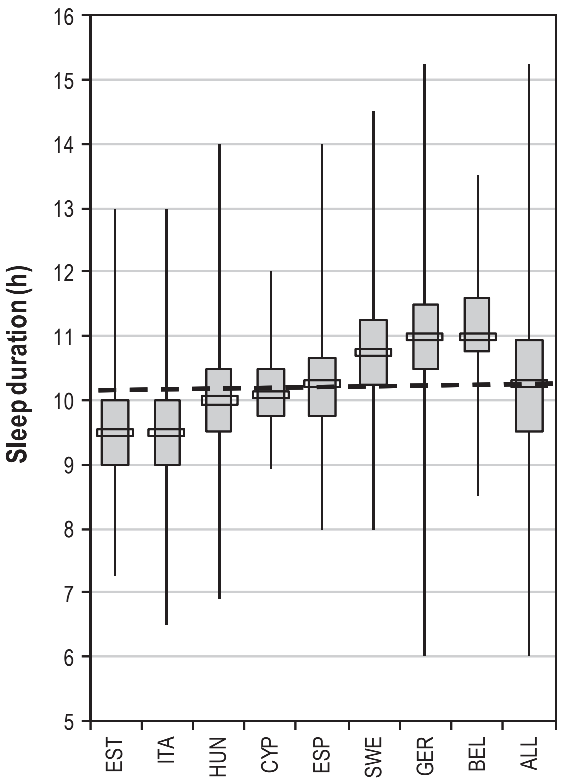

Figure 2—Distribution of unadjusted sleep duration by country. Box plots indicate median, 25th and 75th percentile and min/max. EST, Estonia; ITA, Italy; HUN, Hungary; CYP, Cyprus; ESP, Spain; SWE, Sweden; GER, Germany; BEL, Belgium.

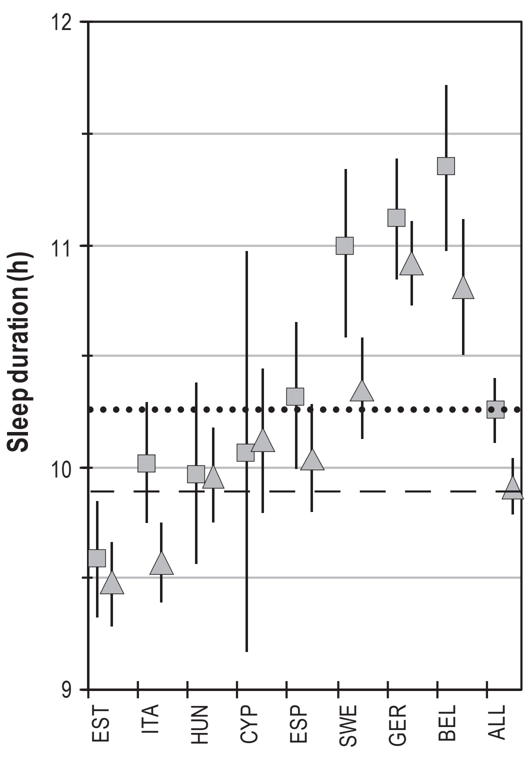

Figure 3—Adjusted (model 2) mean sleep duration in preschool (square) and school children (triangles) by country (99% CI). EST, Estonia; ITA, Italy; HUN, Hungary; CYP, Cyprus; ESP, Spain; SWE, Sweden; GER, Germany; BEL, Belgium.

Previous studies have shown variable results concerning the influence of sex and socioeconomic status on sleep duration. US studies have documented an association between sleep and those variables,[20] while our results are similar to those from a study in New Zealand, showing no such association.[1]

Concerning time spent in front of a television or computer screen, our results were not clearly in line with other studies showing an adverse effect of TV time on sleep duration.[1] However, the estimates for screen time suggest that there might be an inverse trend in the association between screen time and sleep duration in our data, even if a test for trend was statistically not significant at $\alpha = 0.01$. A different categorization of screen time might have led to significant results in this context. It could be assumed that parents who have stricter rules concerning screen time are also more likely to have rules regarding bedtime routines, with the child going to bed earlier, resulting in longer sleep duration. We found that in the southern countries, 14.7% of the children watched TV more than 2 hours each day, while in eastern and northern Europe, these percentages were 9.8% and 6.7%, respectively. Against the background of the beforementioned more flexible bedtime rules in southern families, this result could lead to the consideration that in those countries leisure time in general is less structured and rules concerning this matter are less strict than in other countries.

The effect of physical activity on sleep duration has also been discussed in other papers. A meta-analysis from the US has shown a weak impact of physical exercise,[34] whereas other studies could not report an association between moderate or vigorous physical activity and sleep duration.[1,35] Our data confirmed these findings, since we could not find the weekly hours spent in a sports club and the time spent playing outside being associated with sleep in the multivariate analysis.

Generally, our findings suggest that the effect of country-specific factors, such as culture—as it has already been discussed by Owens[22]—or environmental factors may overlay the individual determinants of sleep duration that have been found in previous studies.

The strengths of our study include a large dataset of international data—collected under strongly standardized procedures—with a population-based sample including children from different age groups, which allows for stratified analyses without losing much power. Weaknesses such as differences between participants and nonparticipants concerning age have been mentioned above. However, the age difference between countries was less than six months and is not expected to lead to bias. Sleep duration in large-scale studies can be most objectively measured by means of accelerometry. Parental report seems to overestimate objectively measured sleep duration.[1] This possible bias is expected to be non-differential and hence should not distort the trends shown in our study. Another aspect that should be discussed is sleep duration on weekends. It may be expected that sleep duration differs between weekend and weekday nights and that different factors may influence these parameters. Since our data on sleep duration on weekend days were very limited in some countries and variability was very high between weekend days, we excluded weekend days from the analysis. The aspect of napping should be considered when interpreting differences between countries. Recent studies have reported an influence of daytime napping on nighttime sleep duration in children and cultural differences in napping patterns have been shown.[32] However, only data on nocturnal sleep duration were available in our study.

To the best of the authors' knowledge, this study is the first of its type to provide a large number of comparable data from several European countries on sleep duration. Based on this data, percentile curves for sleep duration in European children were developed to give an overview of the distribution of sleep duration in this population. Furthermore the present study found, that individual determinants such as overweight and behavioral factors, which have been found to influence sleep duration in children in other studies, did not show any effect after adjustment for age and country. These findings allow for the conclusion that country affiliation, which includes culture (e.g., parenting practices, culturally determined values) and environmental characteristics seems to be one (if not the main) factor that influences sleep duration in children—overlaying the effects of individual factors such as age, parental education, overweight, and behavioral habits. Further internationally comparable studies including napping behavior and more precise measurements of sleep characteristics will be needed to give a more comprehensive picture of factors determining sleeping behavior in different countries and cultures. This may offer further evidence for country-specific recommendations on adequate sleeping behavior of children.

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DISCLOSURE STATEMENT

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REFERENCES

1. Nixon GM, Thompson JM, Han DY, et al. Short sleep duration in middle childhood: risk factors and consequences. Sleep 2008;31:71-8.
2. Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. Sleep 2008;31:619-26.
3. Ortega FB, Ruiz JR, Castillo R, et al. Sleep duration and cognitive performance in adolescence. The AVENA study. Acta Paediatr 2010;99:454-6.
4. Paavonen Jeal. Short sleep duration and behavioural symptoms of attention-deficit/hyperactivity disorder in 7- to 8-year-old children. Pediatrics 2009;123:e857-e864.
5. Agras WS, Hammer LD, McNicholas F, Kraemer HC. Risk factors for childhood overweight: a prospective study from birth to 9.5 years. J Pediatr 2004;145:20-5.
6. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. Obesity 2008;16:265-74.
7. Gillman MW. Developmental origins of childhood overweight: potential public health impact. Obesity 2008;16:1651-6.
8. Kleiser C, Schaffrath RA, Mensink GB, Prinz-Langenohl R, Kurth BM. Potential determinants of obesity among children and adolescents in Germany: results from the cross-sectional KiGGS Study. BMC Public Health 2009;9:46.
9. Ozturk A, Mazicioglu M, Poyrazoglu S, Cicek B, Gunay O, Kurtoglu S. The relationship between sleep duration and obesity in Turkish children and adolescents. Acta Paediatr 2008;98:-699.
10. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. Obesity 2008;16:643-53.
11. Reilly JJ, Armstrong J, Dorosty AR, et al. Early life risk factors for obesity in childhood: cohort study. BMJ 2005;330:1357.
12. Knutson KL, Ryden AM, Mander BA, VanCauter E. Role of sleep duration and quality in the risk and severity of type 2 diabetes mellitus. Arch Intern Med 2006;166:1768-74.
13. Knutson KL, Spiegel K, Penev P, VanCauter E. The metabolic consequences of sleep deprivation. Sleep Med Rev 2007;11:163-78.
14. VanCauter E, Holmback U, Knutson K, et al. Impact of sleep and sleep loss on neuroendocrine and metabolic function. Horm Res 2007;67:2-9.
15. Clarisse R, Testu F, Maintier C, Alaphilippe D, Le FN, Janvier B. [A comparative study of nocturnal sleep duration and timetable of children between five- and ten-years-old according to their age and socio-economic environment]. Arch Pediatr 2004;11:85-92.
16. Gianotti F, Cortesi F, Sebastiani T, Vagnoni C. Sleeping habits in Italian children and adolescents. Sleep Biol Rhythms 2005;3:15-21.
17. Iglowstein I, Jenni OG, Molinari L, Largo RH. Sleep duration from infancy to adolescence: reference values and generational trends. Pediatrics 2003;111:302-7.
18. Werner H, Molinari L, Guyer C, Jenni OG. Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. Arch Pediatr Adolesc Med 2008;162:350-8.
19. McLaughlin C, V, Williams NA. Normal sleep in children and adolescents. Child Adolesc Psychiatr Clin N Am 2009;18:799-811.
20. Spilsbury JC, Storfer-Isser A, Drotar D, et al. Sleep behavior in an urban US sample of school-aged children. Arch Pediatr Adolesc Med 2004;158:988-94.
21. Olds T, Ridley K, Dollman J. Screenieboppers and extreme screenies: the place of screen time in the time budgets of 10-13 year-old Australian children. Aust N Z J Public Health 2006;30:137-42.
22. Owens JA. Introduction: Culture and sleep in children. Pediatrics 2005;115:201-3.
23. Ahrens W, Bammann K, De Henauw S, et al. The IDEFICS study: design, participation, socio-demographic characteristics and compliance. Int J Obes (Suppl.) 2011 (in press).
24. Ahrens W, Bammann K, de Henauw S, et al. Understanding and preventing childhood obesity and related disorders--IDEFICS: a European multilevel epidemiological approach. Nutr Metab Cardiovasc Dis 2006;16:302-8.
25. Bammann K, Peplies J, Sjöström M, et al. Assessment of diet, physical activity and biological, social and environmental factors in a multi-centre European project on diet- and lifestyle-related disorders in children (IDEFICS). Public Health 2006;14:279-89.
26. Vereecken CA, Covents M, Sichert-Hellert W, et al. Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe. Int J Obes 2008;32:26-34.
27. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240-3.
28. Sirard JR, Trost SG, Pfeiffer KA, Dowda M, Pate RR. Calibration and evaluation of an objective measurement of physical activity in preschool children. J Phys Activ Health 2005;2:345-57.
29. UNESCO. International Standard Classification of Education. www.uis.unesco.org. 2010.
30. Ottaviano S, Giannotti F, Cortesi F, Bruni O, Ottaviano C. Sleep characteristics in healthy children from birth to 6 years of age in the urban area of Rome. Sleep 1996;19:1-3.
31. vonKries R., Toschke AM, Wurmser H, Sauerwald T, Koletzko B. Reduced risk for overweight and obesity in 5- and 6-y-old children by duration of sleep--a cross-sectional study. Int J Obes Relat Metab Disord 2002;26:710-6.
32. Jenni OG, O'Connor BB. Children's sleep: an interplay between culture and biology. Pediatrics 2005;115:204-16.
33. Ward TM, Gay C, Anders TF, Alkon A, Lee KA. Sleep and napping patterns in 3-to-5-year old children attending full-day childcare centers. J Pediatr Psychol 2008;33:666-72.
34. Youngstedt SD, O'Connor PJ, Dishman RK. The effects of acute exercise on sleep: a quantitative synthesis. Sleep 1997;20:203-14.
35. Youngstedt SD, Perlis ML, O'Brien PM, et al. No association of sleep with total daily physical activity in normal sleepers. Physiol Behav 2003;78:395-401.