SLEEP DURATION, SLEEP BROBLEMS AND RELATED HEALTH BEHAVIOURS IN 6 – 8 -YEAR-OLD CHILDREN

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The significance of sleep for functional capacity and health is emphasized in childhood. Besides causing subjective discomfort, such as excessive daytime sleepiness, sleep disorders have been associated with an increased risk for cardiovascular and metabolic diseases in adults. However, there is still a lot to discover about how sleep affects quality of life and functional capacity, or what the potential determinants of insufficient sleep are in children. This study was conducted as a part of larger children's lifestyle intervention study called The Physical Activity and Nutrition in Children (PANIC) Study, carried out at University of Eastern Finland, Faculty of Health Sciences, Institute of Biomedicine. The aim of the study was to estimate the prevalence and associations of common sleep problems in 6 – 8-year-old children. Moreover, the associations between short sleep and other health behaviours such as physical activity, electronic media time and meal pattern, after adjustment for possible confounding factors, were investigated.

Cross sectional data of 511 participants were analysed, at the baseline of the study. Children's sleep problems were assessed by the PANIC Sleep Questionnaire, administered by the parents. Based on previous studies sleep duration was divided into short sleep (< 10 hours/night) and normal sleep (≥ 10 hours/night). Physical activity (PA) and electronic media time were assessed by the physical activity and sedentary behaviour questionnaire, administered by the parents. Meal intake frequency was estimated by a 4-day food diary. Cardiorespiratory fitness (CRF) was measured by a graded maximal exercise stress test on a bicycle ergometer. Proportion of body fat was assessed by dual-energy x-ray absorptiometry (DEXA). In addition, age, gender and parental socioeconomic status (SES) were assessed by a questionnaire administered by the parents.

The main findings were that different health behaviours were associated with sleep duration. The association remained after adjusting for CRF, proportion body fat, gender and SES. The risk for short sleep duration was associated with longer duration of electronic-media use (P=0.005) and less habitual physical activity (P=0.023). Children who slept longer had more regular meal pattern (P=0.001). Sleep duration was also negatively associated with different sleep problems such as daytime sleepiness and behavioural insomnia.

In conclusion, sleep duration in primary school children can be affected by or have an effect on different health behaviours such as physical activity, electronic media time, meal pattern or sleep problems. Therefore it is important to pay more attention to the sleep quality of primary school children by parents and healthcare professionals. In the future, it would be of interest to study possible causal relationships between sleep duration, other lifestyles and possible health outcomes.

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Biolääketieteen yksikkö
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Unen merkitys terveyden ja toimintakyvyn kannalta on olennainen ja se on korostunut lapsuudessa. Epämukavuutta lisäävän päiväaikaisen väsymyksen lisäksi unihäiriöiden on todettu lisäävän mm. valtimo- ja verisuonitautien ja metabolisen oireyhtymän riskiä aikuisilla. Varsin vähän kuitenkin tiedetään unen vaikutuksesta elämänlaatuun ja toimintakykyyn sekä riittämätöntä unta aiheuttavista tekijöistä lapsilla. Tämä tutkimus on osa Itä-Suomen yliopistossa toteutettavaa laajempaa Lasten liikunta ja ravitsemus (PANIC) -tutkimusta. Tässä tutkimuksessa määritettiin 6 – 8 -vuotiaiden lasten unen kestoa ja yleisimpiä unihäiriöitä kuten toiminnallista unettomuutta, uniapneaa sekä päiväaikaista väsymystä. Lisäksi tarkasteltiin unen keston yhteyttä erilaisiin elintapoihin kuten fyysiseen aktiivisuuteen, viihdemedia-aikaan ja ateriarytmiin.

Tutkimus toteutettiin poikkileikkausasetelmana ja tutkimusaineistona oli 6-8-vuotiaita (N=511) lapsia, PANIC-tutkimuksen alkutilanteessa. Vanhemmat vastasivat lasten unitottumuksista unikyselylomakkeella. Lapsen keskimääräistä unen pituutta kysyttiin puolen tunnin tarkkuudella. Tutkimustietoon perustuen määriteltiin vähäinen uni (< 10 tuntia/yö) ja normaali uni (≥ 10 tuntia/yö). Fyysisen aktiivisuuden sekä viihde-median vuorokautinen ajankäyttö määritettiin liikuntalomakkeen avulla. Ateriarytmiä arvioitiin neljän vuorokauden ruokapäiväkirjalla. Kestävyyskunto määritettiin maksimaalisella polkupyöräergo rasituksella ja kehon rasvakudoksen osuus kaksienergiaisella röntgenabsorptiometrillä (DEXA). Lisäksi sosiodemografiset taustatiedot kuten lasten ikä, sukupuoli ja perheen sosioekonominen status (SES) selvitettiin vanhempien täyttämän kyselylomakkeen avulla.

Päälöydöksenä havaittiin, että useat terveystavat ovat yhteydessä unen kestoon ja nämä yhteydet säilyivät fyysisen kunnon, kehon rasvakudoksen ja sosiodemografisten taustatietojen vakioinnin jälkeen. Vähäisen unen riski oli yhteydessä runsaaseen viihdemedia-aikaan (P=0.005), sekä vähäiseen fyysiseen aktiivisuuteen (P=0.023). Pidempi unen määrä oli puolestaan yhteydessä säännöllisempään ateriarytmiin (P=0.001). Unen kesto oli lisäksi käänteisesti yhteydessä unihäiriöihin kuten päiväaikaiseen väsymykseen sekä toiminnalliseen unettomuuteen.

Yhteenvetona voidaan todeta, että ala-kouluikäisten unen kestolla näyttäisi olevan vaikutusta toisiin elintapoihin, kuten fyysiseen aktiivisuuteen, viihde-media aikaan, ateriarytmiin, sekä muihin uniongelmiin. Sen vuoksi on tärkeätä että vanhemmat ja terveysalan ammattilaiset huomioivat lasten unen keston entistä tärkeimpänä osana terveellisiä elintapoja. Tulevaisuudessa olisi tärkeää tutkia unen keston, erilaisten elintapojen sekä mahdollisten terveysriskien välistä kausaliteettia.

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1 INTRODUCTION

The significance of sleep for functioning and health has indisputably been demonstrated (Rechtschaffen et al. 1989). Importance of adequate amount and quality of sleep for the secretion of growth hormone and sustainability of body homeostasis has been observed (Nieminen et al. 2002), as well as for the development of the child (Dahl 1998). Insufficient sleep has been related to different types of health problems in childhood, including obesity (Patel and Hu 2008), impaired cognitive functioning (Touchette et al. 2007), and altered emotionality (Nixon et al. 2008).

It has been demonstrated that children's sleep pattern varies during different developmental phases (Thorsleifsdottir et al. 2002, Iglowstein et al. 2003). The sleep pattern can be disturbed by several factors and the cause of insufficient sleep can vary between the development periods. At the primary school-age sleep can be affected by different environmental, social or behavioural distractions (Hoban 2010). Epidemiological studies have found an association between sleep duration and age (Hitze et al. 2009), school-start time (Zhang et al. 2010), time spent for electronic devices (Li et al. 2007) and parental sleeping duration (Li et al. 2010).

Undoubtedly, sleep has an important role in the development and health of school-age children. However, there are only few studies that estimated the prevalence and associations of common sleep problems (Liu et al. 2005, Van Litsenburg et al. 2010). In addition, few studies have assessed associations between sleep duration and other health behaviors such as habitual physical activity, media time and nutrition. These studies have not been able to demonstrate a clear association between insufficient sleep and unfavorable health behaviors (Hitze et al. 2009, Nixon et al. 2008). Therefore, it is of interest to study sleep duration and health behaviors in more detail.

Today we live in the 24-hour society, where information skills and technical competences are dominating. In this type of society the significance of sufficient sleep is even more emphasized so that we can cope with the challenges of everyday life. This change can be already seen at school where children today meet more expectations. For these reasons, it is important to concentrate on sleep behaviors and their possible associations with other health behaviors during the first decade of lifespan. By identifying the factors that are promoting or impairing sufficient sleep duration and quality in childhood, it may be possible to prevent later health hazards of sleep problems.

The present study aimed to investigate possible associations between sleep duration and other health behaviors such as habitual physical activity, electronic media-time and eating patterns. Also study the prevalence of common sleep problems in 6 – 8-year-old school children.

2 REVIEW OF LITERATURE

2.1 PHYSIOLOGY OF SLEEP

A human being spend about one-third of life asleep. The definition of normal human sleep is described as “a state of perceptual disengagement from and unresponsiveness to the environment” (Carskadon and Dement 2005). Sleep involves a mixture of physiological and behavioural functions. Some of these behaviors are natural components of sleep but there are also inappropriate functions that can deteriorate the sleep quality.

Sleep is traditionally divided into two main stages, the rapid-eye movement (REM) sleep and non-REM (NREM) sleep. According to the 2007 American Association of Sleep Medicine (AASM) standards the NREM sleep is subdivided to stages N1, N2 and N3 representing the depth of the sleep (Silber et al. 2007). Normal sleep consists of sleep periods, each of which in adulthood last for 90 to 120 minutes, except for the first cycle after sleep onset, which lasts for 70 to 100 minutes. The sleep cycle begins with a short period of NREM stage 1 followed by stages N2, N3 and back to N2, before finally moving to REM sleep. Stage 1 NREM sleep serves as a transitional phase between wakefulness and sleep. Stage 2 NREM sleep is somewhat deeper than the stage 1 sleep. The last NREM phase is the N3 which is described as the slow wave sleep. This stage occurs mostly during the first third of the night, and decreases along the later sleep cycles, and is considered to be important in the recovery from the previous day (Silber et al. 2007). After NREM sleep phases, the sleep shifts into REM sleep. Most of the REM sleep occurs in the latter parts of the sleep. REM and NREM sleep have several differences in the physiological and neurological functioning e.g. muscle tone, brain activity, heart rate, sympathetic nerve activity and respiration (Carskadon and Dement 2005).

Circadian rhythms (the 24-hour clock) refer to the daily rhythms in physiology and behavior. These rhythms are thought to regulate sleep-wake cycle, modulate physical activity and nutritional intake and control different bodily functions e.g. temperature, heart rate or hormone secretion. Circadian rhythms are generated by neural structures in the hypothalamus (Dunlap et al. 2004). Circadian timing, working in tandem with the neurotransmitter adenosine and melatonin hormone, determines the ideal timing of and a correctly structure of the sleep episode (Wyatt et al. 1999).

The architecture of sleep changes with the age. Newborn babies can sleep up to 18 hours per day, and the duration declines throughout the childhood and adolescence settling to adults' 7 to 8 hours' sleeping time. Moreover, there are differences in the sleep stage incidences at the early development period. The major alteration in the sleep structure takes place during the first year after birth. The first 2 or 3 months' sleep is discontinuous, consisting of 2 to 4 -hour episodes. Furthermore, the sleep onset starts with REM sleep, rather than NREM. At 3 months of age the sleep cycle attains a more regular pattern, where sleep onset begins with NREM, and REM sleep starts to decrease and shifts to the later parts of sleep. After the first year, the sleep changes become less dramatic.

For children the significance of sleep is even more critical than for adults. Sleep is evidently important for growth, and it has been shown that poor sleep quality is associated with decreased serum levels of biological growth markers (Nieminen et al. 2002). Furthermore sleep deprivation and sleep disturbances are potentially harmful for academic performance, health and cognitive behavior in children (Gozal and Pope 2001, Touchette et al. 2007).

2.2 DEVELOPMENT OF SLEEP HABITS IN CHILDHOOD

The development of organized sleep structure is emphasized in the childhood when body and brain develop (Dahl 1998). It is possible to separate 2 major elements from the development of the children's sleep-wake pattern: 1) change from a fragmented sleep to a consistent sleep and 2) progressively decreasing need of sleep (Sadeh et al. 2000). Sleep problems are also fairly common in children with an estimated proportion of 20 – 30 % (Anders and Eiben 1997, Sadeh et al. 2000).

The reference values for sleep duration across childhood have been presented in different populations. In a Swiss population of 493 children a longitudinal study designed to calculate percentile curves for total sleep duration per 24 hours, from early infancy to late adolescence was executed (Iglowstein et al. 2003). The average sleep duration of 6–8-year-old children was 10 to 11 hours. Curves for 25, 50 and 75 percentile of sleep duration for 0 – 16-year-olds are shown (Figure 1). According to this and another study measuring the sleep duration of children from infancy to early adulthood, sleep duration decreases linearly through the childhood, and this change comes mainly from diminishing daytime sleep (Thorleifsdottir et al. 2002, Iglowstein et al. 2003). Most of the variation in sleep duration between 1 to 5-year-old children seems to come from the amount of daytime sleep. In addition, the family's social status can mediate the sleeping pattern of a child (Acebo et al. 2005). An Icelandic study found that children aged 6 – 8 years had constant 10 - 11 hours' sleep duration. This study also highlighted an important detail that before 9 years of age the sleep duration is quite identical between weekdays and weekends. Nocturnal sleep duration was decreased at the beginning of adolescence, which was accompanied with an increase in daytime sleepiness and naps (Thorleifsdottir et al. 2002).

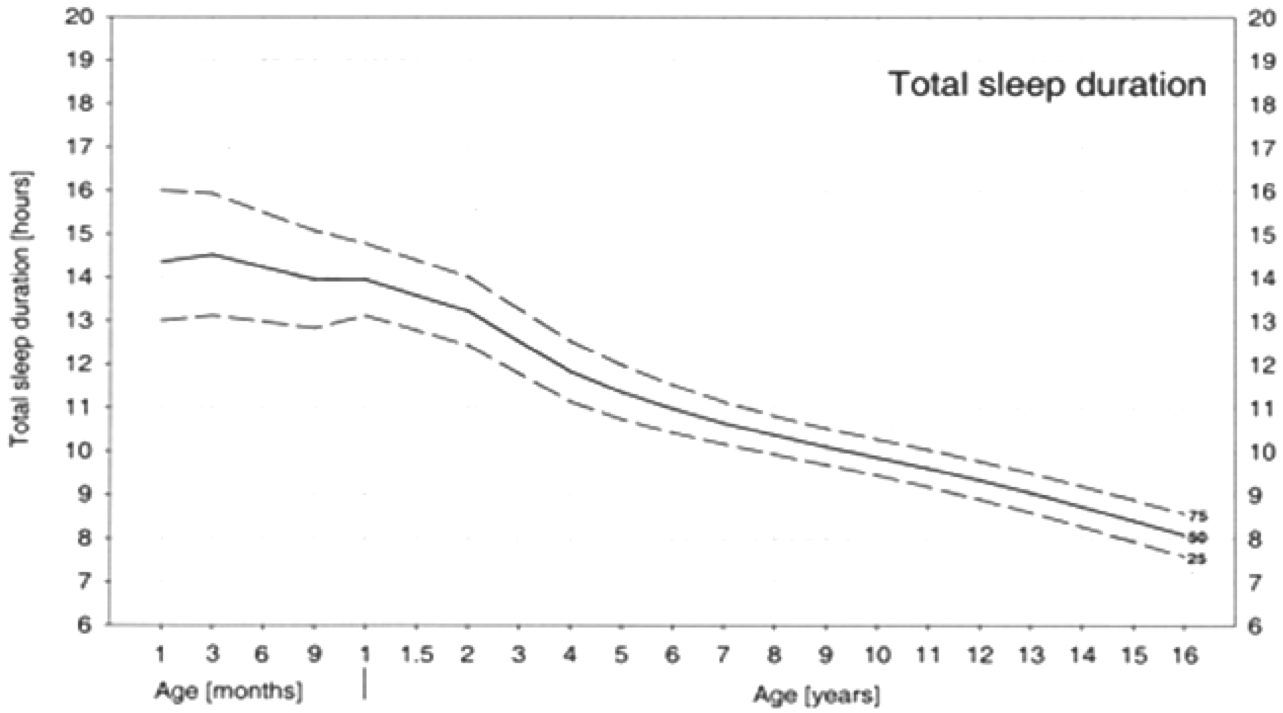

Figure 1. Percentiles (25,50,75) for total sleep duration per 24 hours from infancy to adolescence. Modified from Iglowstein et al. 2003.

In infancy and toddler ages, sleep problems are common, temporary and thus considered rather benign (Moore et al. 2006). They can be prevented with early intervention and teaching of children about correct sleeping habits, for example regular bedtimes and sleeping routines. During the school-age period children are very susceptible to insufficient sleep because of increased awareness of the surrounding environment. Also increased participation in academic, social and extracurricular activities can affect the sufficient sleep pattern. A common way to improve sleep hygiene is to give healtheducation to parents and to children when they are in developmentally appropriate level. The counseling should target areas such as: bedroom circumstances (temperature, lighting and noise), avoidance of the late use of stimulants like energy drinks and restricted use of electronic equipment e.g. TV, computer, video games, mobile phones, or developing a consistent bedtime routine.

2.3 ASSESSMENT OF SLEEP-WAKE BEHAVIOR AND SLEEP DISORDERS

The methods used to assess the sleep-wake pattern of children differ as regards duration, costs and devices. Determination of sleep-wake behavior usually encompasses elements like sleep onset, waking up time, nocturnal sleeping time, time of daytime sleep. Also variables of transition from wake to sleep, and the other way around, can be assessed (Werner et al. 2008).

This chapter covers commonly used assessing methods for sleep-wake behavior and sleep disorders focusing on the usability, validity and comparability between different methods. The scope of different sleep problems is wide, and so are the assessment methods used in sleep medicine. More comprehensive information of children's sleep disorder assessment methods and evaluation algorithms are available from other sources (Ferber and Kryger 1995, Mindell and Owens 2003). This chapter concentrates on the assessing the two most prevalent causes of insufficient sleep for children, SDB and the behavioural insomnia.

The sleep-wake pattern which includes variables such as sleep start, sleep end, sleep duration, and repetition of nocturnal waking, is traditionally assessed subjectively using a questionnaire, interview or diary in larger population based studies because of affordability and smaller investments (Werner et al. 2008). Parental reported questionnaires have been frequently used and accepted for the assessment of children's sleep behaviors (Owens et al. 2000a, Chervin et al. 2000). The use of questionnaires for sleep-wake pattern assessment is the most practical in large epidemiologic studies, but could be inaccurate in clinical settings. Parental questionnaires can overestimate the amount of the child's sleep compared to that measured objectively (Goodwin et al. 2007, Werner et al. 2008). The use of sleep diaries is quite common in clinical sleep studies. In this assessment method, the parents write down times on other details of sleeping behavior of a child for a predetermined time frame, usually 1 – 2 weeks. Sleep diaries are a good supportive method for objective measures, in case of inaccurate recordings or lost data (Acebo et al. 2005).

Objective evaluation of sleep-wake behavior has become more common in field studies after the launching of the actigraphy method in sleep research (Sadeh et al.1995). A systematic literature review revealed that actigraphy suites well into sleep-wake pattern evaluation for normally sleeping children and adults. The same article also pointed out that actigraphy has been successfully used to detect changes in sleep in intervention studies (Sadeh and Acebo 2002). The accuracy of actigraphy-assessed sleep decreases if the sleep embodies long periods of waking without movement, e.g. insomnia (Hauri and Wisbey 1992), or if there is diverging movement during the sleep like in restless leg syndrome (Sadeh and Acebo 2002).

There have not been many surveys to investigate the reliability and validity of different sleep-wake behaviour assessing methods for children older than 2 years. One study was designed to measure the sleep of 4 – 7-year old Swiss children (N=50), by using questionnaire, diary and actigraphy simultaneously (Werner et al. 2008). This study revealed that there were association between sleep diary and actigraphy method as regarded start of sleep, time of waking up and the sleep duration. On the other hand, measured sleep duration and the repetition of nighttime waking did not synchronize. According to this study a questionnaire of sleep habits was not comparable with either sleep diary or actigraphy.

The selection of assessment method of SDB, including OSA, depends on the purposes of the study. A large variety of different types of questionnaire on sleep habit or quality have been used to evaluate sleep disorders of large populations. The correlation between parentally reported frequent snoring or other risk sleep behavior and clinically predicted SDB risk has shown to be good (Chervin et al. 2000, Montgomery-Downs et al. 2004). The prevalence of SDB can roughly be estimated in epidemiological purposes by questionnaires and clinical history, but it may not provide adequate details for clinical practice to differentiate primary snoring from SDB (Carroll et al. 1995).

In children the most suitable method of diagnosis and the criteria of abnormal nocturnal breathing events vary. Therefore it would be important to create common assessment criteria for SDB diagnostics (Lumeng and Chervin 2008). Another article also emphasizes the prospects of novel SDB diagnostics for improved diagnostic technologies and delineation of a more pragmatic and reliable diagnostic approach for pediatric SDB. According to this article, use of other relatively nonobstructive sensor technologies that record snoring, body position, airflow and moment-to-moment autonomic responses may be promising substitute methods. Also diagnosis of particular biomarkers e.g. vascular endothelial growth factor related to SDB risk may be an optional way to diagnostics (Gozal and Kheirandish-Gozal 2010).

Another common sleep problem group in children are behavioural sleep disorders, which are less frequently recognized in clinical sleep medicine, although they are found to be frequent among otherwise healthy children (Anders and Eiben 1997). The principal methods for assessing behavioural sleep disorders are interviews and sleep habit questionnaires (Owens et al. 1998). A children's sleep habits questionnaire (CSHQ) was designed to assess common behavioural and medical-based sleep disorders in children. The CSHQ appeared as a specific and sensitive tool for assessing the behavioural sleep problems of school-age children (Owens et al. 2000a).

2.4 DESCRIPTION AND PREVALENCE OF SLEEP PROBLEMS IN CHILDREN

The most quoted description for sleep disorders is based on the International Classification of Sleep Disorders-2 (ICSD-2) by American Academy of Sleep Medicine (AASM) (2005). Typical examples of the ICSD-2 sleep disorder groups are presented in Table 1.

There are no such official classifications for children's sleep disorders. The ICSD-2 contains to some extent, most of common sleep disorders of children. Sleep problems in childhood can be classified into four different groups, in terms of pathological causes (Owens 2009). These groups are 1) insufficient sleep 2) fragmented sleep 3) primary disorders of excessive daytime sleepiness and 4) circadian rhythm disorders.

Table 1. Examples of four different sleep disorder groups by the ICDS-2 (AASM 2005).

Sleep disorder group	**Dyssomnias**	**Parasomnias**	**Other disease associated sleep disorders**	**Proposed disorders**
Example disorders:	**Instrinsic disorders:** OSAS, Narcolepsy, Restless leg syndrome	**Arousal disorders:** Sleepwalking, Sleep terrors	**Mental disorders:** Mood, Anxiety, Panic disorders	Short sleepers, Long sleepers, Subwakefulness syndrome,
	Extrinsic disorders: Behavioral insomnia : 1.sleep-onset association, 2.limit-setting type	**REM-sleep associated:** Nightmares, Sleep paralysis	**Neurological disorders:** Sleep-related epilepsy, Cerebral degenerative disorders	Medication Drugs related
	Circadian rhythm disorders: Delayed sleep phase syndrome, Irregular sleep-wake pattern	**Other parasomnias:** sleep bruxism, sleep enuresis	**Other medical disorders:** Sleep-related gastro esophageal reflux, Sleep-related asthma Drugs and medication	

OSAS = Obstructive sleep apnea syndrome.

2.4.1 Insufficient sleep

According to Owens (2009), sleep can be insufficient for one's physiological sleep needs. nsufficient sleep e.g. sleep onset delay or restless sleep is thought to be caused by poor sleep hygiene. According to a systematic review behavioural insomnia in younger children is typically related to bedtime resistance and other behaviors intended to hinder sleep onset. Two types of behavioural insomnias have been defined. Sleep-onset association type occurs when a child associates falling asleep with an association, eg. at parents presence, and is unable to fall asleep if separated from that association. Limit-setting type occurs when a child delays and refuses to go to sleep in the absence of strictly enforced bedtime limits. These types of bedtime resistance occur frequently in 20 % of children between 1 and 3 years of age, and in 10 % of 4-year-olds (Ramchandani et al. 2000).

As for older children, insufficient sleep is related to social, environmental, and developmental changes. For 6-10-year-old children the amount of sleep becomes limited because of various disturbing factors such as homework, sport club participation and other extracurricular or social activities (Hoban 2010). Moreover, school children have often TV, computer, or music players in their own rooms, which is associated with an increased number of sleep problems (Li et al. 2007). A large sleep poll in The U.S. indicates that overall 37 % of children aged 6 – 10 years suffer from behavioural sleep disorders, including bedtime resistance 15 – 25 %, sleep-onset delay 10 % and daytime sleepiness 10 %, according to parental reporting (National Sleep Foundation 2004). These numbers were explained by disturbing factors as discussed earlier.

2.4.2 Fragmented sleep

Fragmented sleep can be described as a condition that results from frequent or prolonged arousals during the sleep. There are various types of sleep fragmentations, which are generally called parasomnias. These are a group of abnormal physiological behaviors occurring during different stages of sleep or sleep-wake transitions. Parasomnias are more prevalent in early childhood aged 1 to 5, and not so much in later childhood and adolescence. These disturbances are typically classified to four different groups: arousal disorders, sleep-wake transition disorders, REM-sleep associated parasomnias and other parasomnias (AASM 2005). The most frequent parasomnias in children are bruxism, sleep-talking & walking and nightmares. The prevalence of different parasomnias is approximately around 10 – 30 % and they are strongly related to the developmental stage (Robinson and Waters 2008).

Respiratory related sleep disturbances are universally named as sleep disordered breathing (SDB), ranging from primary snoring to obstructive sleep apnea (OSA) (AASM 2005). Although, these disturbances are common in childhood, they are probably not as frequent as other sleep disorders, like behavioural insomnias. However, the importance of respiratory related sleep disorders are highlighted by the recent findings suggesting them to be harmful to the neurobehavioural function (Gozal 2008), and predisposing to metabolic and cardiovascular risks (Gozal et al. 2008). Primary snoring has been defined as snoring without associated apneas, hypopneas, hypoxemia, hypercapnia, or sleep fragmentation (American Academy of Pediatrics 2002). Primary snoring has traditionally been considered as the principal screening variable for SDB risk, and initially snoring has been shown to be related to development of SDB (Nieminen et al. 1997). A meta-analysis that included 41 studies, studied parental reported snoring frequency in children. They found a prevalence of 7 % for habitual snoring (Lumeng and Chervin 2008).

A modern definition for OSA syndrome is ‘‘a disorder of breathing during sleep characterized by prolonged partial upper airway obstruction and/or intermittent complete obstruction (obstructive apnea) that disrupts normal ventilation during sleep and normal sleep patterns’’ (American Thoracic Society 1996). The prevalence of OSA varies due to methods and the diagnostic criteria used. In average, the estimated OSA prevalence has varied between 1 – 4 % in children (Lumeng and Chervin 2008). In addition, SDB prevalence risk symptoms of which include snoring, mouth breathing and breathing pauses, as assessed by parental answered sleep questionnaires has fluctuated from 4 to 11 %, varying between the questionnaire protocols used (Archbold et al. 2002, Spruyt et al. 2006). The prevalence of SDB and OSA depends by far on the controversial selection and diagnostic methods and criteria that have been used in epidemiological and clinical settings.

Clearly additional work is needed for standardization of selection and diagnostic criteria (Lumeng and Chervin 2008).

2.4.3 Primary disorders of daytime sleepiness and circadian rhythm disorders

These sleep disturbance groups are important part of paediatric sleep medicine, although they are not commonly diagnosed in primary school children. The most well-known disorder in this group is narcolepsy. It is a neurological disorder that is characterized by several sleep-associated defects, e.g. excessive sleepiness, cataplexy, hallucinatory phenomena, and sleep paralysis (AASM 2005). Epidemiological studies have estimated the prevalence of narcolepsy to be approximately 0.05 % in both European and American populations (Ohayon et al. 2002, Silber et al. 2002). The average age for the onset of narcolepsy is at 15 to 25 years.

The fourth group, circadian rhythm disorders, is an abnormal sleep-wake rhythm relating to conventional clock times. The most common disease form of circadian rhythm disorders in children or adolescents is delayed sleep phase syndrome (DSPS) (AASM 2005). DSPS is especially frequent during the adolescence, with an estimated prevalence of 10 % between the ages of 13 and 18. Predisposing factors to DSPS in adolescence are various, encompassing biological, genetic, social and psychological factors (Takahashi et al. 2000).

2.5 DETERMINANTS OF INSUFFICIENT SLEEP DURATION IN SCHOOL-AGE CHILDREN

The relatively high prevalence of insufficient sleep duration in school-age children is globally recognized (Smaldone et al. 2007, Nixon et al. 2008). There is also rising evidence showing that short sleep can cause severe impairment in health and well-being of children, related with obesity

(Patel et al. 2008), cognitive function and learning (Touchette et al 2007) and emotional problems (Nixon et al 2008). The influences of childhood sleep problems on chronic health risks in adulthood are yet to be determined, but should be of interest in a future research.

A multidimensional network of factors has been connected with inadequate sleep. Sleep duration can be confounded at least by sociodemographic, behavioural, parental control or genetic factors (McLaughlin Crabtree et al. 2005, Li et al. 2007, Hitze et al. 2009, Zhang et al. 2010, Li et al. 2010).

Socioeconomic status (SES), described by parental education and household income have been associated with sleep duration of children in few studies. However, the association has not been homogeneous. Studies in American and Australian children discovered that lower family SES was associated with insufficient sleep (McLaughlin Crabtree et al. 2005, Dollman et al. 2007). On the other hand, a Chinese study found a relationship between higher family SES and a short time in bed (Chang et al. 2010). There is also evidence suggesting that SES and race may be mediating the impact on sleep problems through increased prenatal and perinatal risks (Calhoun et al. 2010).

A study group from Hong Kong constructed a model to explain the sleep-wake pattern of primary school children with various interactive factors. Using standardized regression weight (SRW) they found that the strongest predictors for time in bed, are school start time (SRW= 0.42), socio economic status (SRW= -0.24), media use (SRW= -0.20) and maternal sleep duration (SRW= 0.17). This study also assessed the association between children's and mothers' or fathers' sleep-wake patterns. They pointed out that the child-mother sleep correlation was stronger than the child-father correlation. This link was thought to be in context with mothers' closer role as a behavioural and lifestyle model. The relatively high explanation by the school-start time can be partially explained through the participation in the study of both morning and daytime schools, which explain largely the high significance of sleep duration. When sleeping time was adjusted with school-start time, the significance disappeared. Their study did not specify the association between exercise and sleep, although they addressed the possible effect of leisure extracurricular activities to promoting longer sleep duration (Zhang et al. 2010).

Another large cross-sectional survey (N~ 20 000) was designed to test the possible determinants of short sleep duration in Chinese 5–11-year-old children. There was a multidimensional pattern of factors that were associated with sleep duration. Factors from domains like sleep environment, chronic health problems, school schedules and lifestyles were associated with short sleep duration, after adjusting for demographic and socioeconomic variables. The most significant factors were more time on homework, poor bedtime hygiene, exciting activities during bedtime, irregular bedtime and shorter sleep duration of parents. Furthermore this study did not found significant relation between physical activity and sleep duration (Li et al. 2010).

A cross-sectional study in German children and adolescents (N=414), aged 6 – 19 years, investigated the determinants of sleep duration and its impact on nutritional status, resting energy expenditure and hormones in children and adolescents (Hitze et al. 2009). Short sleep duration (< 10 hours for <10-year-old) was pared to physical activity, media use and dietary habits. A negative association between media use (TV and computer) and short sleep was found. Moreover, short sleep was associated with BMI (age and gender adjusted) and waist circumference. Also lower resting energy expenditure (boys), higher serum leptin (girls) and lower adiponectin levels (boys) were associated with shorter sleep. However, this study did not found association between physical activity and sleep duration.

Positive correlations between several health promoting behaviors and sleep duration were found, according to a cross-sectional study that was carried out to find interactions between adequate sleep and health behaviours in Taiwanese adolescents (N=656), aged 13 – 18 years. This study is one of the few so far that has studied sleep duration and nutrition and exercise behaviors. They found that adequate sleep (6-8 hours per night) was positively correlated with healthy nutritional choices, physical activity and also taking own responsibility for health in adolescents (Chen et al. 2006).

2.6 SHORT SLEEP AND HEALTH

There is yet no firm evidence about the associations between the amount of sleep duration and neurobehavioural or somatic health for children and adolescents. The recommendation for adequate sleep duration therefore is based mostly on expert assessments. Normal sleep duration is recommended to be 10 hours for 6 – 10-year-old children (National Sleep Foundation 2004). Moreover it is accepted that different sleep problems and especially chronic reduction of sleep duration can cause a major risk for neurobehavioural function and somatic health in children and adolescents.

2.6.1 Sleep and neurobehavioural function

It has been observed that short sleep may deteriorate neurobehavioral function (NBF), including cognitive performance and behaviors such as attention and learning of children (Dahl 1998). Also the possible association with sleep duration and attention-deficit/hyperactivity disorder (ADHD) has been under research in recent years.

A Canadian study conducted as part of the Quebec longitudinal study of child development examined (N=1492 families) children for 6 years. Sleeping patterns were reported by mothers at 2.5, 3.5, 4, 5, and 6 years of age. Peabody Picture Vocabulary Test-Revised (PPVT-R) at the age of 5 years, and the Block Design subtest (WISC-III) at the age of 6 years were used to test the cognitive function of children. Also child's behavioural aspects were measured with a 6 question hyperactivity-impulsivity (HI) questionnaire administered to mothers. Results from these tests showed that short sleep duration of the child was clearly associated with higher HI, and with lower PPVT-R and WISC-III performances after adjusting for confounding variables. This study used 10 hours as the limit for short sleep duration (Touchette et al. 2007).

Sleep restriction and NBF of school-age children were assessed in an experimental study. This study measured sleep in 77 children 9 to 12 years of age (Sadeh et al. 2003). The sleep was either extended or restricted by one hour from normal sleep duration on three nights in a row. This study reported a significantly lowered NBF in the one-hour sleep restriction group compared to the longer sleepers.

Another interesting research topic has been the possible interaction between sleep and the attention-deficit/hyperactivity disorder (ADHD). A Finnish cross-sectional study was performed in 7- to 8-year-old children (N=280) from random, population-based cohort (Paavonen et al. 2009). They showed that shorter sleep duration assessed by the actigraphy was an independent risk factor of the ADHD and HI. The limit for short sleep was estimated to relatively low (< 7.7 hours per night), that was 10^{th} percentile of the study group. This study also underlined that sleep duration was not associated with other sleep difficulties and thus the association between sleep duration and ADHD was not mediated by other sleep difficulties.

These studies clearly reveal the fact that sleep is a vital instrument for supporting adequate cognition and learning skills. In addition it can also affect behavior and vigilance which can deteriorate school performance of children. Nonetheless the association between sleep and ADHD is quite complicated, and therefore more evidence is needed before this relationship can be approved (Sadeh et al. 2006).

2.6.2 Sleep and somatic health

Besides of the NBF, there is evidence for the association between sleep and alterations in somatic health. Many epidemiological studies have shown that the major public health risks in adulthood like obesity (Fogelholm et al. 2007), coronary heart diseases (Ayas et al. 2003) and type 2 diabetes (Yaggi et al. 2006, Tuomilehto et al. 2008, Beihl et al. 2009) are associated with abnormal sleep habits in both men and women. Also a recently published prospective study investigated that short sleep duration increases the risk for chronic diseases, especially the risk for strokes and cancer in multivariable adjusted models (von Ruesten et al. 2012). The cause – effect -relationship between chronic sleep deficit and different health risks is still unclear, but most likely complex and multi-factorial.

According to meta-analyses, short sleep duration increases the risk for obesity in both children and adults (Cappucio et al. 2008, Patel and Hu 2008). Few mechanisms that could be behind these health outcomes have been illustrated. One laboratory-study has proposed that there is a probable relationship between sleep abnormality and neuroendocrine control of appetite. According to the study 6 days of short (4 hour/night) sleep led to a decreased serum concentration in the appetite regulating hormone leptin, and was followed with elevation in sympathovagal balance (Spiegel et al. 2004). The same topic was also explored by a Finnish study (van Leeuwen et al. 2010). In their study 23 healthy young men were allocated to a control and experimental groups. After two baseline nights (8 hour sleep), the experiment group slept 4 hours/night for 5 days, followed by a two 8 hour nights again. The control group slept 8 hours during the whole period. Findings of this study were that insulin, and insulin-to-glucose ratio and leptin levels were elevated for the experiment group, while control group had no changes observed. This study illustrates that sleep restriction may increase the risk for developing type 2 diabetes.

Another mechanism that has been suggested in children is the raised core temperature of overweight person during the night, which can degrade sleep quality (von Kries et al. 2002). To gain more reliable information of association between overweight and short sleep duration, it is important to conduct longitudinal studies on dose-response between sleep duration and overweight. One longitudinal cohort study in 1 – 6-year-old children (N=1138) pointed out that short sleep in early childhood was significantly associated with the risk of overweight during the school-age, after controlling for confounding variables (Touchette et al. 2008).

An association between short sleep and risk of impaired glucose tolerance has been observed. Two studies have found that less than 5 hour sleep for a 4 - 6 days period can cause a significant lowering of glucose tolerance compared to those who slept normally (8 hours) (Spiegel et al. 1999, van Leeuwen et al. 2010). Mechanisms to explain the insufficient glucose tolerance differ. Spiegel and others (1999) found the sympatic-activity related increases in the growth hormone and cortisol level, which can disturb glucose regulation. Another experimental study that lasted for 12 days studied the effects of sleep restriction in 19 – 34-year-old healthy adults. They found that increased inflamation factors such as, interleukin- 6 and tumor necrosis factor- α were related to short sleeping hours and T2D occurrence (Vgontzas et al. 2004). In addition, it has been demonstrated that the association between short sleep duration and T2D ameliorate after a lifestyle intervention including increased exercise, healthy diet and weight reduction (Tuomilehto et al. 2009).

The scientific data for the relationship between sleep restriction and coronary heart decease is also well recognized. One possible mechanism that has been illustrated is the low-grade inflammation factor highly sensitive C-reactive protein (hS-CRP) that is shown to be elevated after restriction of sleep (Meier-Ewert et al. 2004). In addition, there is evidence suggesting that short sleep can increase the blood pressure of children, although the effect is not so strong after adjusting for BMI (Nixon et al. 2008).

In conclusion, there is still little information about the somatic health effects of chronic sleep loss for children. It can be speculated whether these above-mentioned health risks of short sleep in adulthood are partially explained by poor sleep habits learned in childhood. To get better awareness in this question, it is important to conduct prospective studies that investigate the impact of childhood sleep to adulthood health.

3 AIMS OF THE STUDY

1. To estimate the prevalence of short sleep assessed by parental questionnaire and common sleep disturbances in 6-8-year-old school-age children

2. Examine associations of common sleep problems such as short sleep duration, behavioural insomnia, SDB, parasomnias and daytime sleepiness.

3. To investigate the association between short sleep (parental questionnaire) and other health behaviors such as habitual physical activity (parental questionnaire), media time (parental questionnaire) and meal pattern (food record), after adjusting for confounding factors like age, SES, body composition (DEXA) and cardiorespiratory fitness (maximal exercise test).

4 SUBJECTS AND METHODS

4.1 STUDY POPULATION

The present study is part of The Physical Activity and Nutrition in Children (PANIC) Study, which is an ongoing 2-year cluster-randomized controlled exercise and diet intervention study in a representative population sample of 511 girls and boys (Eloranta et al. 2011). Children were 6 – 8 years of age and lived in the city of Kuopio in Eastern Finland during baseline examinations in 2007–2009. The study protocol was approved by the Research Ethics Committee of the Hospital District of Northern Savo. Both children and their parents gave their written informed consent.

A total of 484 (95 %) of 511 children who participated in the baseline examinations returned the sleep questionnaire that was used for the assessment of sleep habits and disorders. Gathering of the baseline data occurred in all around a year. The present study is based on these data.

4.2 ASSESSMENTS

4.2.1 The PANIC sleep questionnaire

The questions in the PANIC sleep questionnaire were based on previously validated Finnish questionnaires that have been used to screen for sleep disturbances and sleep apnoea, mostly for adults (Partinen and Gislason 1995). The questionnaire consisted of 22 questions about children's sleep duration and behavior as well as a variety of sleep disorders (Appendix 1). Questionnaires were answered by the parents. They were asked about current sleep behaviors of their child. Average time of sleeping (hours) was inquired in 30 minutes' accuracy. To determine short sleep, we dichotomized sleep into <10 and ≥10 hours groups. Sleep quality was assessed with a five-point scale (1=never to 5=very often).

A probability score was used to estimate the prevalence of behavioural insomnia and SDB. Three different variables were used to estimate the probability of behavioural insomnia. These variables were "sleep onset delay", "sleep quality" and "number of nocturnal wakings per night". The scale for sleep onset delay was between 0= less than 10 minutes, to 2 = more than 30 minutes. Restfulness was scaled from 0= restful every night to 4= restless in 5 or more night per week. Occasions of nocturnal wakening question was scaled from 0= no waking to 4= more than 3 waking per night. The points for these questions were summed up to create a probability score 0 to 10 of behavioural insomnia. Furthermore, behavioural insomnia was classified into 4 groups based on the size of the risk of behavioural insomnia.

The probability for SDB was created the same way by using the following variables "mouth breathing", "breathing pauses", "snoring frequency" and "loudness of snoring", which all had an answer scale from 0 to 4. Thus, the SDB probability score interval was between 0 to 16 points, SDB score was also classified in 4 groups to further label the size of the risk. The higher the sum of points, the higher was the probability to suffer from SDB.

In addition, parasomnias (bruxism, nightmares, sleepwalking and-talking), daytime sleepiness, napping, sleepiness compared to other children, compulsive sleepiness and insomnia were assessed by the PANIC sleep questionnaire.

4.2.2 Physical activity

Physical activity was assessed by using The Panic physical activity questionnaire administered by the parents (Appendix 2, Questions 4 - 9). We assessed daily duration of total physical activity as a sum of the durations of structured and unstructured leisure time physical activity, physical activity to and from school, as well as physical activity at school (school breaks, physical education classes). The frequency (sessions/week) and time spent in each session (minutes/session) were assessed. Time spent for each activity per week was assessed by multiplying the frequency (sessions/week) by the duration (minutes/session). The average daily duration of total physical activity was finally calculated by the following equation: (leisure time activities/7 + school-based activities/5). We used a continuous variable for total physical activity that was expressed as minutes per day.

4.2.3 Media time

The daily time of media use was estimated from a parental reported questionnaire (Appendix 2, Questions 13 - 14). The variable was sum of the time spent watching TV, using the computer, videogames and mobile phone games. The media time was assessed separately for weekdays and weekend days and was expressed as minutes per day.

4.2.4 Meal and snack intake

Dietary intake was assessed by food records of four consecutive days that consisted of two weekdays and two weekend days (99.5% of children) or three weekdays and one weekend day (0.5% of children) (Eloranta et al. 2011). The food records were analysed by a nutritionist using The Micro Nutrica® dietary analysis software (version 2.5, The Social Insurance Institution of Finland) with the food composition data from national analyses and international food composition tables (Rastas et al. 1993). Breakfast, lunch and dinner were classified as main meals and all in-between eating and drinking occasions as snacks. A main meal intake was defined by assessing the average number of main meals included breakfast, lunch, supper eaten per day from the assessed days. Average number of snacks eaten per day was recorded by using the same method. Moreover, main meal frequency was categorized in two groups, lower intake (< 2.75 meals per day) and higher intake (> 2.75 meals per day) group, based on the variable distribution mean value. This dichotomized variable was used in the multivariate logistic regression.

4.2.5 Cardiorespiratory fitness

A maximal exercise test was performed with an electromagnetic cycle ergometer (Ergoselect 200K, Ergoline, Germany), which was controlled by Cardiosoft program (V6.5 GE Healthcare Medical Systems, Freiburg, Germany). The test was supervised by a physician and a nurse. The testing protocol included a 3-minute warm-up period at a work load of 5 watts (W), a 1-minute steady state period at a work load of 20 W, progressive increase in work load by 1 W every 6th second until exhaustion, and a 4-minute cooling-down period at a work load of 5 W. The children were asked to keep the cadence stable within 70 to 80 rotations per minute (minimum of 65 rotations). The test was continued until exhaustion, which was defined as inability to maintain the cadence within the required limits. The test was considered maximal if at least 85% of the age-predicted maximal heart rate (220 beats per minute – age) was achieved and the physician considered the effort maximal. Cardiorespiratory fitness (CRF) was defined as max watts per kg lean body mass (W/lm). This was used instead of the more commonly used max watts per mass (w/kg), to avoid possible confounding effect of body fat percentage on fitness.

4.2.6 Body composition

Trained study nurses measured body height and waist circumference three times with the accuracy of 0.1 cm. The mean of the nearest two values were used for the analyses. Body height was measured in the Frankfurt plane without shoes by a wall-mounted stadiometer on top of the head. Body fat mass, body fat percentage and body lean mass were measured by a dual energy X-ray absorptiometry (DXA) method with the Lunar® DXA device (Lunar Prodigy Advance, GE Medical Systems, Madison, Wisconsin, USA).

4.2.7 Socio-demographic information

Age and sex were assessed by a questionnaire administered by the parents, and decimal age at the time of baseline examinations was calculated. The indicator of Socio economic status (SES) consisted of information about the parental education and family's income level. The level of parents' education based on the highest completed degree of parents (vocational school or less, applied university or university) and the total yearly income of the family (≤30000 €, 30001–60000 €, ≥60001 €) were inquired in the children's background questionnaire.

4.3 STATISTICAL METHODS

Statistical analyses were performed by the SPSS statistical analysis software (v. 14.0 for Windows, SPSS Inc., Chicago, IL, USA). Normality of distributions was analysed by the Kolmogorov-Smirnov test.

The prevalences of different sleep behaviours and problems were assessed. In addition the possible association of different sleep problems (Sleep duration, behavioural insomnia, SDB, parasomnias and daytime sleepiness) were measured. The significances of the associations were assessed by using the Pearson's χ^2 correlation.

Two different analyses were conducted to assess the associations between sleep duration, lifestyle factors (physical activity (PA), media use, meal pattern and snack eating, body composition and CRF. First, Pearson's χ^2 -test or T-test and Mann-Whitney's U-test were used to assess the association between sleep duration and independent lifestyle factor.

Subsequently, multivariate logistic regressions were performed to estimate odds ratios (OR, 95 % confidence interval, (CI) between lifestyle patterns and sleep duration. "Model I" assessed the lifestyle factor independently after controlling for age, sex and socioeconomic status. "Model II" was performed by stepwise multivariate logistic regression for all the lifestyle factors, and adjusted for age, sex and socioeconomic status. Associations with a *P*-value of < 0.05 were considered statistically significant.

5 RESULTS

The data consisted of 511 children (265 boys, 246 girls). The mean (standard deviation) age of children was 7.6 (0.4) years for both genders. Boys were taller (129.6 cm vs. 127.8 cm), weighed more (27.3 kg vs. 26.5 kg) and had a lower body fat percentage (17.4 % vs. 22.4 %).

5.1 PREVALENCE OF AND ASSOCIATION BETWEEN DIFFERENT SLEEP PROBLEMS

Altogether 484 children (boys= 249 and females=236), were included to sleep behaviour analyses. Sleep questionnaire was not returned or some of the data were missing for 27 children. The median sleeping time was 10.0 hours (range 7.5 to 12.0 hours). There were 178 (37 %) children whose average sleep duration was < 10 hours. Prevalence of sleep habits and problems asked by the PANIC sleep questionnaire are presented in Table 1. There were no significant differences in any sleep variable between genders. Questions 6, 7, 8 and 9 were excluded from the analyses because there were little or not at all occurrences of these sleep problems.

Associations between sleep problems and their significances are shown in Table 2. Short sleep (<10 h) was associated with increased behavioural insomnia risk ($P = 0.003$), and daytime sleepiness ($P = 0.043$). There was no significant association between short sleep and any parasomnias or SDB risk. Furthermore, behavioural insomnia was associated with higher SDB risk ($P = 0.02$), frequent nightmares ($P = 0.03$), sleepwalking or –talking ($P < 0.001$) and daytime sleepiness ($P < 0.001$).

Table 1. Sleep habits & problems by gender. N (%).

	ALL	BOYS	GIRLS
Study sample	484	249	236
Sleep duration (h)			
short sleep (<10)	178 (37)	85 (34)	93 (40)
adequate sleep (≥ 10)	306 (63)	164 (66)	142 (60)
Sleep onset delay			
delayed (30 min or more)	22 (4)	8 (3)	14 (6)
Sleep restlessness			
sometimes or often	74 (15)	44 (18)	30 (13)
Occasion of wakening per night			
2 times or more weekly	16 (3)	11 (4)	5 (2)
Daytime sleepiness			
Once or more weekly	79 (15)	38 (15)	41 (17)
Behavioural insomnia probability of (score)			
no behavioural insomnia (0-1)	261 (54)	135 (54)	126 (53)
mild behavioural insomnia (2-3)	187 (39)	93 (37)	94 (40)
modest behavioural insomnia (4-5)	36 (7)	20 (8)	16 (7)
severe behavioural insomnia (6-10)	1 (<1)	1 (<1)	0
Bruxism			
Once or more weekly	62 (12.1)	35 (14.1)	27 (11.5)
Nightmares			
Once or more weekly	13 (2.5)	7 (2.8)	6 (2.6)
Sleepwalking or –talking			
Once or more weekly	41 (8.0)	24 (9.7)	17 (7.2)
SDB:			
mouth breathing			
frequent	39 (7.7)	25 (10.2)	14 (6.0)
breathing pauses			
frequent	10 (2.0)	7 (2.8)	3 (1.3)
Snoring behavior			
frequent	52 (10.2)	31 (12.4)	21 (8.9)
Snoring loudness			
fairly loud	23 (4.5)	10 (4.1)	13 (5.6)
Probability of SDB (score)			
no SDB risk (0-4)	415 (81.1)	210 (84.3)	205 (86.9)
low SDB risk (5-6)	51 (10.0)	27 (10.8)	24 (10.2)
moderate SDB risk (7-8)	15 (2.9)	10 (4.0)	5 (2.1)
high SDB risk (9-16)	4 (0.8)	2 (0.8)	2 (0.8)

Table 2. Associations between sleep duration and other sleep variables, χ^2 (p-value).

Sleep problem or risk	Short sleep (< 10 h)	Behavioural insomnia probability	SDB-probability
Behavioural-insomnia probability	8.87 (0.003)		
SDB probability	0.54 (0.46)	5.14 (0.02)	
Parasomnias:			
Bruxism	0.33 (0.86)	0.15 (0.70)	3.75 (0.05)
Nightmares	2.49 (0.12)	4.69 (0.03)	0.83 (0.36)
sleepwalking or talking	1.79 (0.18)	12.9 (<0.001)	3.54 (0.06)
Daytime sleepiness	4.11 (0.043)	21.3 (<0.001)	2.59 (0.11)

The significance of correlations was calculated by Pearson's χ^2 -test

Short sleep = "< 10 hours per night", Behavioural insomnia probability = "probability score ≥ 4", SDB-probability = "probability score ≥ 5".

Daytime sleepiness, Parasomnias = "≥ 1 time per week".

5.2 ASSOCIATION BETWEEN SLEEP DURATION AND HEALTH BEHAVIOURS

First, the independent associations between short sleep and different health behaviours or possible confounding factors were assessed in Table 3. Children who had short sleep (< 10 h) were less often physically active, used more time on electronic media during weekdays, ate meals less regularly and had a greater body fat percentage than those with adequate sleeping time (≥ 10 h).

Secondly, the possible associations between short sleep duration and other health behaviors were assessed after adjusting for possible confounding factors. Of the health behaviours, snack eating frequency and media time during weekends were excluded from this assessment, because they did not have a significant (p=0.05) independent association between sleep duration as shown in Table 3.

Table 3. Characteristics of the study population (N=484) classified as short and adequate sleep

	Short sleep (<10 h)	Adequate sleep (≥ 10 h)	*P* – value
Age in years †	7.7 (0.4)	7.6 (0.4)	0.27
Sex (girls) #	93 (52)	142 (46)	0.20
Low parental education level #	71 (40)	139 (47)	0.15
Low household income #	32 (18)	61 (21)	0.70
Height in cm †	128.6 (5.3)	128.8 (5.9)	0.63
Weight in kg †	27.2 (5.0)	26.8 (5.0)	0.38
Body fat percentage by DEXA †	22.4 (7.73)	17.4 (8.07)	0.03
Physical activity min/day †	103.7 (40.3)	115.3 (42.6)	0.004
Media time on weekdays min/day †	97.0 (55.5)	83.2 (48.8)	0.009
Media time on weekends min/day †	148.1 (87.0)	138.2 (74.6)	0.46
Cardiorespiratory fitness (W/LBM) †	3.6 (0.52)	3.71 (0.50)	0.09
Number of meals per day †	2.7 (0.25)	2.8 (0.26)	0.01
Number of snacks per day †	2.8 (0.98)	2.6 (0.86)	0.06

= frequencies (%); †= mean (SD)

Significance of categorized variables was tested by Pearson's χ^2 -test, and for continuous variables by t-test for independent samples and Mann-Whitney U-test.

P-value = statistical probability test. Significance level ≤ 0.05

In multivariate logistic regression, longer time of physical activity and higher intake of main meals were associated with adequate sleep, while higher weekday electronic media time and body fat percentage were associated with the risk for having a short sleep duration after adjusting for age, sex and SES (Model I, Table 4). Low physical activity duration and higher weekday electronic media time remained statistically significant risk factors for short sleep after adjusting for other health behaviours and confounding factors (Model II, Table 4).

Short sleep, low CRF, higher electronic media time and body fat percentage were associated with the risk for low (< 120 min/day) physical activity duration after adjusting for age, sex and SES (Model I, Table 4). High electronic media time, low CRF and high body fat percentage remained statistically significant risk factors for low habitual physical activity duration after adjusting for other health behaviours and confounding factors (Model II, Table 4).

Low physical activity duration, lower frequency of main meal intake and higher body fat percentage were associated with the risk of excessive (> 120 min/day) media time in weekdays after adjusting for age, sex and SES (Model I, Table 4). Low physical activity duration and lower frequency of main meal intake remained significant risk factors for excessive electronic media time in weekdays after adjusting for other health behaviours and confounding factors (Model II, Table 4).

Short sleep duration and higher weekday electronic media time were associated with lower frequency (< 2.75 meals/day) of main meal intake after adjusting for age, sex and SES (Model I, Table 4). Only short sleep duration remained a statistically significant risk factor for low frequency of main meal intake after adjusting for other health behaviours and possible confounding factors (Model II, Table 4).

Table 4. Multivariate models for the associations between different lifestyle patterns.

	Model I		Model II	
Short sleep duration (< 10 h)	OR (95%CI)	*P*-value	OR (95%CI)	*P*-value
Habitual physical activity (1/30min)	0.79 (0.69 – 0.92)	0.002	0.84 (0.72 – 0.98)	0.023
Electronic media use weekdays (1/30min)	1.20 (1.07 – 1.35)	0.002	1.19 (1.05 – 1.34)	0.005
Intake of main meals/day	0.43 (0.21 – 0.94)	0.033	-	0.053
Cardiorespiratory fitness (W/kg/LBM)	0.74 (0.49 – 1.11)	0.141	-	0.412
Body fat % (SD)	1.03 (1.00 – 1.05)	0.039	-	0.070
Low physical activity (< 120min/day)				
Cardiorespiratory fitness (W/kg/LBM)	0.29 (0.19 – 0.45)	<0.001	0.29 (0.18 – 0.46)	< 0.001
Body fat % (SD)	1.04 (1.01 – 1.07)	<0.001	1.35 (1.07 – 1.72)	0.012
Electronic media use weekdays (1/30 min)	1.15 (1.03 – 1.29)	0.017	1.17 (1.03 – 1.33)	0.014
Sleep duration (1/30min)	0.63 (0.44 – 0.89)	0.010	-	0.053
Intake of main meals/day	1.64 (0.78 – 3.44)	0.191	-	0.226
High electronic media use (≥ 120 min/day)				
Habitual physical activity (1/30min)	0.79 (0.68 – 0.92)	0.002	0.79 (0.67 – 0.94)	0.006
Intake of main meals/day	0.39 (0.18 – 0.88)	0.022	0.35 (0.15 – 0.80)	0.013
Body fat % (SD)	1.03 (1.00 – 1.06)	0.022	-	0.249
Sleep duration (1/30min)	0.75 (0.52 – 1.08)	0.118	-	0.385
Cardiorespiratory fitness (W/kg/LBM)	0.96 (0.62 – 1.47)	0.847	-	0.375
Lower meal intake (< 2.75 main meals/day)				
Sleep duration (1/30min)	0.54 (0.38 – 0.78)	0.001	0.54 (0.37 – 0.78)	0.001
Habitual physical activity (1/30min)	0.96 (0.83 – 1.11)	0.571	-	0.684
Electronic media use (1/30 min)	1.16 (1.03 – 1.30)	0.015	-	0.070
Body fat % (SD)	1.02 (0.99 – 1.04)	0.174	-	0.301
Cardiorespiratory fitness (W/kg/LBM)	0.95 (0.63 – 1.43)	0.811	-	0.873

Model I = adjusted for decimal age, sex and socioeconomic status (SES); **Model II** = additionally to Model I, all health behaviours (sleep duration, habitual physical activity, electronic media use, meal pattern, body fat percentage and cardiorespiratory fitness) included to the model.

OR = the odds ratio, is the ratio of the odds of an event occurring in one group to the odds of it occurring in another group

P-value = statistical probability test. Significance level ≤ 0.05

1/30min = influence per 30 minutes, SD= influence per standard deviation

6 DISCUSSION

6.1 MAIN FINDINGS

The present study showed that there are multiple associations between sleep duration and different health behaviors in 6 – 8-year-old school children. Higher duration of habitual physical activity were associated with a lower risk for short sleep (< 10 hours), whereas higher time of electronic media use were related to increased risk for short sleep after adjusting for other health behaviours. Moreover, short sleep was associated with lower frequency main meal intake (< 2.75 meals/day) after adjusting with other health behaviours. Short sleep was also associated with lower physical activity duration as an independent factor.

These findings show that healthy lifestyle behaviors such as daily physical activity, restricted time for electronic media use or adequate meal pattern could help to promote sufficient sleep duration. This study also illustrated for the first time in literature that health behaviours such as physical activity, media use or frequency of meal intake explained a larger proportion of children's sleep duration than did physiological and social indicators such as body fat proportion, CRF, or SES.

Furthermore, short sleep was associated with other important sleep problems, such as daytime sleepiness or behavioural insomnia that also plays a crucial part in healthy growth and development of young children. Unhealthy lifestyles such as lack of physical activity, excessive media use and irregular eating habits are the major reasons for the development of global health problems such as obesity or type 2 diabetes, and this study indicates that poor sleep may have a major impact on these lifestyles. Therefore, in the future, more resources should be placed in the healthcare sector, for counseling of sleep hygiene and its supporting behaviours to parents and children. Actions such as controlling the time (< 120 min/day) children spent with electronic devices (TV, video games, internet and mobile phones), supporting the attendance of recommended daily physical activities (≥ 120 min/day) and providing information about correct dietary habits of children should be heavily consider by the parents, teachers and all the professionals in children's healthcare field.

6.2 PREVALENCE AND ASSOCIATION BETWEEN SLEEP BEHAVIOURS

The prevalences of various sleep disorders in this study (2.0% - 15.4%) based on the PANIC sleep questionnaire was in line with the prevalences that have been found in previous studies conducted in primary school children (Owens et al. 2000b, Stein et al. 2001).

There were no significant differences in any sleep behaviour or problem between the genders. Previous studies have presented inconsistent results on gender related differences in sleep behaviors of children aged 2 – 14 years. (Owens et al. 2000b, Archbold et al. 2002). Comparison between the prevalences of sleep problems in the present study with earlier studies is complicated, because of the different measuring scales and the cultural variations of sleep behaviors (Wing and Chen 2009). Nevertheless, it is possible to compare the trend of the associations with previous findings.

In the present study short sleepers (< 10 hours) were more likely to have a higher risk for behavioural insomnia than normal sleepers (≥ 10 hours), and they also had more daytime sleepiness. These results support a previous study that found a similar link between short sleep and behavioural insomnia and a suggestive association with daytime sleepiness in Chinese primary school children (Liu et al. 2005). Interestingly, that study did not find similar association between sleep duration and daytime sleepiness with the U.S. primary school age children. The difference between countries in daytime sleepiness could be explained with different school starting times and time for commuting. The parental evaluation of sleep and sleepiness of children may also vary between different countries. The association between short sleep and behavioural insomnia in the present study is probably caused by decreased sleeping time caused by the longer sleep onset, restless sleep or nocturnal wakening.

There were no association between SDB or parasomnias with short sleep duration in to the present study. Previous studies on the associations of sleep restriction and SDB risk in children is far from clear. A parental questionnaire study showed a significant association between short sleep and SDB risk in primary school children aged 6 – 10 years (Liu et al. 2005). Another study that assessed the risk of SDB by overnight polysomnography did not find a clear link between any other sleep problems including insufficient sleep and elevated SDB risk in 90 children aged 7 – 12 years. This lack of the association was thought to occur due to a stronger sleep drive of children compared to adults (Yang et al. 2010). More studies are needed to get a better view on this matter.

Moreover, in the present data, the risk for behavioural insomnia was related with more frequent parasomnias (nightmares and sleepwalking), higher SDB risk, and daytime sleepiness. There are not many previous data available about the associations between behavioural insomnia and other sleep problems. Some studies have touched this topic but used partially different assessment methods. One study found that longer sleep onset and bedtime resistance were associated with sleep fears and nocturnal waking (Blader et al. 1997). Another study demostrated that restless sleep or sleep onset delay were related with daytime sleepiness in US children (Liu et al. 2005). The association between behavioural insomnia and parasomnias or sleep fears is probably explained by emotional disturbances that may reflect the restfulness of the sleep. Negative experiences from night terrors may also increase the resistance of sleeping and sleep onset delay in the present study. The association between SDB risk and behavioural insomnia is apparently caused by the breathing pauses of SDB, which will lead to nocturnal waking and restless sleep.

Finally, there was a less strong association between a probable risk for SDB (score ≥ 5) and bruxism, sleepwalking or –talking. Previous research data have also shown an association between SDB and parasomnias, when polysomnography has been used (Goodwin et al. 2004). Furthermore, a trend for an association between SDB risk and daytime sleepiness was found in the present data, but it did not achieve statistical significance. It has been previously shown that higher SDB risk is significantly associated with daytime sleepiness in 4 – 11-year-old children, but this relation could also be affected by some mediating factors such as race (Goodwin et al. 2003).

In the present study there were some important associations between short sleep and other sleep problems. The association between short sleep and behavioural insomnia was somewhat expected, because of the subjective nature of the questionnaire. Evidence from the present study support the view that sleep duration is inversely associated with daytime sleepiness. Moreover, there was no association between sleep duration and SDB probability. This may indicate that the sleep drive of children is strong enough to prevent from the negative effects of SDB on sleep duration, but may become a concern in older age.

6.3 ASSOCIATIONS BETWEEN SLEEP DURATION AND OTHER HEALTH BEHAVIOURS

Besides other sleep problems, sleep duration may be distracted by other lifestyles. Therefore, associations between sleep duration and other health behaviors were also investigated.

6.3.1 Low physical activity level as a risk factor for short sleep duration

A positive association between higher duration of physical activity (PA) and adequate (≥ 10 hours/ night) sleep duration was found in the present study. Additionally, this association remained after adjustment for other health behaviours and confounding factors such as proportion of adipose tissue and CRF. This is the first time in literature that the association between sleep duration and PA has been found after adjustment for other health habits in elementary school children aged 6 – 8 years.

Several theories for the supportive role of PA in sleep duration have been suggested. These include thermoregulation, body restoration, energy conservation (Driver et al. 2000). Additionally, benefits on sleep through anxiety reduction or anti-depressive effect of PA have been demonstrated (Youngstedt 2005).

Experimental studies in adults have found only moderate or little improvement in sleep after acute PA or exercise training. This small impact is thought to be explained by small study samples, or because the studies were carried out in healthy adults or sportsmen who were mainly good sleepers, which leaves little room for sleep improvements (Youngstedt et al 1997, Youngstedt 2005). However, there have not been any clinical trials investigating PA and sleep in primary school children.

Epidemiological studies in children have failed to consistently show an association between longer duration of PA and adequate sleep duration. According to a large study of Chinese elementary school children PA was not associated with short sleep duration, when analyzed together with other lifestyles like media use (Li et al. 2010). Also a German study in 6 – 19-year-old did not find an association between PA and sleep duration (Hitze et al. 2009). It is worth mentioning, that these studies used relatively limited measures for assessing PA, by assessing only the participation of structured exercises. Therefore, the strength of the present study is that the association between PA and sleep duration was assessed with an extensive PA variable, which covers a large range of children's physical activities. This is important, because in childhood PA is not as structured as it is for adults, and therefore it needs to be assessed in diverse ways, noticing school, structured and leisure related activities (Sallis 1991).

Altogether, the findings indicate for the first time in literature that sufficient (≥120 min/day) PA can promote better sleep independently from other health behaviors and confounding factors such as CRF, amount of adipose tissue or SES in 6 – 8-year-old children.

6.3.2 Electronic media use as a risk factor for short sleep duration

Besides PA, excessive electronic media use appeared as another factor associated with sleep duration, but inversely. The role of electronic media use on sleep has been discussed in a review article (Cain and Gradisar 2010), which underlines that excessive media use has consistently been related with short sleep duration and delayed bedtime. Different studies have illustrated that television watching for more than 2 hours daily or having electronic media devices in the bedroom, has a negative impact on sleep duration of primary school children (Owens et al. 1999, Li, et al. 2007). Furthermore, excessive time spent playing computer or electronic games and internet use have been associated with shorter sleep in 6 – 18-year-old children. This association is considered more prevalent among adolescents, but also younger children are found to be predisposed to sleep restriction by computer and videogame influence (Li et al. 2007, Oka et al. 2008).

It is not clear how media use impacts sleep duration. Some mechanisms have been proposed. First, excessive media use may directly restrict sleep or reduce participation in other activities that can promote better sleep, e.g. physical activity or healthy eating (Cain and Gradisar 2010). Secondly, media use could expose the child to arousal, and thereby complicates the onset of sleeping or causes insomnia (Anderson and Bushman 2001). A third hypothesis is related to the late evening bright light exposure, which can suppress the melatonin secretion, and subsequently postpone the biological rhythm (Higuchi et al. 2005).

Whether the association of sleep duration with media use is mediated through the above mentioned mechanisms or by something else, it seems clear that these two are strongly related lifestyle behaviors. Therefore, electronic media use has to be taken into account in clinical practice of insufficiently sleeping children and in the prevention or treatment programs for sleep problems by sleep professionals and other pediatric care.

6.3.3 Sleep as a risk factor for inadequate meal pattern

The risk of eating main meals infrequently (< 2.75 times/day) was explained by short sleep duration in the present study. This finding is important because of the strong evidence that support the negative role of short sleep on risk for obesity and metabolic syndrome risk in children (Patel and Hu 2008). Moreover, the link between a short sleep duration and obesity has been a major interest among sleep researchers during the past decades. Strongest evidence has been presented for the theory that sleep deprivation might lead to obesity through altered appetite hormone responses in adults (Spiegel et al. 1999, Vgontzas et al. 2004). These mechanisms have not been studied from children yet.

At least two studies focusing on primary school children have found associations between short sleep duration and unhealthy diet. One cross-sectional study conducted in 10-11-year-old Finnish children surveyed the sleep duration and food consumption of more than 1200 participants. The study revealed that high intake of energy-rich food was associated with short sleep duration during school nights (Westerlund et al. 2009). Another study, conducted in approximately 1000 Portuguese children, found a link between short sleep and unhealthy diet, as well as long sleep and consuming of healthier nutrients such as fruits and vegetables (Moreira et al. 2010).

It has been suggested that the frequency of meal intake might be as important indicator of obesity as any particular food composition or energy intake (Rodriguez and Moreno 2006). A Japanese study revealed that short sleep duration was associated to less frequent breakfast eating in 196 fifth-grade school children (Haruki and Kawabata 2005). Also, a cohort study of 28 000 U.S. and Puerto Rican women aged 35-74 years showed that short sleep was associated with a low tendency of eating during conventional eating hours and greater snack dominance (Kim et al. 2010). The present study did show similar type of trend for the 6 – 8 year-old children as well. So, it seems that there might be an important link between sleep duration and tendency of meal intake that should be studied more thoroughly in the future.

The findings of the present study bring up a new perspective for the research field of sleep, nutrition and obesity. Gaining an adequate night's sleep might be in a major role as a determinant of childhood eating habits or the other way around, and by consequence an important factor for the obesity prevalence in childhood.

6.4 METHODOLOGICAL ASPECTS AND STUDY LIMITATIONS

In the present study, a parental questionnaire was developed to assess children's sleep behaviors and problems. Questionnaires administered to parents have been previously used for assessment of sleep habit and problem in children (Owens et al. 2000b, Archbold et al. 2002, Liu et al. 2005,). Compared to the earlier studies, this questionnaire does not provide as broad a question pattern, but instead was designed to assess the most common sleep problems like insufficient sleep, probability of behavioural insomnia and of SDB for children starting primary school. An inter-study comparison of prevalence of sleep habits and problems is complicated. This is due to the different scaling used in the answering alternations. Probably the best possible benefit comes later from follow-up studies of the same population or by using the same questionnaire in the future studies designed for children.

Overall, the PANIC sleep questionnaire that was designed for epidemiological studies on sleep pattern and prevalence of different types of sleep problems was quite comparable to the prevalences of previous studies. The probability score of multiple variables for behavioural insomnia and SDB in children has been used in previous studies with partially different variables (Archibold et al. 2002, Liu et al. 2005). The probability score is a more reliable way to characterize individuals at risk for certain sleep problems e.g. SDB, compared to single item questions. This type of scoring could be more widely used in the epidemiological sleep research in the future. The best possible combination of questions and risk classification still needs to be further studied.

One limitation of this questionnaire when compared to prior sleep studies is the broad assess of sleep pattern. The duration of sleep was asked by the average time of sleep in a “normal” night, whereas usually the time of staying in bed, sleep start time and wakeup time have been assessed in these types of questionnaire. Moreover, the sleep behaviors during weekend were not separately queried. Therefore, it cannot be surely address whether some children in this population sample obtained less sleep during the week and attempted to ‘catch up’ during the weekend. Additionally, the data gathered were all subjective in nature. Therefore, it relied on parent perception of their children’s sleep without any objective assessment being conducted. It has been previously found that sleep duration estimated by parents might overestimate the amount of sleep compared to objective measurements in 6 – 11-year-old children (Goodwin et al. 2007).

A sum of multiple variables to assess habitual PA and electronic media use was utilized, so that the average duration of exposure to these activities per day could be as accurate as possible. This can be seen as strength in the present study, because many previous questionnaire based studies have only used one or two questions to assess PA and media duration (Hitze et al. 2009, Li et al. 2010). In the future, it would be interesting to also measure the intensity of physical activity by accelerometer.

Objective methods for assessing CRF by maximal bicycle-ergometer and proportion of adipose tissue by DEXA were used. There is a strong correlation with proportion of body fat and CRF, when CRF is calculated as watts per body weight (W/kg). Therefore the watts per kg lean body mass (W/LBM) as a measurement unit of CRF.

6.5 FUTURE IMPLICATIONS

As a research field, sleep medicine is a newcomer with the history of last few decades, particularly in children. Sleep disturbances have been investigated in recent years, with several study data showing negative effects of insufficient sleep on health and functioning of children (Touchette et al. 2007, Patel and Hu 2008, Nixon et al. 2008). Still, little is known about the possible determinants of short sleep duration and effects of short sleep duration may have on health behaviors such as physical activity, inactivity or nutrition in children.

The evidence from the present study demonstrates that there are several connections between sleep duration and health behaviors, like duration of PA and media time, and meal frequency. The findings from the present study can provide more information to many sectors including parents, teachers and children’s healthcare professionals about the role of short sleep as an important mechanism affecting other health behaviours. This evidence could also be developed to new tools for the ongoing fight against worldwide lifestyle diseases like obesity, type 2 diabetes that today occur even in younger children.

Some future directions of study can be suggested based on these results. Sleep and other health behaviors were assessed by a parental questionnaire and it would be interesting to see how more objective methods such as accelerometers could detect associations between sleep and PA. It would be also important to further test the validity of probability scoring scales that were used for assessing SDB and behavioural insomnia, by evaluating it with more objective measures, such as polysomnography. Finally, the results of this study encourage conducting prospective studies and clinical trials to estimate the impact of health behavior changes on sleep duration and on cognitive, behavioural, emotional and physical development of children.

7 CONCLUSIONS

1. The prevalences of sleep duration and sleep problems were similar with the findings of previous studies that have used sleep questionnaires and have been conducted in primary school children. A short sleep duration, behavioral insomnia and daytime sleepiness were associated with each other. In addition, behavioral insomnia, SDB and parasomnias were associated to each other. These findings are important research data for prediction and prevention of children's common sleep problems.

2. Low habitual physical activity and high electronic media time were associated with an increased risk for short sleep. Meanwhile, short sleep predicted inadequate meal intake frequency. These findings emphasize the role of adequate sleep as one of the main health behaviors of future health promotion of children. The causality between different health behaviors in childhood and their effects on lifestyle diseases in adulthood should be investigated in the future.

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9 APPENDICES