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# Prevalence and consequences of insomnia in pediatric population

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*The innocent sleep,*
*Sleep that knits up the raveled sleave of care,*
*The death of each day's life, sore labor's bath,*
*Balm of hurt minds, great nature's second course,*
*Chief nourisher in life's feast.*

W. Shakespeare "Macbeth"

**Summary**

Insomnia presents an increasing and significant health issue in pediatric population. As the problem had grown over past decade, it became recognized by the specialists dealing with children and adolescents. In a recent study American Academy of Child and Adolescent Psychiatry members were asked about their experience with patients complaining about sleep disturbances. Doctors reported that sleep was a problem for 1/3 of their patients out of which 1/4 required pharmacotherapy [1]. Multiple studies concerning adults confirmed significance of healthy sleep in optimal cognitive, emotional, social and biological functioning. Adequate sleep is important in prophylaxis of many chronic diseases such as obesity, diabetes, hypertension, myocardial infarction, stroke [2]. Due to increasing prevalence of insomnia in children and adolescents growing attention is paid to its short and long term consequences in this group. This review summarizes available data on chronic insomnia prevalence and its consequences in population under 18 years old.

**Key words**: children, insomnia

The study was not sponsored.

## Introduction

Insomnia presents an increasing and significant health issue in pediatric population. As the problem had grown over past decade, it became recognized by the specialists dealing with children and adolescents. In a recent study American Academy of Child and Adolescent Psychiatry members were asked about their experience with patients complaining about sleep disturbances. Doctors reported that sleep was a problem for 1/3 of their patients out of which 1/4 required pharmacotherapy [1].

Multiple studies concerning adults confirmed significance of healthy sleep in optimal cognitive, emotional, social and biological functioning. Adequate sleep is important in prophylaxis of many chronic diseases such as obesity, diabetes, hypertension, myocardial infarction, stroke [2]. Due to increasing prevalence of insomnia in children and adolescents growing attention is paid to its short and long term consequences in this group. This review summarizes available data on chronic insomnia prevalence and its consequences in population under 18 years old.

## Aim

The aim of this paper is to gather available data on the prevalence and consequences of chronic insomnia in the population under 18 years of age.

## Method

The authors reviewed articles in PUBMED database regarding the importance of sleep and short – and long-term consequences of its disorders in pediatric population. Impact on the patient's family was also taken into consideration.

## Insomnia in children and adolescents

Although sleep disorders are included in both the US DSM-5 and WHO ICD-10 classifications, most complete summary is assembled in the International Classification of Sleep Disorders (ICSD). Andrzejczak and Gmitrowicz, in their review, carefully discussed the second edition of the classification in respect to sleep disorders in children and adolescents [3]. In 2014 the third edition of the ICSD was published, where insomnia is divided based on the time criteria (criterion E): Chronic Insomnia and Short-Term Insomnia [4]. ICSD-III also distinguished Other Insomnia Disorder, the category reserved for situations when parents have unrealistic expectations for the child's sleep need or short sleepers, who function well during the day. Insomnia is defined as difficulty falling asleep and/or staying asleep, waking up too early, bedtime resistance or difficulty sleeping without parent or caregiver intervention (criterion A) occurring at least 3 times a week (criterion D) resulting in fatigue, irritability, mood disturbance, daytime sleepiness, impaired concentration, attention, memory, impaired social, family or academic performance (criterion B). Sleep problems cannot be ex-

plained purely by inadequate opportunity or environment for sleep (criterion C) and are not better explained by other sleep disorders (criterion F).

Data on the insomnia prevalence in children and adolescents differ depending on the source. This distinction results from different criteria adopted to assess the problem prevalence, incidence inconsistency depending on the development stage, assessment methods (parents' questionnaires, self-assessment questionnaires versus actigraph studies). It is considered that various sleep disorders may affect 25–62% of pediatric population [2, 5, 6]. A few Polish studies estimate its incidence locally within 19–67% [7–10]. However, they assessed sleep disorders with non-standardized, often self-assessment questionnaires and mostly included lower and upper secondary school students. As far as we know, there is no reliable data on the prevalence of sleep disorders in children in Poland.

## Importance of sleep

In recent years, due to their impact on the health and functioning of children and adolescents, sleep disorders receive more attention. Sleep is essential in everyone's life, especially child's life, in view of its dynamic biological and social development. Sleep need decreases with age, Szymańska states that in the neonatal period it is 16–19 hours, at the age of 2 – 13 hours, for preschool children – 10 hours, while in schoolchildren – 9 hours a day [11]. Duration and quality of sleep affects one's physiological processes (i.e. hormone synthesis), circadian rhythm regulation, intellectual and emotional development [12]. In a broader context it has an impact on parents, their mood and family functioning [13].

In our review we have divided insomnia consequences in children into 3 categories: somatic, psychological and social consequences.

## Somatic consequences

### Decreased physical activity

In the last decade, lots of attention is paid to healthy lifestyle, meaning diet, physical activity and adequate sleep. It was noted that these three components are correlated, however, the direction and the pathomechanism has not been clearly defined yet. There are few studies drawing attention to the relationship between sleep and physical activity in pediatric population. Stone, who studied physical activity of more than 800 11-year-olds with accelerometer, observed the impact of sleep duration and regularity during the week on the children's physical activity level. Children who slept less than nine hours were less active in terms of overall intensity compared to those sleeping recommended number of hours [14]. Gomes et al., who investigated sedentary lifestyle determinants using accelerometer and actigraph, came to similar conclusions. Their observations show that people sleeping longer than their peers are more likely to have an active lifestyle [15].

Similar results occur with respect to the adult population. Several studies have shown that shorter sleep is linked to the reduction of physical activity among adults [15–17].

Taking into account the objectiveness of the assessment methods used in the cited studies (actigraphy) their results should be carefully considered. Although still scarce, they indicate potential pathomechanism of obesity emergence in people experiencing chronic sleep deprivation, whether behavioral or resulting from insomnia.

## Risk of obesity and diabetes

The increasing obesity pandemic in the world forces us to seek its causes and treatments. In the last decade, many studies have highlighted the link between short sleep and the high BMI prevalence [18–21]. Taheri in his review included 13 studies on large children and adolescents groups at various stages of development. All of them showed negative correlation between the total sleep time and weight. Taking into account the biological and psychosocial factors he created a theoretical model presenting how short sleep determines obesity. It draws attention to the three factors, that is fatigue, which reduces the physical activity level; behavioral circumstances (more opportunities to eat); abnormal hormone levels (low leptin, high ghrelin levels etc.), which affect hunger perception along with selection of high-energy-dense food accompanied by low energy expenditure [19].

Following studies by Nixon et al., who evaluated more than 500 children using actigraph, confirmed the link between sleep deprivation and obesity. However, multivariate data analysis did not associate this observation with decreased physical activity or increased television watching [22]. In the meta-analysis including studies from around the world, Cappuccio et al. proved that this relationship is independent of race and confirmed by data collected in various regions [21]. Taveras et al. did not observe short sleep and increased BMI correlation to be associated with age [20]. Similarly Drescher et al. did not relate it to gender [23].

Despite multiple studies suggesting the link between inadequate sleep and obesity in children, there are also surveys negating the correlation. An example might be a statistical data analysis of the National Survey of Children's Health conducted by Hassan et al. It included more than 81 thousand telephone health questionnaires regarding the US pediatric population. Although the results showed no significant association between sleep and BMI, collected data quality is a study weakness (a telephone interview from a parent, lack of impartial indicators) [24].

Tasali et al. conducted an interesting experiment that may help to understand the pathogenesis of obesity and diabetes in people suffering from sleep disorders. They selectively suppressed stage 3 and 4 NREM sleep without awakening subjects in nine healthy young adults (20–21 years old) for three consecutive nights. After three experimental nights glucose tolerance and insulin sensitivity were significantly deviated from the baseline (a decline of 23 and 25% respectively) indicating an increased risk of obesity and diabetes [25].

Recently there have been several small studies evaluating the relationship between sleep duration, the diet selection and leptin levels in the blood. Hart et al. assessed an impact of the experimental weekly sleep curtailment and its weekly elongation (measured with actigraph) on calorie intake, fasting leptin level and weight in children.

Consumption decreased on average by 134 kcal/day. Also leptin level reduction and the average weight loss of 0.22 kg were found during the increased sleep in comparison to the decreased sleep condition [26]. Burt et al. reached similar conclusions, while assessing with actigraph correlation between sleep quality and quantity and the eating habits of 56 children. They found that short sleep duration and poor sleep continuity were associated with increased number of eating behaviors shown to be correlated with higher food intake [27]. Boeke et al. performed two cohort studies analysis, which included children (n = 655) and adolescents (n = 502). It indicated that impact of sleep duration on the leptin level may be dependent on the patient's age and sex [28].

The previous objective studies have shown the relationship between reduced sleep and obesity, but pathomechanism of the relationship is still not fully understood. On the basis of the above studies, it appears that shorter sleep determines not only reduced physical activity but also increases the opportunity to eat. Moreover it affects biological parameters that increase the risk of obesity, such as levels of leptin, insulin sensitivity, glucose tolerance. Sleep deprivation causes increased energy expenditure, but also leads to physiological and behavioral changes that cause a positive energy balance.

## Hypertension risk

Multiple studies have documented the impact of obstructive sleep apnea on elevated blood pressure. Researchers have started to pay attention to the relationship between sleep duration and blood pressure in children. Data from previous studies suggest that chronic sleep restriction can be a risk factor for hypertension in patients under 18 years of age. The conclusions from pediatric population survey in China (n = 4,902) indicate an increased risk of hypertension in boys aged 11–14 years [29]. Lee obtained similar results investigating Korean youth (n = 1,187). He observed that those who slept less than 5 hours had a higher risk of hypertension and obesity [30]. Moreover, lower secondary school students in the Lithuanian research (n = 6,940) showed prehypertension and hypertension incidence of 12.6% and 22.5% respectively. After excluding the impact of variables, such as age, sex, BMI, physical activity, smoking, study documented the relationship between reduced sleep duration and elevated blood pressure [31]. Similarly, in the study objectively evaluating sleep (actigraphy and polysomnography) in 238 healthy adolescents, Javaheri et al. have shown that sleep quality and duration is directly correlated with an increased hypertension risk in young people [32].

The increased risk of hypertension in children and adolescents sleeping less, worse than peers is not fully understood. Potential mechanism explaining the underlying causes may be hormonal imbalance of the body subject to chronic sleep restriction (increased production of catecholamines, cortisol secretion abnormalities [33], activation of the renin-angiotensin system) or autonomic dysfunction [34]. Slight disorder of breathing during sleep, leading to its fragmentation, which does not meet the criteria of OSA also appear to be important. Improving the length and quality of sleep through the application of the rules of sleep hygiene and behavioral

interventions may prove to be one of the effective elements of conservative treatment of hypertension.

## Metabolic syndrome risk

The relationship between reduced sleep and the overall metabolic syndrome risk, understood as BMI above the 85$^{th}$ percentile, waist circumference above the 90$^{th}$ percentile, hypertension, hypertriglyceridemia, reduced HDL cholesterol, fasting glucose intolerance, is also controversial. Although Lee documented link between shorter sleep and obesity and increased blood pressure values, he has not proven correlation between sleep and metabolic syndrome [32]. Sung et al. in their prospective study results, which included evaluation of 133 obese adolescents with actigraph, also undermine the relationship [35]. Interestingly, both studies demonstrated a worse lipid profile (hypertriglyceridemia) in children sleeping longer than their peers. Likewise population studies conducted in Europe (n = 699), assessing sleep quality with self-assessment questionnaire, did not show correlation between sleep duration and metabolic risk [36].

Data from the survey conducted by Iglay Reger et al., evaluating 37 obese adolescents using actigraph, lead to different conclusions. Results indicated negative correlation between total sleep time and cardiovascular risk. However, due to the study nature causal connection cannot be determined [37]. The Dutch population study outcomes (n = 1,481) suggest an increased risk of metabolic syndrome triggered by shorter sleep, but only in girls. Though, the sleep quality evaluation with self-assessment questionnaire and small effect of scale make unequivocal interpretation of the results difficult [38]. On the other hand, a large Canadian population study (n = 4,104) showed a significant correlation between adolescents' sleep duration and quality and the cardiovascular risk manifested by BMI above the 85$^{th}$ percentile, blood pressure above the 90$^{th}$ percentile, non-HDL lipid level above 3.1 mmol/L [39].

On a basis of available research, due to results heterogeneity and insufficient follow-up time, it is not possible to draw convincing conclusions. The link between sleep and cardiovascular risk in children and adolescents requires further in-depth observations and analysis. Difficulty in conducting research on the relation between sleep duration and the development of metabolic syndrome is, on the one hand the complexity of the metabolic syndrome criteria, on the other hand long term development of the problem. Furthermore the presence of interfering factors such as sleep breathing disorders impede drawing firm conclusions (SBD do not objectively shorten sleep but considerably impair its quality). Differences in the cited studies may be due to both, heterogeneity of the length and quality of sleep assessment methods, as well as the study groups' selection. Due to the increasing metabolic syndrome prevalence and its significant social consequences more studies are needed on this issue.

## Psychological/individual consequences

### Depressed mood/anxiety disorders

Mood and anxiety disorders in children are frequently accompanied by insomnia. Krysiak-Rogala wrote that 73% of children with depression, and 88% of children with anxiety disorders report sleep problems [40]. Bidirectional correlation between the above has been highlighted recently. In his literature review, Kahn et al., has taken into account many papers regarding the influence of sleep deprivation/restriction on emotional deregulation [41]. They indicate the existence of "vicious circle" in which sleep disorders adversely affect the emotional regulation. In turn, negative emotions make sleep onset difficult and disturb sleep. Pathomechanism of this phenomenon is still unclear. The available data suggest several theoretical pathways. One assumes that sleep, through networks in the prefrontal cortex, may have an inhibitory effect on the experienced negative emotions. Another model points to the moderating influence of REM sleep on emotional regulation and mitigation of negative experience interpretation during dreaming. It is also postulated that unpleasant feelings are processed during sleep and only those that have adaptive significance are preserved. The inverse relationship points to the stress that causes excessive excitation hindering sleep. Moreover, emotional stress coping styles affect sleep duration and quality [41].

Although the researches on sleep influence on children's emotions are fragmentary, the subject is paid increasing attention. Study conducted on 676 school children have shown that late sleep onset (after 10 p.m.), especially in combination with a discordant family life or lack of close parent-child relationship, increased fourfold depression risk in children [42]. Prospective study conducted by Silva et al., using a home polysomnograph, documented that children sleeping less than 7.5 hours at the age of 9, after 5 years had a slightly increased risk of anxiety and depressive symptoms [43]. Similar results were obtained in a population-based study conducted in 11 countries (Estonia, France, Germany, Israel, Austria, Hungary, Slovenia, Italy, Spain, Romania, Ireland), on a group of more than 12,000 adolescents. Multivariate model demonstrated a strong correlation between sleep duration and emotional problems, difficulties in relationships with peers, suicidal ideation and moderate correlation with anxiety symptoms and conduct disorders [44].

Somewhat different conclusions can be drawn from the study conducted by Moore et al. on 247 healthy adolescents. The results indicate a relationship between sleepiness reported by subjects and anxiety and depressed mood, but there was no correlation between negative emotions and objectively assessed sleep duration (actigraphy) [45]. The study found that 1/4 of people slept too short and had elevated sleepiness levels.

Short-term sleep deprivation adversely affects the regulation of emotions [41]; however, cited studies indicate chronic problems' persistence and the development of mental disorders in people experiencing long-term difficulty sleeping. Considering the pediatric population and the most common insomnia cause in this group, which are behavioral problems, you have to take into account that many children suffering from sleep disorders develop in discordant families, who cannot put boundaries, further

deepening child's sleeping problem. It is likely that the emotional problems associated with sleep disorders are multifactorial in origin, and chronic sleep deprivation makes it difficult to work on them and solve them. Further studies should take into account the family system stability factor as one of the mediators.

### Attention deficit, impulsiveness, executive functions disturbance

Children suffering from ADHD often experience sleep disorders [46]. This may result equally from disorder severity, pharmacotherapy [47], as well as concomitant disorders [48].

However, it should be emphasized that children with insomnia without concomitant ADHD symptoms may suffer from concentration problems, attention and impulse control difficulties, which can be mistaken for ADHD symptoms. In his analysis Turnbull suggests a significant impact of behavioral sleep disorders on the executive functions development, which play an important role in the ability to self-regulate [49]. Velten-Schurian et al. evaluated the daytime functioning of children (n = 34) who presented with sleep disorder. The study results show a significant total sleep time effect on attention deficit and undesirable behavior severity [50]. Gruber et al., who assessed healthy, well-developing school children (n = 35), made similar observation. They investigated the relationship between impartially assessed sleep duration and quality (actigraphy and polysomnography) and ADHD-like symptoms reported by teachers. Results showed a significant relationship between sleep duration and attention deficits, but did not indicate correlation with hyperactivity [51]. In the following parallel group study, parents were asked to either restrict or extend their children's opportunity to sleep by an hour. After five experimental days, teachers, who were uninformed about children's assignment to groups, completed questionnaires assessing students' emotional functioning, attention and behavior. Ultimately, sleep extension was associated with a significant improvement in terms of emotional stability, attention and impulsive behavior, while sleep restriction was related with a substantial deterioration of these parameters [52]. Even a small, but persistent sleep deprivation (compared to age-appropriate sleep duration) may cause concentration problems, hyperactivity, aggressive behavior intensification, persistence of conduct disorders. That fact should be emphasized in context of global total sleep time reduction in pediatric population.

### Memory impairment and poor academic performance

Aspects closely related to attention and executive functions impairments are memory and school performance. The positive impact of sleep on memory processes has been well documented. Recently, Giganti et al. confirmed the positive role of naps in explicit memory consolidation [53]. Kurdziel et al. reported similar results. Their study illustrates nap-dependent improvement of memory consolidation. Napping children performed better in memory tests than their non-napping peers. Moreover, it was also noted that better performance was maintained even after recovery overnight

sleep [54]. Researchers suggest that with increasing curriculum demands classroom nap opportunities become devaluated which may be counterproductive.

Insufficient sleep quantity and quality also has a marked impact on school-aged children's academic achievements. Sleep-deprived students perform worse on school tests compared to their peers. Li et al. conducted a prospective cohort study (n = 612), which showed association between reduced sleep and impaired academic achievement. Children who slept less than nine hours had significantly worse results than those who slept more. Moreover, daytime sleepiness was significantly associated with impaired attention, learning motivation and academic achievement [55]. Perez-Lloret et al., who assessed the association between sleep duration and school performance in 1,194 school adolescents in Argentina, had similar observation. Their multi-step pathway analysis showed that diurnal somnolence and reduced attention were in the middle of the pathway connecting insufficient sleep to poor academic outcomes [56]. Likewise Kornholm et al. analyzed trends in insomnia symptoms, daytime fatigue and school performance reported by students in Finland in the years 1984–2011. Analysis included more than one million questionnaires. The researchers found an increasing trend in the prevalence of insomnia symptoms and chronic fatigue that were associated with lower school performance. Reported school performance in well-rested group steadily improved, which was not observed in the fatigued one [57]. The necessity of parents' and teachers' education in regards to sleep hygiene for children as a way to improve school functioning should be stressed.

## Social consequences

### Impaired social functioning

There is an increasing interest in relationship between social functioning and sleep. Although available data are still insufficient, it suggests that young people experiencing insomnia often experience social withdrawal, interpersonal deficits and reduced self--esteem [58]. In a study of more than 11,000 adolescents in 11 European countries, Sarchiapone et al. found a strong correlation between reduced total sleep time and peer-related problems accompanied with conduct disorders [44]. Furthermore, Tomisaki et al. observed functioning of over 300 parent-child dyads in the first 30 months of child's life in the context of its psychosocial development and parent's attitude to its sleep. Children, whose parents provided regular sleep schedule (day to day variability of less than 1 hour) at the age of 30 months presented better social competence in terms of autonomy, emotional regulation and empathy [59]. Adequate sleep seems to be positively correlated with peer acceptance, higher social competence, emotion understanding, receptive vocabulary and social engagement [60].

Soffer-Dudek et al. in a prospective study on 94 healthy adolescents illustrated one of the plausible explanations for this phenomenon. They assumed that emotional information processing may be compromised in the ones sleeping less than their peers. As a result they may interpret stimuli more negatively than others. Evidence showed that youth experiencing less efficient sleep with elevated night awakenings underachie-

ved in emotional facial processing tests [61]. The results illustrate that young people suffering from insomnia may withdraw from social contacts due to their emotional overtone misinterpretation.

Another explanation for the lower social competence and worse peer relationships experienced by children with insomnia can be their lowered self-esteem and pessimistic attitude towards the world. Lemola et al., who examined the group (n = 291) of healthy 8-year-olds, confirmed this hypothesis. Their study results showed that children sleeping optimal number of hours are more optimistic and have better self-esteem [62].

### Mother's depressed mood and family dysfunction

Undoubtedly, maternal depression, parental stress or family dysfunction have a negative impact on child's sleep [63–66]. However, the bidirectional nature of this relationship is also highlighted [13]. Insomnia in children adversely affects parental daytime stress and somnolence level, mothers' mood [67–69] and family functioning [70]. Meltzer's study results showed that sleep disorders in children are a significant risk factor for mothers' sleep disorders and these consecutively predispose them to depressed mood, fatigue and elevated stress levels [68]. Mindell et al. conducted a 3-week experiment with a control group on a total of 405 mother-child dyads (aged up to 36 months), introducing bedtime routine in half of the families. The intervention group reported a significant reduction in behavioral sleep disorders, as well as a significant improvement in mothers' mood [69]. Childhood sleep problems persisting in families may create negative feedback loop, intensifying the existing difficulties. Observation of Australian children in their first 24 months (n = 483) revealed that persistent sleep problems in infants and young children lead to increased parenting stress level, maternal depression and subsequent child behavior problems [70]. Another long-term prospective study demonstrated a positive effect of sleep intervention in infancy on children behavioral sleep disorders incidence reduction later in life. Additionally, study proved maternal depression symptoms to be less common [71].

## Recapitulation

Sleep disorders, in particular insomnia, are being increasingly diagnosed in the pediatric population. Data on the prevalence of the problem are heterogeneous due to various criteria adopted in the assessments, incidence rate variation depending on the developmental stage, and also assessment methods (self-assessment questionnaires, parents' questionnaires, actigraphy). It seems, however, that different types of sleep problems affect most children, at least temporarily.

The analysis of literature indicates a high prevalence of insomnia in the population under 18 years of age (25–62%).Chronic insomnia in children can have long-term consequences. On the basis of available data, the authors demonstrated a significant impact of sleep deterioration and/or curtailment on:

- decreased physical activity;

- increased obesity and diabetes risk;
- attention deficit, impulsiveness, executive functions disturbance;
- memory impairment and poor academic performance;
- impaired social functioning;
- maternal depression, family dysfunction.

Potential influence of sleep disorders on other aspects of children's health is suggested as well, however, the correlation between analyzed problems requires further in-depth, long-term follow-up. These include:

- hypertension risk;
- metabolic syndrome risk;
- depression and anxiety incidence.

In the authors' opinion, given the problem scale and the significant consequences of untreated insomnia, specialty programs in pediatrics and child and adolescent psychiatry should be supplemented with additional training on sleep disorders in children.

Due to serious implications the problem, both for the individuals and society, it is also essential to educate parents, teachers and other caregivers about sleep hygiene for children and adolescents as the primary aid in sleep disorders.

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