# Gender-specific factors associated with shorter sleep duration at age 3 years

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**ABSTRACT**

Total sleep duration has been decreasing among children in the last decades. Short sleep duration (SSD) has been associated with deleterious health consequences such as excess weight/obesity. Risk factors for SSD have already been studied among school aged children and adolescents but inconsistent results have been reported regarding possible gender differences. Studies reporting such relationships are scarce in pre-schoolers, despite the importance of this period for adopting healthy behaviour.

We aimed at investigating factors associated with SSD in 3-year-old boys (N=546) and girls (N=482) in a French mother-child cohort (EDEN study). Children were born between 2003 and 2006 in two French university hospitals. Clinical examinations and parent self-reported questionnaires allowed us to collect socio-demographic (e.g. income, education, family situation, child-minding system), maternal (e.g. BMI, parity, depression, breastfeeding duration), and child's characteristics (e.g. gender, birth weight, term, physical activity and TV viewing duration, food consumption, usual sleep time). Sleep duration/24-hour period was calculated and SSD was defined as <12 hours. Analyses were performed using logistic regressions.

The mean sleep duration was 12hrs35 ± 56 min, with 91% of the children napping. Patterns of risk factors associated with SSD differed according to gender. In addition to parental presence when falling asleep, short sleep duration was strongly positively associated with high BMI-z-score and TV viewing duration among boys and with familial home child minding and lower scores on "fruits and vegetables" dietary pattern among girls. These results suggest either a patterning of parental behaviours that differs according to gender, or a gender-specific sleep physiology, or both.

**Keywords**

Pre-schooler, gender effect, body mass index, sleep duration, dietary patterns

## Introduction

A decrease in children's total sleep duration has been reported in the last decades, suggesting that more and more children are now in chronic sleep debt (Galland *et al.*, 2012; Blair *et al.*, 2012). There is now accumulating evidence that insufficient quantity and/or quality of sleep have a negative impact on children's physical and mental health development, cognitive function, behaviour and academic success. Sleep disorders and short sleep duration in childhood have also been suggested as predictors of sleep disorders and short sleep duration in adolescence and adulthood (Quach *et al.*, 2009; Al Mamun *et al.*, 2012).

Cross sectional and/or longitudinal studies have shown that among children (and according to their age), short sleep duration is associated with adverse effects such as an increased risk of overweight/obesity, sleepiness, aggressiveness, anxiety, hyperactivity, attention deficit, lower academic performance, and increased risk of domestic accidents (Chen *et al.*, 2008; Gruber, 2012; O'Callaghan *et al.*, 2010; Berger *et al.*, 2012).

Risk factors associated with shorter night sleep durations in school aged children and toddlers are lower socio-economic status, non Caucasian ethnic group, higher maternal age, maternal stress and/or depression, prematurity, low birth weight, care outside the home, TV/screen viewing especially before going to sleep, and male gender (McDonald *et al.*, 2014; Nevarez *et al.*, 2010; Sadeh *et al.*, 2000; Blair *et al.*, 2012; Foley *et al.*, 2013) and late bedtime. Moreover, parental behaviour at bedtime (e.g. parental presence until sleep onset, feeding), especially among toddlers, is an additional important risk factor for fragmented sleep and consequently shorter sleep duration (Touchette *et al.*, 2005; Mindell *et al.*, 2010).

Girls have been shown to sleep consistently longer per 24-hour period than boys in the ALSPAC English cohort between the age of 6 months to 11 years (Blair *et al.*, 2012). Similar results have been observed for night sleep duration in early infancy (14-27 months) (McDonald *et al.*, 2014) and school-aged children (Sadeh *et al.*, 2000; Biggs *et al.*, 2013). This gender difference has also been observed in the relationship between sleep and obesity, with an increased risk of obesity amongst short sleeper children OR=1.58 (95% confidence interval 1.26-1.98) that was stronger among boys OR=2.50 (1.88-3.34)(Chen *et al.*, 2008). In this meta-analysis, short sleep was defined as <11hrs/24hrs for children aged under 5 years.

The aim of the present study was to describe sleep duration in preschool aged children from a French pre-birth cohort and to investigate gender-specific factors associated with shorter sleep duration.

## Materials/Subjects and Methods

### Study design

This analysis was carried out as part of the French EDEN mother–child cohort study, which aims to investigate the role of pre- and postnatal determinants of child development and health. Pregnant women were recruited between 2003 and 2006 in the university hospitals of Poitiers and Nancy. During a clinical visit, pregnant women with <24 weeks of amenorrhea were invited to join the cohort. Exclusion criteria were multiple pregnancies, known diabetes before pregnancy, illiteracy, and intention to move outside the selected regions in the next 3 years. Among the 3758 women invited to participate, 2002 (53%) accepted to be enrolled in the study. Written informed consent was obtained twice from parents, once at enrolment and once after the child's birth. The study was approved by the ethics research committee (Comité Consultatif de Protection des Personnes dans la Recherche Biomédicale) of the Bicêtre Hospital and by the Data Protection Authority (Commission Nationale de l'Informatique et des Libertés).

### Data collection

Data were collected through parental self-administered questionnaires at inclusion, birth, and 3 years old and clinical examinations including anthropometric measurements of each child at birth and at 3 years old.

**Child's sleep measures at age 3 y**

Sleep durations were calculated based on the answers to the following questions: "Usually, at what time does your child go to bed?", "Usually, at what time does your child wake up?", and "Does your child regularly take naps?" "If yes, what is their average daily duration of napping?". Responses were recorded in hours and minutes. Short sleepers were defined as children with total sleep duration of less than 12hrs/24hrs. This threshold of 12hrs/24hrs corresponded to the 19$^{th}$ percentile of the sleep duration distribution across the studied sample and to the lower limit of the sleep need for 3-year-old children as reported by American National Sleep Foundation (Sleep Foundation, 2013). It was also chosen to identify children who get a low amount of sleep for their age while classifying enough of them as having low sleep (i.e. 18.1% of all children, 19.1% of boys and 17.0% of girls – Figure 1) and to retain adequate statistical power.

The question "Did your child wake up during the night in the last month?", along with 5 possible answers "never or almost never, sometimes, every other night, often, almost every night" was used to define frequent night awakenings at age 3 as waking one night every two nights or more (yes/no) over the month prior to the date of questionnaire completion. Parental presence when falling asleep was collected through questions on sleeping habits (place (e.g. living room), parental interaction (e.g. holding hands) and bed sharing)). A child was considered to sleep without parental presence when declared falling asleep in his or her own bed and without parental interaction.

Based on both our literature review and the data availability in the present study, we considered the following factors for their possible link with a child's sleep duration.

1) *Parent variables*

**Familial variables**. Highest diploma obtained for each parent was used to define the parental educational level in three categories, with 12 years of total education as a threshold, i.e. both parents have less than 12 years of education; only one parent has at least 12 years of education; or both parents have at least 12 years of education. Household income in euros per month was collected into categories (≤1500, 1501–2300, 2301–3000, 3001–3800, ≥3800). The main child-care arrangement during daytime was divided into three categories: community childcare (i.e. preschool, nursery school or childcare centre), nursery assistant (external to the child's home), and home child minding (mother, partner, another family member, friends, nanny, neighbour).

**Maternal variables**. Mothers were considered isolated when there was no external help available (family, partner). Mothers reported information on smoking and alcohol consumption during pregnancy (classified as yes if reported at any time during pregnancy/no), age at the child's birth. Maternal depression status at inclusion and at 3 years postpartum was assessed by the CES-D questionnaire (Radloff, 1977). A mother with a CES-D score ≥23 was considered depressed (threshold validated in French women) (Führer and Rouillon, 1989).

2) *Child's variables:*

**Neonatal period.** We collected child's gender, birth order (first born: yes/no) and breastfeeding duration (exclusive or mixed, in months) considered both as a continuous variable and a variable in three categories (<3, 3-6, >6). Gestational age, obtained from birth medical records, was considered as continuous and dichotomized with 37 weeks as a threshold to defined prematurity (yes/no).

**Sedentary/active behaviours at 3 years old**. Number of hours per day spent in physical activity (walking, playing outside) and watching television or other screens during a usual week were collected separately for weekdays, wednesdays (weekday without preschool in

France) and for weekend days. As expected, the mean number of hours per day spent in physical activity was statistically different according to the season when the self-questionnaire was completed. We therefore split this variable in quartiles according to each season. As this was not the case for the number of hours spent watching TV, the latter was analysed continuously.

**Diet at 3 years old.** Children's dietary intake was collected using a short food frequency questionnaire composed of 27 food items with pattern of response on a 7 point scale ranging from never to 3 times per day or more. These are a short versions of the food frequency questionnaire used to assess maternal diet during their pregnancy, which was validated in adults and adolescents (Deschamps *et al.*, 2009). In these short versions, the food classification was established based on similarities in food type and context of consumption and was set to be able to describe the patterns of the diet. Two dietary patterns were previously identified using principal component analysis (Kline, 1994; Cattell, 1966) and accounted for 22% of the explained variance (Lioret *et al.*, 2015). The first pattern was positively correlated to the consumption of breaded fried fish, meats, processed meats, French fries, legumes, potatoes, fat fish, crisps, pizza, rice, biscuits, chocolate and sweets, fruit juices and custards. This pattern was labelled "high-fat-, starchy- and processed foods". Pattern two, labelled "fruits and vegetables", was mainly characterized by high consumption of both cooked and raw vegetables, as well as fruits; and inversely correlated with intake of soft-drinks, crisps, French fries, chocolate and sweets, and biscuits. A factor score for each dietary pattern was calculated at the individual level by summing the observed standardized frequencies of consumption per food group, weighted according to the factor loadings.

**Weight**. Birth weight was obtained from medical records. A BMI-z-score at 3 years was calculated using the WHO age and gender charts. With this definition, obesity corresponds to a BMI-z-score ≥2 SD (de Onis, 2007).

*3) <u>Contextual variables</u>*

We also considered the maternity ward of recruitment (Nancy/Poitiers) and the season at which self-questionnaires were completed according to calendar dates i.e. spring (20$^{th}$ of march – 20$^{th}$ of June), summer (21$^{st}$ of June - 21$^{st}$ of September), autumn (22$^{th}$ of September - 20$^{th}$ of December) and winter (21$^{st}$ of December – 19$^{th}$ of march).

### Statistical methods

Significant interactions were observed between genders on the one hand and BMI-z-score (p=0.03), "Fruits and vegetables" dietary pattern scores (p=0.007) and main child-care arrangement (p=0.05) on the other hand meaning that the associations of the latter variables with short sleep duration varied according to gender. Analyses were therefore conducted separately for boys and girls. Spearman correlation coefficients were estimated between night and nap-sleep durations. Associations between shorter sleep duration and the variables of interest were tested by logistic regressions. Socio-demographic (i.e. inclusion centre, family incomes, educational level, isolated mother) and 3-year-old child's behavioural variables (i.e. sedentary/active way of life, diet) were forced in the multivariate model (model 0). The other variables were then included (model 1) only if a p-value ≤ 0.20 was observed in the gender–specific bivariate analyses. A p-value ≤0.05 was considered significant. All analyses were performed using SAS (SAS 9.1, SAS institute INC, Cary, NC, USA).

## Results

Complete data was available for 1028 Caucasian children out of 1305 with questionnaire returned at 3 years. Excluded cases, because of incomplete data (N=277), were significantly more frequent from Poitiers, more likely to have mothers living single, with lower family income, lower level of education and higher BMI (data not shown). However, no difference was observed regarding the mother's age at delivery, child's gender, child's BMI-z-score or sleep characteristics at 3 years (night, nap, and total sleep durations), when available.

General characteristics of the population are shown in Table 1, globally and separately according to gender. Boys had later bedtimes and earlier wake-up times than girls resulting in significantly shorter mean night sleep duration, but the mean of total sleep duration, nap included, did not differ significantly by gender. The overall Spearman correlation coefficient between night-sleep and nap-sleep durations was -0.10 (p=0.002), with a gender difference (-0.06, p=0.17 among girls and -0.13, p=0.003 among boys). Figure 1 shows the distribution of total sleep duration by gender. A total of 18.1% of children displayed a short sleep duration (<12hrs/24hrs) corresponding to 19% and 17% of boys and girls, respectively. BMI-z-score was ≥2SD for 1.9% of the children (2.6% and 1.0% among boys and girls, respectively, p=0.10). There was no seasonal effect on sleep duration, categorized as short sleep or not, in this dataset (data not shown).

Factors associated with shorter sleep duration at 3 years (<12hrs/24hrs) are presented separately for boys and girls (Table 2 and Table 3 respectively). We identified two distinct sets of associated factors according to gender. Among boys, risk factors associated with short sleep duration were parental presence when falling asleep (OR=2.84, p=0.03), time spent watching television (OR=1.65 per additional hour/24hrs, p=0.0008), BMI-z-score (OR=1.31 per additional standard deviation, p=0.04). Frequent night awakenings showed an OR at 1.61, but not significant (p=0.06). Among girls, parental presence when falling asleep (OR=3.89, p=0.008) was associated with short sleep duration. Concerning childcare management, home child minding showed a significant increased risk compared to community care (OR=2.45, specific p=0.02). On the contrary, the adherence to the "fruits and vegetables" dietary pattern was associated with lower risk (OR=0.55 per dietary pattern score unit, p=0.0003). Forcing of BMI-z-score in the model did not change the results for dietary pattern in girls (data not shown). Physical activity was not significantly different between short sleepers and their counterparts in both analyses. The mean BMI-z-score and the mean score on the "fruits and vegetables" dietary pattern according to sleep duration and gender are illustrated in Figure 2A and 2B respectively.

**Discussion**

This cross-sectional study performed among 3-year-old children from the French Mother-child cohort EDEN showed that total mean sleep duration, estimated by time in bed, among French children was relatively high and that factors associated with shorter sleep duration differed by gender. In addition to parental presence when falling asleep, shorter sleep duration was associated with TV viewing, and higher BMI-z-score and to a lesser extent associated with frequent night awakenings in boys, while in girls, shorter sleep duration was associated with home child minding and lower "fruits and vegetables" dietary pattern scores.

Total sleep duration at 3 years in this cohort was slightly longer than those reported by both a recent British birth cohort reporting time in bed based on maternal answers to postal questionnaires (Blair *et al.*, 2012) and a meta-analysis of sleep duration collected through questionnaires (Galland *et al.*, 2012). Mean total sleep was 12hrs35/24hrs (±56 min) versus 11hrs58 (±66 min) in the British cohort and 11hrs45 (±75 min) in the meta-analysis, both between 2 and 3 years. French children's average night sleep duration, as established in our cohort, is in between those reported by Hense *et al* among North European (Swedish, German and Belgian) and South European (Italian, Hungarian and Spanish) preschool children using parental 24-h recall (Hense *et al.*, 2011). French children slept less during the night than their counterparts in the British cohort (10hrs51 versus 11hrs15) but had more naps (91% versus 59% at age 3) and longer ones (1hrs54 versus 43 min) (Blair *et al.*, 2012). In addition to the negative correlation between night and nap sleep durations, especially among boys who displayed the shortest night-sleep duration, our findings argue in favour of sleep compensation over a 24 hour period in preschool children with short night sleep duration by both napping and increasing nap duration, as reported by others (Acebo *et al.*, 2005). This total sleep duration distribution, which may reflect cultural ways of life, contributed to the cut-off we chose to define short sleepers among the studied population (<12hrs/24hrs). This was a compromise between the American National Sleep Foundation recommendations and statistical power. Despite this relatively high threshold, we were able to identify several risk factors associated with shorter sleep duration.

A number of studies have shown that children who have not learned to fall asleep on their own resist bedtime by crying, demand their parents' attention and are also more likely to wake up during the night (e.g. Touchette *et al.*, 2005; Mindell *et al.*, 2010). This has been identified as a marker for on-going sleep problems in early childhood and was confirmed in pre-schoolers (Johnson and McMahon, 2008; Sadeh *et al.*, 2009). We here confirmed the association between a child's short sleep duration and parental presence when falling asleep in both genders. Concerning childcare management, home child minding showed a significant increased risk compared to community care among girls (OR=2.45, specific p=0.02). This suggests the existence of gender specific characteristics. One of them could be parenting practices. Several authors reported more permissive parents for boys than for girls, for example regarding food intake, media use, physical activity participation or strategies applied to answer to night awakenings (Coulombe and Reid, 2012; Xie *et al.*, 2014; Alsharairi and Somerset, 2014; Rodenburg *et al.*, 2013). The same phenomenon may also apply to sleep duration among girls when cared at home. Sociocultural pressure on girls to conform to gender stereotypes may play a role in this process, even among primary school children (McHale *et al.*, 2003; Agras *et al.*, 2007).

Short sleep duration has been associated with an increased risk of overweight and/or obesity among preschool- and school-aged children (Hart *et al.*, 2011; Chen *et al.*, 2008) in populations/cohorts with high overweight and/or obesity prevalence (≥9% with overweight/obesity defined according to US 2000 CDC Growth Charts or International Obesity Task Force). Despite the low prevalence of obesity in the present study (1.9% of the children with BMI-z-score ≥2SD), which may be due to both the relatively low prevalence in France compared to USA and the relatively high socioeconomic status of the studied population, we still observed a significant association between higher BMI-z-score and shorter sleep duration among boys. This gender difference for short sleep-high BMI has been inconsistently reported across studies but has been highlighted in a meta-analysis (Chen *et al.*, 2008). We here showed that among boys, this relation was independent of physical activities and dietary patterns. Among girls, short sleep duration was associated with lower scores on the “fruits and vegetables” dietary pattern but was independent of all weight/BMI measures, physical activities and “high-fat-, starchy- and processed foods“ dietary pattern. This result is in line with others showing that: 1) shorter sleep duration in hours per night was associated with poor dietary choices (i.e. food with higher energy density, higher intake of added sugar among school-aged children (Kjeldsen *et al.*, 2013) and 2) an decrease in sleep duration resulted in a higher food intake and higher weight in 8 to 11 year-old children (Hart *et al.*, 2013).

Screen and TV viewing has regularly been associated with short sleep duration among preschool- and school-aged children and among adolescents (reviewed in Jolin and Weller, 2011). Nuutinen *et al* recently observed this association in a longitudinal study in Finland, specifically among boys aged between 10 to 13 years and not among girls (Nuutinen *et al.*, 2013). This gender specific association has been previously commented on by Punamaki (Punamäki *et al.*, 2007). In the present study, children were pre-schoolers, with no baseline difference in TV viewing duration between girls and boys, suggesting a gender-specific effect on sleep duration of either TV viewing duration or associated habits still unidentified and thus not accounted for in the analyses. One explanation could be the clustering of parental rules for different aspects of pre-schoolchildren’s life-styles as shown very recently by Jones *et al* for dietary and television viewing rules, meaning that parent who apply rules for diet also apply rules for TV viewing duration. They also showed that both rules were associated with children’s sleep duration and obesity risk among 3 years old children but did not study gender difference (Jones *et al.*, 2014).

Our study has some limitations. Sleep duration was calculated based on self-administered questionnaires asking for usual bedtimes and wake up times with no information on sleep onset. They may be different from bedtimes and difficult for parents to estimate. While sleep duration here reflects time in bed, this is a measure still widely used in epidemiology (Blair *et al.*, 2012; Galland *et al.*, 2012; Hense *et al.*, 2011). To better estimate sleep onset and time spent awake, an independent and objective measure of sleep by actigraphy would have been more accurate but had not been considered at the time of the study design nor on data collection at 3 years (cost and logistical issues). Simple parental reports on their child’s sleep duration have however been shown to be reliable when compared to actigraphy (Sadeh *et al.*, 1995; Iwasaki *et al.*, 2010). Given that the current study is a secondary analysis, we do not have comprehensive information regarding the whole range of possible sleep disorders. For instance, sleep disordered breathing (SDB) is usually detected in children aged 3 to 6, mostly due to enlarged tonsils and adenoids, and with a still debated male predominance according to age (Sinha and Guilleminault, 2010; Ramli and Samsinah, 2012). The SDB prevalence is estimated at 7.45% (Lumeng and Chervin, 2008). SDB may be one of the components not accounted for, resulting in the borderline effect of frequent night awakenings among boys. Altogether, these limitations may lead to an over-estimation of sleep duration and thus reduce our capacity to detect factors associated with short sleep duration. The food frequency questionnaire used is supported by complementary analyses despite the fact that it has not been validated in young children (Lioret *et al.*, 2015). As our analysis is cross-sectional, we cannot infer causality of the relationship. This however suggests early set up of interplay between sleep mechanisms and/or regulation and BMI over a general population range, which is not restricted to more extreme situations especially regarding obesity prevalence (Hart *et al.*, 2011; Chen *et al.*, 2008); the strong gender differentiation may be due to cultural paradigms or physiological mechanisms which both need to be further explored.

In conclusion, we showed that, early in life, factors associated with short sleep duration are mostly gender differentiated. While parental behaviour at bedtime was associated in both genders, among girls short sleep duration at 3 years may be more associated with factors also related to behaviour: home child minding and a diet characterized by lower intake of fruits and vegetables; while among boys short sleep duration at 3 years was associated with more physiological or health oriented variables (high BMI-z-score), and with TV viewing. These results suggest either a patterning of parental behaviours that differs according to gender, or a gender-specific sleep physiology, or both.

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## References


Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Hafer, A. and Carskadon, M.A., Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5-year-old children. *Sleep*. 2005, **28:** 1568–1577.

Agras, W.S., Bryson, S., Hammer, L.D. and Kraemer, H.C. Childhood risk factors for thin body preoccupation and social pressure to be thin. *J Am Acad Child and Adolesc Psychiatry*. 2007, **46:** 171–178.

Alsharairi, N.A. and Somerset, S.M. Associations between Parenting Styles and Children's Fruit and Vegetable Intake. *Ecol Food Nutr*. 2015, 54:93-113.

Berger, R.H., Miller, A.L., Seifer, R., Cares, S.R. and Lebourgeois, M.K. Acute sleep restriction effects on emotion responses in 30- to 36-month-old children: Sleep restriction and emotion in toddlers. *J Sleep Res*. 2012, **21:** 235–246.

Biggs, S.N., Lushington, K., James Martin, A., van den Heuvel, C. and Declan Kennedy, J. Gender, socioeconomic, and ethnic differences in sleep patterns in school-aged children. *Sleep Med.* 2013, **14:** 1304–1309.

Blair, P.S., Humphreys, J.S., Gringras, P., Taheri, S., Scott, N., Emond, A., Henderson, J. and Fleming, P.J. Childhood sleep duration and associated demographic characteristics in an English cohort: *Sleep.* 2012, **35:** 353–360.

Cattell, R.B. The scree test for the number of factors. *Multivariate Behav Res*. 1966: **1**, 245–276.

Chen, X., Beydoun, M.A. and Wang, Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. *Obesity.* 2008, **16:** 265–274.

Coulombe, J.A. and Reid, G.J. Agreement With Night-Waking Strategies Among Community Mothers of Preschool-Aged Children. *J Pediatr Psychol.* 2012, **37:** 319–328.

Deschamps, V., de Lauzon-Guillain, B., Lafay, L., Borys, J.M., Charles, M.A. and Romon, M., Reproducibility and relative validity of a food-frequency questionnaire among French adults and adolescents. *Eur J Clin Nutr*. 2009, **63:** 282–291.

Foley, L.S., Maddison, R., Jiang, Y., Marsh, S., Olds, T. and Ridley, K., 2013. Presleep Activities and Time of Sleep Onset in Children. *Pediatrics*. 2013, **131:** 276–282.

Führer, R. and Rouillon, F. La version française de l'échelle CES-D. Description et traduction de l'échelle d'autoévaluation [The French version of CES-D: Description and translation of the self-report scale]. *Psychiatr. Psychobiol*. 1989, **4:** 163–166.

Galland, B.C., Taylor, B.J., Elder, D.E. and Herbison, P. Normal sleep patterns in infants and children: a systematic review of observational studies. *Sleep Med Rev.* 2012, **16:** 213–222.

Gruber, R. Short sleep duration is associated with teacher-reported inattention and cognitive problems in healthy school-aged children. *Nat Sci Sleep.* 2012, **4:** 33–40

Hart, C.N., Cairns, A. and Jelalian, E. Sleep and Obesity in Children and Adolescents. *Pediatr Clin N Am.* 2011, **58:** 715–733.

Hart, C.N., Carskadon, M.A., Considine, R.V., Fava, J.L., Lawton, J., Raynor, H.A., Jelalian, E., Owens, J. and Wing, R. Changes in Children's Sleep Duration on Food Intake, Weight, and Leptin. *Pediatrics*. 2013, **132:** e1473–1480.

Hense, S., Barba, G., Pohlabeln, H., De Henauw, S., Marild, S., Molnar, D., Moreno, L.A., Hadjigeorgiou, C., Veidebaum, T. and Ahrens, W. Factors that influence weekday sleep duration in European children. *Sleep.* 2011, **34:** 633–639.

Iwasaki, M., Iwata, S., Iemura, A., Yamashita, N., Tomino, Y., Anme, T., Yamagata, Z., Iwata, O. and Matsuishi, T. Utility of Subjective Sleep Assessment Tools for Healthy Preschool Children: A Comparative Study Between Sleep Logs, Questionnaires, and Actigraphy: *J Epidemiol.* 2010, **20:** 143–149.

Johnson, N. and McMahon, C. Preschoolers' sleep behaviour: associations with parental hardiness, sleep-related cognitions and bedtime interactions. *J Child Psychol Psychiatry.* 2008, **49:** 765–773.

Jolin, E.M. and Weller, R.A. Television viewing and its impact on childhood behaviors. *Cur Psychiatry Rep.* 2011,**13:** 122–128.

Jones, C.H.D., Pollard, T.M., Summerbell, C.D. and Ball, H. Could parental rules play a role in the association between short sleep and obesity in young children? *J Biosoc Sci.* 2014, **46:** 405–418.

Kjeldsen, J.S., Hjorth, M.F., Andersen, R., Michaelsen, K.F., Tetens, I., Astrup, A., Chaput, J.-P. and Sjödin, A. Short sleep duration and large variability in sleep duration are independently associated with dietary risk factors for obesity in Danish school children. *Int J Obes.* 2013, **38:** 32–39.

Kline, P. *An easy guide to factor analysis*: Routledge, London, 1994.

Lioret, S., Betoko, A., Forhan, A., Charles, M.A., Heude, B. and De Lauzon-Guillain, B. Dietary patterns track from infancy to preschool age: cross-sectional and longitudinal perspectives. *J Nutr.* 2015, In Press.

Lumeng, J.C. and Chervin, R.D. Epidemiology of Pediatric Obstructive Sleep Apnea. *Proc Am Thorac Soc.* 2008, **5:** 242–252.

Al Mamun, A., O'Callaghan, F., Scott, J., Heussler, H., O'Callaghan, M., Najman, J. and Williams, G. Continuity and discontinuity of trouble sleeping behaviors from early childhood to young adulthood in a large Australian community-based-birth cohort study. *Sleep Med.*

2012, **13:** 1301–1306.

McDonald, L., Wardle, J., Llewellyn, C.H., van Jaarsveld, C.H.M. and Fisher, A. Predictors of shorter sleep in early childhood. *Sleep Med.* 2014, 15:536-540.

McHale, S.M., Crouter, A.C. and Whiteman, S.D. The family contexts of gender development in childhood and adolescence. *Soc Dev*. 2003, **12:**125–148.

Mindell, J.A., Sadeh, A., Kohyama, J. and How, T.H. Parental behaviors and sleep outcomes in infants and toddlers: A cross-cultural comparison. *Sleep Med.* 2010, **11:** 393–399.

Nevarez, M.D., Rifas-Shiman, S.L., Kleinman, K.P., Gillman, M.W. and Taveras, E.M., Associations of early life risk factors with infant sleep duration. *Acad Pediatr.* 2010, **10:** 187–193.

Nuutinen, T., Ray, C. and Roos, E. Do computer use, TV viewing, and the presence of the media in the bedroom predict school-aged children's sleep habits in a longitudinal study. *BMC public health.* , 2013, **13:** 684–691.

O'Callaghan, F.V., Al Mamun, A., O'Callaghan, M., Clavarino, A., Williams, G.M., Bor, W., Heussler, H. and Najman, J.M. The link between sleep problems in infancy and early childhood and attention problems at 5 and 14 years: Evidence from a birth cohort study. *Early Hum Dev*. 2010, **86:** 419–424.

De Onis, M. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ.* 2007, **85:** 660–667.

Punamäki, R.-L., Wallenius, M., Nygård, C.-H., Saarni, L. and Rimpelä, A., Use of information and communication technology (ICT) and perceived health in adolescence: The role of sleeping habits and waking-time tiredness. *J Adolescence.* 2007, **30:** 569–585.

Quach, J., Hiscock, H., Canterford, L. and Wake, M. Outcomes of Child Sleep Problems Over the School-Transition Period: Australian Population Longitudinal Study. *Pediatrics.* 2009, **123:** 1287–1292.

Radloff, L.S. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977, **1:** 385–401.

Ramli, Z. and Samsinah, H. Prevalence of sleep disordered breathing symptoms among Malay school children in a primary school in Malaysia. *Med J Malaysia.* 2012, **67:** 181–185.

Rodenburg, G., Oenema, A., Pasma, M., Kremers, S.P.J. and van de Mheen, D. Clustering of food and activity preferences in primary school children: *Appetite*. 2013, **60**: 123–132.

Sadeh, A., Hauri, P.J., Kripke, D.F. and Lavie, P. The role of actigraphy in the evaluation of sleep disorders. *Sleep.* 1995, **18:** 288–302.

Sadeh, A., Mindell, J.A., Luedtke, K. and Wiegand, B. Sleep and sleep ecology in the first 3 years: a web-based study. *J Sleep Res*. 2009, **18:** 60–73.

Sadeh, A., Raviv, A. and Gruber, R. Sleep patterns and sleep disruptions in school-age children. *Dev Psychol.* 2000, **36:** 291–301.

Sinha, D. and Guilleminault, C. Sleep disordered breathing in children. *Ind J Med Res.* 2010, **131:** 311–320.

Sleep Foundation. How Much Sleep Do We Really Need? | National Sleep Foundation. 2013, http://sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need

Touchette, E., Petit, D., Paquet, J., Boivin, M., Japel, C., Tremblay, R.E. and Montplaisir, J.Y., Factors associated with fragmented sleep at night across early childhood. *Arch Pediatr Adolesc Med*. 2005, **159:** 242–249.

Xie, X., Wu, H., Lee, T., Wang, C.M.B., Zhou, X., Lu, Y., Yuan, Z. and Maddock, J.E. Gender differences in home environments related to childhood obesity in Nanchang, China. *Child Obes.* 2014, **10**: 416–423.

**Table 1**. Sample characteristics.

| | Total, N=1028 % (N) or mean (SD) | Boys, N=546 % (N) or mean (SD) | Girls, N=482 % (N) or mean (SD) | p-value |
|---|---|---|---|---|
| **Centre** | | | | 0.04 |
| Poitiers | 51.1 (525) | 54.0 (295) | 47.7 (230) | - |
| Nancy | 48.9 (503) | 46.0 (251) | 52.3 (252) | |
| **Familial income (euros/month)** | | | | 0.72 |
| >3800 | 20.1 (207) | 19.8 (108) | 20.5 (99) | - |
| 3001 - 3800 | 26.5 (272) | 27.5 (150) | 25.3 (122) | |
| 2301 - 3000 | 23.5 (242) | 22.9 (125) | 24.3 (117) | |
| 1500 - 2300 | 19.5 (200) | 20.3 (111) | 18.5 (89) | |
| ≤1500 | 10.4 (107) | 9.5 (52) | 11.4 (55) | |
| **Educational level** | | | | 0.51 |
| Both parent ≥ 12 years | 41.3 (424) | 42.1 (230) | 40.3 (194) | |
| 1 parent ≥ 12 years | 29.4 (302) | 30.0 (164) | 28.6 (138) | |
| Both parent < 12 years | 29.4 (302) | 27.8 (152) | 31.1 (150) | |
| **Principal child care arrangement** | | | | 0.62 |
| Community child care | 76.0 (781) | 75.6 (413) | 76.4 (368) | |
| Nursery assistant | 14.2 (146) | 13.7 (75) | 14.7 (71) | |
| Home child minding | 9.8 (101) | 10.6 (58) | 8.9 (43) | |
| **Isolated mother (yes)** | 3.0 (31) | 2.2 (12) | 3.9 (19) | 0.11 |
| **Maternal age at birth (years)** | 30.0 (4.6) | 30.0 (4.5) | 30.0 (4.6) | 0.83 |
| **Primiparous (yes)** | 47.2 (485) | 47.6 (260) | 46.7 (225) | 0.76 |
| **Maternal BMI (kg/m2)** | 23.1 (4.3) | 23.0 (4.2) | 23.2 (4.4) | 0.53 |
| **Maternal depression** | | | | |
| During pregnancy | 4.1 (42) | 3.5 (19) | 4.8 (23) | 0.30 |
| At 3 yo | 7.0 (72) | 6.8 (37) | 7.3 (35) | 0.76 |
| **Gestational age (weeks)** | 39.3 (1.6) | 39.3 (1.7) | 39.3 (1.6) | 0.42 |
| **Child's birth weight (g)** | 3313 (491) | 3378 (508) | 3239 (461) | 0.0001 |
| **Physical activities** | | | | 0.20 |
| Q4 | 25.3 (260) | 23.3 (127) | 27.6 (133) | |
| Q3 | 25.0 (257) | 25.6 (140) | 24.3 (117) | |
| Q2 | 24.8 (255) | 24.0 (131) | 25.7 (124) | |
| Q1 | 24.9 (256) | 27.1 (148) | 22.4 (108) | |
| **TV watching (h/24h)** | 1h00 (0h46) | 1h00 (0h46) | 0h59 (0h46) | 0.55 |
| **BMI-z-score** | 0.10 (0.85) | 0.08 (0.89) | 0.12 (0.81) | 0.54 |
| **Food patterns score** | | | | |
| Processed | -0.01 (0.92) | 0.03 (1.01) | -0.06 (0.80) | 0.09 |
| Fruits and vegetables | 0.08 (0.98) | 0.00 (1.01) | 0.17 (0.93) | 0.005 |
| **Night awakenings** | | | | 0.14 |
| No | 74.32 (764) | 76.2 (416) | 72.2 (348) | |
| Yes | 25.68 (264) | 23.8 (130) | 27.8 (134) | |
| **Parental presence when falling asleep** | | | | 0.74 |
| No | 95.6 (983) | 95.4 (521) | 95.8 (462) | |
| Yes | 4.4 (45) | 4.6 (25) | 4.2 (20) | |
| **Total sleep duration** | 12hrs35 (0h56) | 12hrs32 (0h57) | 12hrs38 (0h56) | 0.13 |
| **Night sleep duration** | 10hrs51 (0h40) | 10hrs47 (0h40) | 10hrs56 (0h39) | 0.0004 |
| **Nap duration (N=935)** | 1hrs54 (0h31) | 1hrs55 (0h32) | 1hrs52 (0h29) | 0.08 |
| **Bedtime** | 20hrs36 (0h29) | 20hrs38 (0h31) | 20hrs34 (0h28) | 0.02 |
| **Wake-up time** | 7hrs27(0h36) | 7hrs25 (0h37) | 7hrs29 (0h35) | 0.05 |

Q1-4, Quartile of physical activity according to season of self-administered questionnaire completion.

**Table 2.** Description of male short sleepers (<12h00/24h) and multivariate logistic regression analyses by socioeconomic, maternal and child variables.

| | Short sleepers, N=104<br>19% of boys<br>% in each strata (N)<br>or mean (SD) | Adjusted 104 vs 442<br>Model 0<br>OR [95%CI] | p-value | Model 1<br>OR [95%CI] | p-value |
|---|---|---|---|---|---|
| <u>**Socio-economic factors**</u> | | | | | |
| **Centre** | | | 0.62 | | 0.82 |
| Poitiers | 18.0 (53) | Ref | | Ref | |
| Nancy | 20.3 (51) | 1.12 (0.71 - 1.77) | | 1.65 (0.66 - 1.69) | |
| **Familial incomes (euros/month)** | | | 0.36 | | 0.28 |
| >3800 | 23.2 (25) | Ref | | Ref | |
| 3001 - 3800 | 18.0 (27) | 0.72 (0.38 - 1.38) | | 0.79 (0.41 - 1.52) | |
| 2301 - 3000 | 16.8 (21) | 0.61 (0.30 - 1.25) | | 0.58 (0.28 - 1.21) | |
| 1500 - 2300 | 21.6 (24) | 0.91 (0.43 - 1.92) | | 0.86 (0.40 - 1.85) | |
| ≤1500 | 13.5 (7) | 0.41 (0.14 - 1.19) | | 0.34 (0.11 - 1.03) | |
| **Educational level** | | | 0.87 | | 0.79 |
| Both parent ≥ 12 years | 20.0 (46) | Ref | | Ref | |
| 1 parent with ≥ 12 years | 17.7 (29) | 0.86 (0.50 - 1.50) | | 0.83 (0.47 - 1.46) | |
| Both parent < 12 years | 19.1 (29) | 0.90 (0.46 - 1.75) | | 0.85 (0.43 - 1.68) | |
| **Principal child care arrangement** | | | 0.23 | | 0.24 |
| Community child care | 20.6 (85) | Ref | | Ref | |
| Nursery assistant | 14.7 (11) | 0.63 (0.31 - 1.29) | | 0.70 (0.34 - 1.44) | |
| Home child minding | 13.8 (8) | 0.57 (0.25 - 1.30) | | 0.52 (0.22 - 1.22) | |
| <u>**Maternal factors**</u> | | | | | |
| **Isolated mother** | | | 0.91 | | 0.65 |
| No | 19.1 (102) | Ref | | Ref | |
| Yes | 16.7 (2) | 0.91 (0.18 - 4.55) | | 0.68 (0.13 - 3.57) | |
| **Maternal BMI (kg/m2)** | 23.5 (4.4) | - | | 1.03 (0.98 - 1.09) | 0.25 |
| **Maternal depression at 3 yo** | | | | | |
| No | 18.7 (95) | | | | |
| Yes | 24.3 (9) | - | | - | |
| <u>**Child's factors**</u> | | | | | |
| **Night awakenings** | | | | | **0.06** |
| No | 16.8 (70) | | | Ref | |
| Yes | 26.2 (34) | - | | **1.61 (0.98 - 2.64)** | |

| | | | | | |
|---|---|---|---|---|---|
| **Parental presence when falling asleep** | | | | | **0.03** |
| No | 18.0 (94) | | | Ref | |
| Yes | 40.0 (10) | - | | **2.84 (1.08 - 7.47)** | |
| **Physical activities** | | | 0.92 | | 0.89 |
| Q4 | 19.6 (29) | Ref | | Ref | |
| Q3 | 18.3 (24) | 0.83 (0.42 - 1.62) | | 0.83 (0.41 - 1.66) | |
| Q2 | 20.7 (29) | 0.98 (0.53 - 1.81) | | 1.05 (0.56 - 1.97) | |
| Q1 | 17.3 (22) | 0.85 (0.45 - 1.61) | | 0.87 (0.45 - 1.69) | |
| **TV watching (h/24h)** | 1h17 (0h55) | **1.72 (1.29 - 2.28)** | **0.0002** | **1.65 (1.23 - 2.21)** | **0.0008** |
| **Food patterns** | | | | | |
| Processed | 0.02 (0.94) | 0.98 (0.77 - 1.24) | 0.87 | 0.99 (0.79 - 1.25) | 0.94 |
| Fruits and vegetables | -0.09 (1.09) | 1.01 (0.79 - 1.30) | 0.92 | 1.02 (0.79 - 1.30) | 0.90 |
| **BMI-z-score** | 0.29 (0.83) | - | - | **1.31 (1.01 - 1.69)** | **0.04** |

OR, Odds ratio; (95%CI) 95% confidence interval; Q1-4, Quartile of physical activity according to season of self-administered questionnaire completion; OR are mutually adjusted for all the variables in model 0 and 1.

**Table 3.** Description of female shorter sleepers (<12h00/24h) and multivariate logistic regression analyses by socioeconomic, maternal and child variables.

| | Short sleepers. N=82 17% of girls % in each strata (N) or mean (SD) | Adjusted 82 vs 400 Model 0 OR [95%CI] | p-value | Model 1 OR [95%CI] | p-value |
|---|---|---|---|---|---|
| **Socio-economic factors** | | | | | |
| **Centre** | | | 0.09 | | 0.08 |
| Poitiers | 13.9 (32) | Ref | | Ref | |
| Nancy | 19.8 (50) | 1.59 (0.93 -2.71) | | 1.63 (0.95 - 2.81) | |
| **Familial incomes (euros/month)** | | | 0.64 | | 0.67 |
| >3800 | 13.1 (13) | Ref | | Ref | |
| 3001 - 3800 | 20.5 (25) | 1.31 (0.60 -2.84) | | 1.43 (0.65 - 3.12) | |
| 2301 - 3000 | 12.0 (14) | 0.81 (0.33 -1.96) | | 0.87 (0.35 - 2.13) | |
| 1500 - 2300 | 19.1 (17) | 1.03 (0.40 -2.67) | | 1.04 (0.40 - 2.73) | |
| ≤1500 | 23.6 (13) | 1.50 (0.53 -4.23) | | 1.43 (0.50 - 4.11) | |
| **Educational level** | | | 0.63 | | 0.59 |
| Both parent ≥ 12 years | 17.0 (33) | Ref | | Ref | |
| 1 parent ≥ 12 years | 13.0 (18) | 0.72 (0.37 -1.42) | | 0.70 (0.35 - 1.39) | |
| Both parent < 12 years | 20.7 (31) | 0.90 (0.45 -1.82) | | 0.82 (0.40 - 1.68) | |
| **Principal child care arrangement** | | | 0.03 | | 0.06 |
| Community child care | 16.0 (59) | Ref | | Ref | |
| Nursery assistant | 12.7 (9) | 0.79 (0.36 -1.74) | | 0.84 (0.38 - 1.88) | |
| Home child minding | 32.6 (14) | 2.60 (1.22 -5.55) | | 2.45 (1.13 - 5.29) | |
| **Maternal factors** | | | | | |
| **Isolated mother** | | | 0.39 | | 0.49 |
| No | 16.6 (77) | Ref | | Ref | |
| Yes | 26.3 (5) | 1.70 (0.51 -5.69) | | 1.55 (0.45 - 5.28) | |
| **Maternal BMI (kg/m2)** | 23.5 (4.5) | - | | - | |
| **Maternal depression at 3 yo** | | | | | 0.15 |
| No | 16.3 (73) | | | Ref | |
| Yes | 25.7 (9) | - | | 1.87 (0.80 - 4.38) | |
| **Child's factors** | | | | | |
| **Night awakenings** | | | | | |
| No | 15.8 (55) | | | | |
| Yes | 20.2 (27) | - | | - | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Parental presence when falling asleep** | | | | | | 0.008 |
| | No | 15.8 (73) | | | Ref | |
| | Yes | 45.0 (9) | - | | 3.89 (1.42 - 10.67) | |
| **Physical activities** | | | | 0.47 | | 0.41 |
| | Q4 | 16.7 (18) | Ref | | Ref | |
| | Q3 | 14.5 (18) | 1.37 (0.67 -2.81) | | 0.80 (0.37 - 1.75) | |
| | Q2 | 15.4 (18) | 1.02 (0.47 -2.19) | | 1.05 (0.48 - 2.26) | |
| | Q1 | 20.1 (28) | 0.79 (0.37 -1.69) | | 1.45 (0.70 - 3.00) | |
| **TV watching (h/24h)** | | 1h07 (0h53) | 1.03 (0.74 -1.44) | 0.84 | 1.06 (0.76 - 1.47) | 0.75 |
| **Food patterns** | | | | | | |
| | Processed | -0.13 (0.80) | 0.91 (0.65 -1.26) | 0.56 | 0.89 (0.63 - 1.24) | 0.49 |
| | Fruits and vegetables | -0.23 (0.88) | 0.54 (0.39 -0.75) | 0.0002 | 0.55 (0.40 - 0.76) | 0.0003 |
| **BMI-z-score** | | 0.08 (0.89) | - | | - | |

OR, Odds ratio; (95%CI) 95% confidence interval; Q1-4, Quartile of physical activity according to season of self-administered questionnaire completion; OR are mutually adjusted for all the variables in model 0 and 1.

**Figure 1**. Distribution of sleep duration estimated by time in bed for 3 year old boys N=546 (black) and girls N=482 (grey) in the EDEN cohort study.

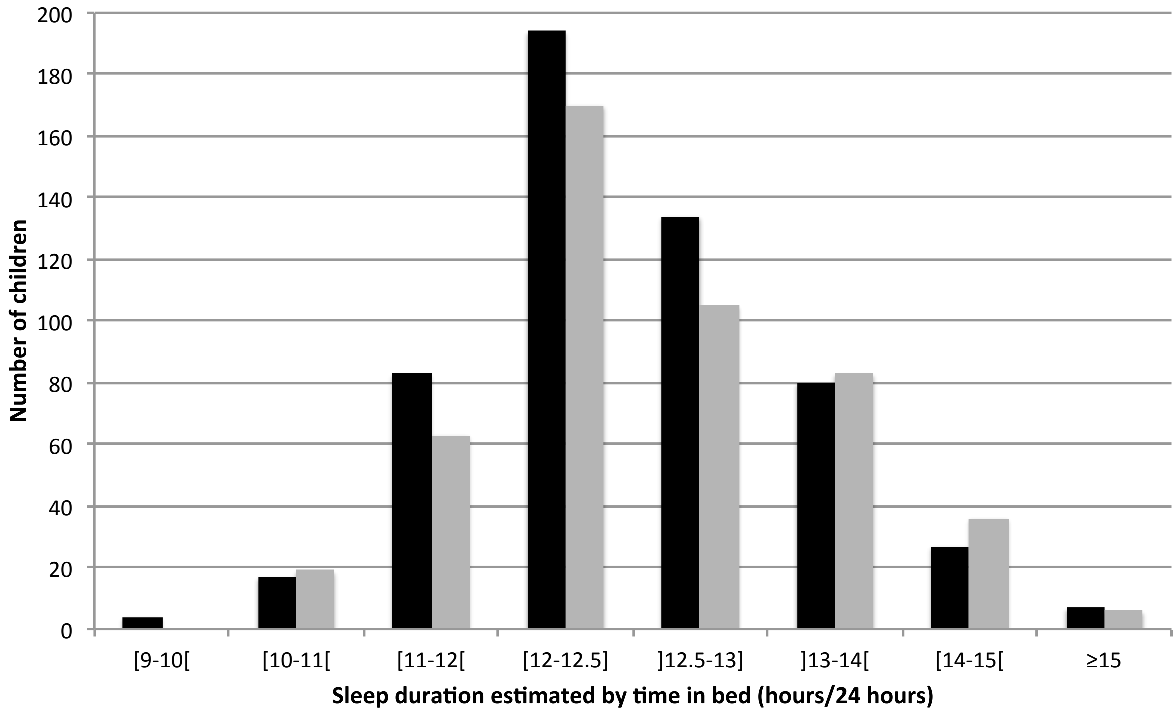
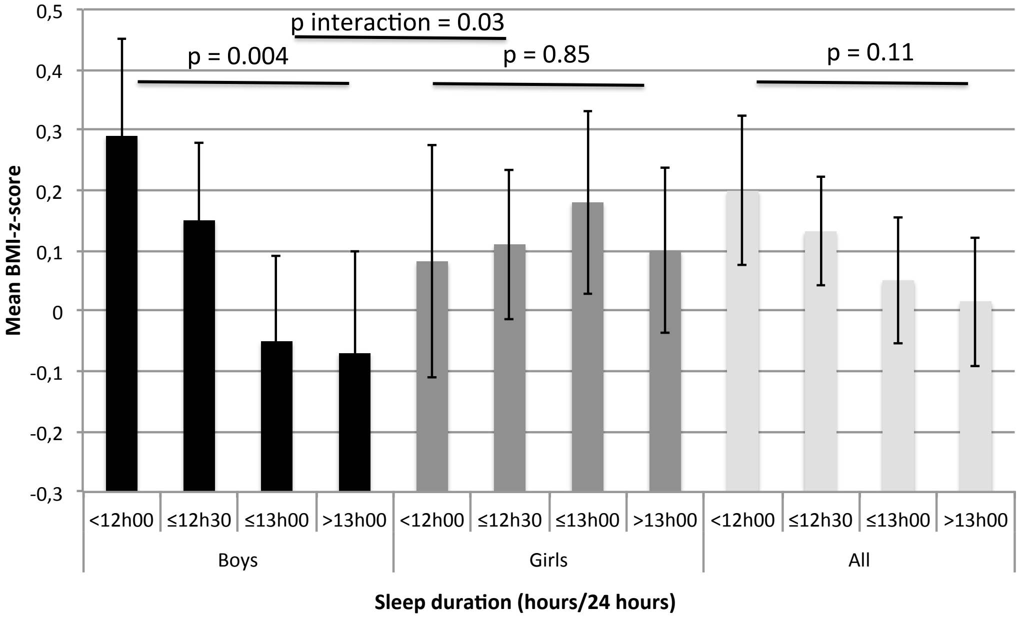


**Figure 2**. Crude mean BMI z-scores (A) and mean scores on “fruits and vegetables” dietary patterns (B) according to sleep duration estimated by time in bed for boys N=546 (black), girls N=482 (dark grey) and all children N=1028 (light grey).

A




B