The sleep quality of children with ADHD type of symptoms:

A study on body motility

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Tässä tutkimuksessa verrattiin yhdeksän ylivilkkaus-tarkkaavaisuushäiriöoireisen (Attention Deficit Hyperactivity Disorder, ADHD) lapsen unta yhdeksän normaalin lapsen uneen. Aikaisemmissa tutkimuksissa on löydetty merkkejä yhteydestä ADHD:n ja unihäiriöiden välillä, tosin osittain ristiriitaisin tuloksin. Tutkimuksessa käytettiin autonomisen hermoston toimintatiloja kuvaavaa Static Charge Sensitive Bed (SCSB)- unimenetelmää. Kehon liikkeisiin perustuva mittausmenetelmä antoi tietoa autonomisen hermoston aktiivisuuden muutoksista, ja kuvasi siten unen laatua. Kolmena peräkkäisenä arkipäivien välisenä yönä suoritetut mittaukset mahdollistivat lasten normaalin nukkumisen omissa sängyissään. ADHD-oireisilla lapsilla oli merkitsevästi enemmän vaihtelua heidän autonomisen hermoston toiminnassa yön aikana kuin muilla lapsilla. ADHD oireiden ja unihäiriöiden välinen yhteys näytti tässä tutkimuksessa liittyvän ylivilkkaiden lasten autonomisen hermoston aktiivisempaan ja nopeammin vaihtelevaan toimintaan.

Avainsanat: ADHD, unihäiriö, autonominen hermosto, SCSB- unipatjamenetelmä

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Abstract

In this study the sleep of 9 children with symptoms of Attention Deficit Hyperactivity Disorder (ADHD) was compared with the sleep of 9 normal children. Previous research has found some evidence of the relationship between ADHD and sleep disorders. However, the results have been partly contradictory. In this study Static Charge Sensitive Bed (SCSB) method of describing activity states of autonomic nervous system was used. SCSB system utilizes body motility as basis for describing activity states of the autonomic nervous system. The measurements were conducted at 3 consecutive nights during weekdays, and they allowed the children to sleep in their own beds as they would normally do. The children with ADHD type of symptoms did have significantly more variation in their activity during the night than the other children. In this study the relationship between ADHD and sleep disorders appeared to be related to more active and more variable functioning of autonomic nervous system on children with ADHD type of symptoms.

Keywords: ADHD, sleep disorder, autonomic nervous system, SCSB- system

Introduction

The quality of sleep has a great effect on the quality of life. The children need more sleep than the adults, so possible sleep disorders may cause them more harm than the similar disorders in adults. The researchers seem to agree on that sleep disorders and problems with hyperactivity and attention disorders are related to one another (e.g. Brown & Modestino, 2000; Chervin, Dillon, Bassetti, Ganoczy & Pituch, 1997; Corkum, Tannock & Moldofsky, 1998; Gruber, Sadeh & Raviv, 2000; Kaplan, McNicol, Conte & Moghadam, 1987; Picchietti, England, Walters, Willis & Verrico, 1998). However, much of this research is based on subjective reports and there is not yet

any coherent knowledge on the effects of sleep disorders (Corkum et al., 1998). Thus, there is a need for objective data on children's sleep and possible sleep disorders. The present study addressed this concern by using static charge sensitive bed (Alihanka, Vaahtoranta & Saarikivi, 1981) to investigate the sleep quality of normal children and children with symptoms of attention deficit hyperactivity disorder.

A human being spends normally about one third of his or her life asleep. Early in childhood, when human development is at its fastest, sleeping covers a great part of every day. Sleep, which means here the entirety of time spent asleep daily, is an interesting and question provoking state at the one end of the continuum of alertness in humans (Dahl, 1996). It is characterized by minimal perception of the environment and a general state of rest with the brain and the body functioning on a sort of standby mode. Human sleep is often described with standardized sleep stages according to the electrical functioning of the brain (Rechtschaffen & Kales, 1968). When falling asleep, electroencephalography (EEG) measurements show fast alpha and beta waves decreasing in frequency to slow delta waves as person's sleep gets deeper. When dividing sleep into stages, stages 1 and 2 are descending into deeper sleep and stages 3 and 4 are time of actual deep sleep, or slow wave sleep (SWS). The sleep proceeds in cycles so, that gradually deepening sleep changes into lightening sleep in inverse order of the stages. After that a new cycle begins again with gradually deepening sleep. These stages belong to Non Rapid Eye Movement (NREM) sleep and the SWS seems to be the time when the recovery and repair of the previous wake period takes place in the brain (Stores, 1996). A slightly different standard has been developed for the sleep of infants (Anders, Emde & Parmelee, 1971).

Rapid Eye Movement (REM) periods start to appear in between the lightest sleep stages especially later in the night (Rechtschaffen & Kales 1968). REM periods are the times for dreaming. During REM sleep the electrical activity of the brain is very similar to one of waking period, but almost complete loss of muscle tone in skeletal muscles hinders a person from moving to his or her dream images. The exact reason or mechanism for occasionally vivid and complex dream imaginary is not yet known, but REM sleep is thought to be related to learning (Stores, 1996). Smith and Lapp (1991) tested how increased cognitive load during daytime influenced REM sleep on following nights. REM periods (REMs) had longer duration after strenuous studying but the same number as during cognitively less demanding periods. Therefore REM density was considered to be increased when much learning was taking place. Contrary to the

common view Horne (1988) has stated REM sleep having no relation to learning or memory processes.

Dahl (1996) clarifies changes in need for sleep throughout human development in his article about arousal regulation. Newborn babies are asleep most of their time, that is about 16 hours a day. When reaching the school age (6-7 years in the Nordic countries) a child sleeps about 10 hours a day. By adulthood the need for sleep has decreased normally to about 7-9 hours a day. Like the amount of sleep, also the structure of sleep changes during development. A baby sleeps great portion of the time and spends great amount of time in SWS. The proportion of SWS peaks at about when a child stops taking naps, declines then slightly over the development. Elderly people may have almost no SWS at all. Similar changes are detected in REM sleep (Horne, 1988). A newborn baby spends almost half of the sleep time in REM sleep. By the first birthday this portion has declined to about 35%, since then the portion of REM dimishes more subtly so, that by the age of 25 it covers 20-25% of total sleep (Roffwarg, Muzio & Dement, 1966; Williams, Karacan & Hursch, 1974).

There are many examples about the relationship between children's sleep disturbances and problems with inattention and hyperactivity, especially in the form of parents' subjective reports and clinical descriptions (Chervin, et al., 1997; Corkum, et al., 1998). Barkley (1990) has defined Attention Deficit Hyperactivity Disorder (ADHD) consisting of developmentally inappropriate degrees of inattention, impulsivity and overactivity. Hyperactivity presents itself in almost constant movement and playing in children. In disorder of attention a child has great difficulties in concentrating on any subject matter for more than a brief period of time. Impulsivity refers to doing things without thinking about the consequences (Sandberg, Santanen, Jansson & Lauhaluoma, 2000). In the present study problems with inattention and hyperactivity are referred with single term ADHD. The prevalence of ADHD is about 3-5% among children (Chervin et al., 1997).

Sleep-related problems may present themselves in falling asleep, maintaining continuous sleep and waking-up. Especially children may be worried about nightmares, sleep- walking and other parasomnias, but fortunately they are normally transient or single disorders (Stores, 1996). Most common sleep disorders in children with ADHD are difficulties in falling asleep, restless night sleep with several arousals and too early waking up. With adults, long term problems with sleep lead normally to tiredness during the day and therefore to lower vigilance and performance. With children however, problems with sleeping lead often to lower ability to concentrate and

paradoxically to hyperactive behavior (Chervin et al., 1997). However, Corkum et al. (1998) emphasize, that the relationship between sleep disorders and ADHD has not yet been affirmed thoroughly with objective research methods. The results have been contradictory. Generally only two consistent findings have been made concerning children's sleep disorders. First, ADHD children do not differ from other children in the terms of total sleep time. Second, ADHD children are more restless in their sleep than the other children.

The reasons for children's sleeping disorders have been started to be explored recently on the level of brain structures. It has been found out that brain areas which control sleep-wake rhythm, attention and mood are closely connected to each other (Brown & Modestino, 2000). Dahl (1996) has identified prefrontal cortex to be crucial in controlling wake, sleep and attention. It has been suggested also, that one reason for ADHD problems could be a minor damage on prefrontal cortex during prenatal development (Mash & Barkley, 1998). According to Thoman et al. (1981) great variation in sleep and wake rhythm during 3 week observation period predicted later health and behavior problems. In this respect considerable variation in timing and length of different sleep stages can be seen as risk factor concerning later development. On the other hand Horne (1981) has noted, that practically everybody has variation in sleep stages from night to night.

There are few specific aspects to consider when conducting sleep research. Sleeping in unfamiliar environments may cause difficulties in getting a good and restful night sleep. This is typical especially for the children, who do not have much experience in sleeping in unfamiliar places. The first night slept in a laboratory has been noticed to differ from the following nights (Agnew, Webb & Williams, 1966). This phenomen is called first night effect. The disadvantage of laboratory research is that only relatively few participants can be studied due to the lack of time and resources. Thus, subjective reports are used often in sleep research, and they are normally views about sleeping by the people themselves or by their parents or cohabitants. Chervin et al. (1997) consider using subjective reports especially useful in determining the prevalence of the researched phenomena. With them can a great amount of information be gathered from large sample of people. However, Corkum et al. (1998) state, that by this far no coherent empirical data has been found about the relation between children's sleep disturbances and behavior problems. Furthermore, the subjective data and the objective research results are often contradictory. One reason for that may be a small sample size in studies with objective methods, which may easily lead to type 2 errors in statistical

analysis, meaning the significant result failing to be noticed among total variance. The objective methods in sleep research include the polysomnography measuring EEG, eye movements and muscular tone, videotaping a sleeping person and a wrist watch like actigraph which measures movement activity (Corkum et al., 1998).

Static charge sensitive bed (SCSB) uses person's motility in bed as a basis for classifying sleep into activity states of autonomic nervous system (Alihanka et al., 1981; Kaartinen, Erkinjuntti & Rauhala, 1996). Its advantage is that it consists only of a thin movement detector plate placed under normal plastic foam mattress, an amplifier unit and a lap top computer. No wires or electrodes need to be attached to the participant. SCSB filters motility related to ballistocardiography, breathing, and actual movements from the distinct frequencies of motion in which they take place (Kaartinen, 1997). The cyclic changes in the structure of sleep coincide with changes in the function of the autonomic nervous system, which can also be seen in the motility of a body. Based on variability scores from short movements, breathing amplitude changes and ballistocardiography amplitude changes autonomic nervous system activity of quiet, intermediate and active state can be attained (Kaartinen et al., 1996). Even though polysomnography is considered to be the most accurate measurement device for sleep, SCSB and actigraphy may in certain situation be more appropriate methods in collecting sleep data. They are easier to use and enable measurements at people's homes without disrupting their normal sleeping environments and daily rhythms.

Chervin et al. (1997) studied the effect of children's sleep related breathing disorders (SRBD) on ADHD. They stated that even minor breathing disorder and long term snoring disturbed children's sleep that much, that next day children had ADHD type of symptoms related to lack of sleep. They assumed disturbance of sleep be due to slight more effort children had to put into breathing which lead to little arousals but not actual wakening. These small arousals disturbed normal cyclic structure of sleep so, that the children were not refreshed normally after sleep, even though they had spent normal time asleep. These results are intriguing in the respect of consequences of children's sleep disorders. They should be treated with slight caution though, because the results were based on subjective parental reports of children's SRBDs and Chervin et al. (1997) verified the breathing disorders of only some children of their sample later with polysomnography.

Picchietti et al. (1998) studied motor sleep disorders and their effect on the children with ADHD. Periodic limb movement disorder (PLMD) consists of short repetitive jerks in lower limbs in early stages of sleep, mostly during stages 1 and 2.

PLMD causes serial short arousals and disturb therefore normal course of falling asleep. Restless legs in turn is an uncomfortable sensation in legs, which causes unbearable urge to move legs to ease up the symptoms. Picchietti et al. (1998) used an electrical movement sensor in calf muscle to measure leg movements during sleep. The results indicated that children with PLMD had often ADHD, but restless legs in itself was not related to ADHD. Additionally children with both PLMD and restless legs had often ADHD. The researchers presented alternatives, that PLMD and restless legs are one subgroup in ADHD or that movement disturbing falling asleep cause lack of sleep and lead to ADHD type of symptoms during daytime.

Gruber et al. (2000) studied the timing and peacefulness of sleep in children with ADHD and control children with an actigraphy measuring movement activity. The measurements were conducted at homes of the children during 5 consecutive nights. The advantage of this type of measurement is that it does not affect children's normal evening or night- time behavior disturbingly, so the results are easier to generalize. The results reveal, that the rhythm of sleep- wake system of the children with ADHD has more variability than the one of the control children. The differences appeared as great variation in bed-time, duration of night sleep and true sleep time excluding nightly wakenings.

There is a need for objective and ecologically valid data on children's sleeping behavior and possible disorders of sleep. Objective methods should therefore be so easy to use, that they would not disrupt children's normal behavior too much. SCSB is good in this respect, because it does not require any other special arrangements than turning on the recording program in the evening as a child is going to bed and turning it off in the morning. This way a child can go to his or her own bed and sleep normally and still objective data can be attained about body movements and the present functions of autonomic nervous system during the night.

In the present study the question of whether children with ADHD type of problems are more restless in their sleep than the normal children was studied. The changes in autonomic nervous system described by the SCSB- system were meant to depict the restfulness of the sleep. The hypothesis was that the children with ADHD type of symptoms are more restless and have more variability in breathing amplitude and ballistocardiography than the normal children during night sleep.

Method

<u>Participants</u>

Participants (n = 18) were contacted from a pool of about 200 families in Central Finland, who were either taking part in ongoing Jyväskylä Longitudinal Study of Dyslexia (JLD) or were participating in family school, which was organized by JLD to help the families cope with children with ADHD (Lyytinen et al., 2001). Based on parental questionnaires Behavioral Assesment Scale for Children (BASC) scores had been counted in JLD for the children when they were 5 or 6 years of age (Reynolds & Kamphaus, 1992; Vaughn, Riccio, Hynd, & Hall, 1997). The control children (n = 9) were taking part in JLD which investigates reasons and precipitating factors of reading disorders. Test group (n = 9) was contacted from the family school based on especially high BASC scores in hyperactivity subscale, teacher reported hyperactivity in school or otherwise diagnosed ADHD. The control group was contacted randomly of the participating families in JLD whose children did not meet any of the above mentioned criteria. The participants (test group n = 9 all boys, control group n = 7 boys n = 2 girls) were between 5-8 years of age, so they were either in day care, preschool or in 1st two grades in elementary school. The age of the children in the test group and in the control group were same. The participants were given a pair of colorful stickers for the participation, and the families of the children were given an overall analysis and estimation of the sleep of their own child.

<u>Apparatus</u>

The measuring equipment are illustrated in Figure 1. It included the SCSB-movement detector placed under a standard junior mattress, a preamplifier unit and a lap top computer using BR 99 program to record the events of the night. Movement time and variability scores were used to assess the restfulness of sleep. BR 99 program was modified according to Kaartinen et al. (1996) to score variability points most accurately to activity states of autonomic nervous system into quiet (QS), intermediate (IS) and active state (AS). In SCSB analysis QS reflects behaviorally SWS in traditional sleep staging, IS and AS depict lighter stages of sleep (Kaartinen, Polo, Sallinen & Lyytinen, 2003). The program was also modified to use sleeping parameters of breathing amplitude change, changes in ballistocardiography and short movements, which

according to Kaartinen et al. (1996) correlate best with the changes in standard sleep stages. Initial analyses were done with BR 99 program to report the parents of their children's sleep and then SPSS 8.0 was used to analyze data by the whole night, by thirds of a night and by hours of a night.

Figure 1. While being measured, the children were able to sleep in the comfort of their own bed.

Procedure

The participating children were contacted through their families with a letter, which contained description of the study and question of their willingness to participate in the study. After the families had informed the researchers to be ready to participate, they were contacted by phone and the time of the measurements was agreed. The measurements were conducted during consecutive nights either between Monday and Thursday or Tuesday and Friday. Three nights in a roll were used to eliminate first night effect and excitement that might influence children's sleep in test situation. The measurements were conducted during normal workweek, because the daily rhythm was consired to be most normal at those times. After adjusting the SCSB in a child's bed before the first night a researcher collected information on discs after every night. It was also checked out that the measurements had been recorded correctly.

Questionnaire

The parents were given a questionnaire, which included questions about the normal sleep of their child and an overall evaluation of the sleep of the test nights. The

evaluation consisted of a 5-step Likert- scale type of evaluation of child's sleep in general. Additionally normal bed-time and sleep onset were asked to be evaluated. There was also a chance to give some special data of the sleep each night if parents had noticed something worth mentioning. However it was emphasized, that parents would not have to observe their child especially rather than to live as they normally do.

Statistical analysis

The analyses of the recordings were based on movement time, total score of variability and activity state of the autonomic nervous system. Additionally duration of the longest continuous QS periods and sum of the 3 longest QS periods were used to asses the restfulness of the sleep. The General Linear Model (GLM) repeated measurement analyses were performed with SPSS 8.0 program, and they were done by the thirds of a night, by hours of a whole night and by the two first hours of a night. Two first hours of a night were analyzed to describe time spent normally mostly in SWS sleep.

Results

The results showed how there were great differences in the cyclic structure of the sleep when comparing the two groups. As seen in Figure 2., the sleep profiles show quickly the overall quality of child's sleep.
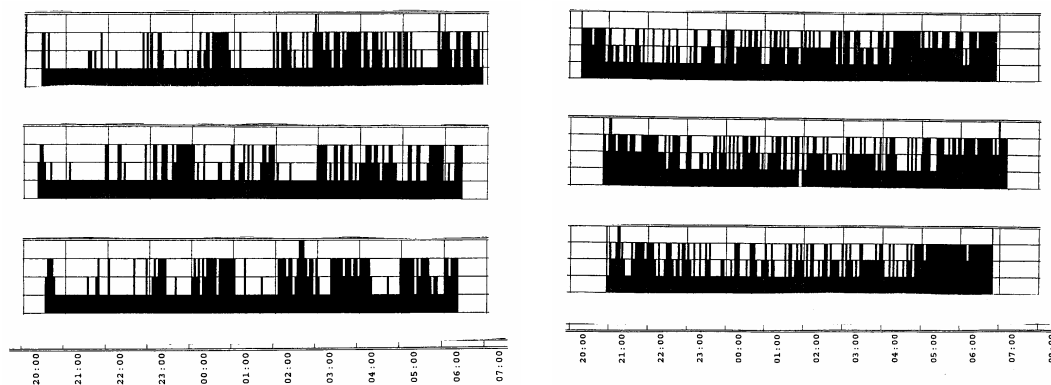

Figure 2. The sleep report of a control child (on the left) and a child with ADHD type of symptoms. The reports show level of autonomic nervous system activity. The control child had more regular and restful night sleep.

ANOVA analysis of the questionnaire revealed control group children as being more restful during their habitual sleep than the children in test group [F (1, 16) = 5.953, p =

0.027). In other questions differences were not found. There was not significant difference between the groups in parents' evaluations of the sleep of the recording nights.

The GLM revealed main effect of increasing variation in measured parameters throughout the night [F (1, 7) = 5.948, p = 0.006]. As can be seen in Figure 3. the variability scores decreased during first 2 hours of sleep and increased steadily thereafter over the whole night.
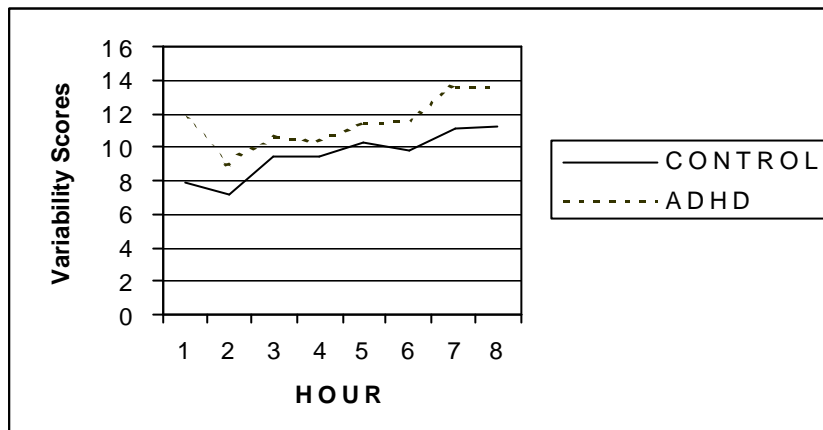

Figure 3. Variability scores reveal main effect of increasing activity after 2 first hours of sleep and the difference between the groups.

The variability scores describe how much variation there is in the autonomic nervous system and through that how restful is person's sleep. The GLM revealed significant differences by the thirds [F (1, 16) = 6.846, p = 0.019], by the hours of all night [F (1, 16) = 5.838, p = 0.028] and by the first two hours of sleep [F (1, 16)= 5.011, p = 0.040]. These results show that the children in test group had significantly more variation in their sleep than the control children.

The GLM did not reveal any significant results in the respect of movement time. The results between the groups were by thirds [F (1, 16) = 3.787, p = 0.069], by hours of the whole night [F (1, 16) = 3.052, p = 0.100] and by 2 first hours of sleep [F (1, 16) = 0.001, p = 0.979]. Contrary to the expectations movement time of children in control group appeared to be even slightly greater than the one of the test group.

The measure of activity state revealed significant results by thirds [F (1, 16) = 6.225, p = 0.024], by the hours of whole night [F (1, 16) = 5.225, p = 0.036]. This means that when analyzed by the activity states the children in test group were more restless in their sleep when considering the whole night. The results pointed to the same

direction when analyzing the sleep of the early night by the first 2 hours of sleep, but the difference did not reach the limit of signifigance [F (1, 16) = 4.255, p = 0.056].

The duration of the longest and a sum of three longest QS periods were counted to evaluate for how long the participants spent time in deep, slow wave sleep. The results show that the control children had longer periods of the longest quiet activity state than the test children [F (1, 16) = 5.578, p= 0.031]. On average the longest QS periods lasted 42.04 min in control group and 32.63 min in test group. The sum of three longest QS periods were slightly greater in the control group, but it did not reach the limit of significance [F (1, 16) = 3.196, p = 0.093].

Discussion

The purpose of this study was to investigate with objective methods whether the sleep of the children with ADHD type of symptoms is different from the sleep of the normal children. Much of the research concerning the topic has been based on subjective reporting. The SCSB- method offered a convenient way of obtaining objective data with very little disturbance on the lives of the children. The hypothesis was that children with ADHD type of symptoms would have more variability in the functions of autonomic nervous system than the control children. The results supported the hypothesis. The level of autonomic nervous system activity was higher, and it was more irregular among children with ADHD type of symptoms.

The results indicated that children with ADHD type of symptoms had more variability in the functions of their autonomic nervous system during sleep than the normal children. The variation and higher level of functioning was expressed by greater variation in body motility among the participants in the test group. These results give support to the idea that these children tend to have more instability in the cyclic changes of arousal than the normal children. According to Gruber et al. (2000) children with ADHD had more variation in sleep- wake rhythm than the normal children. Thus the results of the present study and Gruber et al.'s study suggest that, problems with ADHD appear to be related to disturbed functioning of arousal control.

The results indicated that there was a main effect of increasing activity of autonomic nervous system after the first 2 hours of low levels of activity and variation with all children. This finding is consistent with the common view of the sleep being

most quiet and deepest after falling asleep and then becoming lighter and more active towards the morning (Rechschaffen & Kales, 1968). The results also revealed that there was a difference between the groups in the activity during sleep. The test group has got significantly higher variability scores than the control group. When these variability scores are known to reflect well the functioning of the autonomic nervous system, the participants in the test group seem to have had more autonomic nervous system activity than the participants in the control group. Could this higher level of activity in the autonomic nervous system be related to hyperactive behavior in children with ADHD type of symptoms?

Brown and Modestino (2000) have noted that brain areas which control sleep-wake rhythm, attention and mood are closely connected to each other. Mash and Barkley (1998) suggested minor damage to prefrontal cortex during prenatal development as one possible reason for ADHD. How could these two clues about factors involved in ADHD be related to elevated and more irregular function of autonomic nervous system with ADHD children analyzed in the present study? More active nocturnal functioning of the autonomic nervous system could influence both problems of ADHD and restless night sleep. Finding out more about the effects and causes of elevated and more irregular functioning of autonomic nervous system might give important information about how to alleviate problems related to it.

In the present study three sleep parameters were used to analyze the sleep. Short movements, breathing amplitude changes and ballistocardiography were analyzed from the measured data and when combined they resulted the variability scores. Thus variability score is an overall value of the state of activity in the autonomic nervous system, or restfulness of sleep in this study. Variability scores were also classified into three states of autonomic nervous system activity. These states were adjusted according to Kaartinen et al. (1996) for the parameters used in this study. Due to person's shifting and changing positions over night any of the parameters may be recorded insufficiently momentarily. So having three sleep parameters instead of only one gives better picture of bodily functions during sleep. Movement time during sleep might appear to be the best way to analyze the restfulness of sleep. However actual movements during sleep are controlled also partly by central nervous system to react to external stimuli like noise and temperature, for instance. Additionally movement time represents only one aspect of the nervous system function and depicts therefore less precisely activity states than the total variability scores.

Small sample sizes are usually a problem in sleep research. Getting reliable data requires consecutive nights of measurements and therefore it is difficult to get large numbers of participants. In this study sample size was 18 divided in two groups. Common problem of studies with small sample sizes is finding significant results among the total variance. Even though in this study significant results were attained, this size of a sample should be considered as minimum size in sleep research. Very small number of girls as participants (n = 2 in control group) in this study makes generalizing results more difficult. Within control group small number of girls was unintentional and coincidental, but within test group total lack of girls was more due to higher prevalence of ADHD type of symptoms among the boys and having only boys as available participants. This problem is common in many studies involving ADHD (Kaplan et al., 1987).

The SCSB- system proved to be useful measuring method in conducting sleep research with children. When having large enough samples is difficult in sleep research, SCSB system makes it easier for people to participate, because they can live their lives normally despite being measured. SCSB is not as precise as polysomnography, but it enables getting relatively good and reliable data from much larger number of participants. The advantage of SCSB system is that it does not require any other arrangements than turning on the measuring device when going to bed. Naturally having a measuring device under mattress was exciting for young children, but at least after the first night no one said it would have bothered his or her sleep. Additionally being able to conduct the study at participants homes is likely to increase the validity of the results, especially when the participants are young children.

The analysis based on parental questionnaire revealed parents being aware at least to some extent of the problems their children may have with sleep. When the problems with sleep seem to be so well known in the families of the children, what could the parents do to help their children sleep better? Medical interventions are one way of helping children to sleep better. However an easy, practical and recommendable way to enhance good sleep in children is to take care of sleep hygiene (Brown & Modestino, 2000). It means making the external factors influencing sleep as favorable to sleep as possible. Regular rhythm of life, avoiding strongly exciting TV programs and computer games before bed time, calming the child down before going to sleep and having the bed in room which is quiet, dim and with plenty of fresh air are factors that make falling asleep easier and improve the quality of sleep. Additionally life style choices like physical activity in fresh air, balanced diet, being able to avoid long term

stressful situations and other things alike may help sleep quality while improving also the overall quality of life.

This study verified the assumption that children with ADHD type of symptoms have usually slightly worse quality of sleep than the other children. It was also found out that this worse quality of sleep is related to elevated and more irregular function of autonomic nervous system. The sample size in this study was quite small and SCSB system is not as precise as polysomnography as measuring device. Nonetheless these results give clues about how the research on these kind of problems could continue. Investigating factors influencing children's autonomic nervous system activity may be an interesting direction of research in the future for both studies involving sleep disorders and ADHD.

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