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Sleep Duration in Association with Subjective Health and Well-Being

Summary of the Doctoral Thesis for obtaining
the scientific degree “Doctor of Science (*PhD*)”

Sector Group – Medical and Health Sciences
Sector – Health and Sports Sciences
Sub-Sector – Public Health

Rīga, 2023



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Introduction

Insufficient sleep is recognised as a global, growing public health problem, the importance of which is often underestimated and reported (Chattu et al., 2018). Thus, it is especially important to research the impact of various factors on both the quantity and quality of adolescents' sleep, including various factors related to the individual's physical and mental health, as well as the physical and social environment around them, which in general form the daily well-being of adolescents – satisfaction with life, fulfilment and positive functioning (Andrews and Withey, 1976; Diener, 2000; Ryff and eyes, 1995).

Research results highlight the relationship between adolescent sleep and the ability to function daily, the quality of forming social contacts and the ability to overcome stressful situations. Likewise, physiological disturbances associated with insufficient sleep can lead to poorer school performance, less resilience to daily stress, memory and attention retention, concentration disorders, as well as behavioural and emotional problems (Roesser et al, 2012; Kronholm et al., 2015). Insufficient sleep is also associated with more frequent various health complaints, especially in the female population (the most frequent complaint is headache) (Paiva et al, 2015; Roesser et al, 2012). In contrast, adolescents' ability to learn, remember and concentrate increases as they spend more time sleeping at night. Adequate sleep duration is also associated with less frequent episodes of anger and rage, as well as depression, suicidal thoughts and ideas, and fatigue (Bartel et al, 2016).

Different sources specify a different duration of sufficient sleep in nuances. However, a common conclusion is that for 11–15 y.o. sleep duration of less than 7 h is insufficient, even if taking into account possible individual differences in the duration of sufficient sleep (Hirshkowitz et al., 2015; Tremblay et al., 2016).

It is important to note that over the past 100 years, the average sleep duration of adolescents has decreased by an average of 70 minutes, mainly at the expense of ever later bedtimes. At the same time wake-up time has remained relatively unchanged – mostly linked to the time of school start (Matricciani et al., 2012b). Research also reveals that adolescents are often sleep deprived over longer periods of time, especially on school days (Hirshkowitz et al., 2015). There is evidence that up to 20–25 % of adolescents would like to sleep longer and feel sleepy during the day (Roesser et al., 2012), which complements the above mentioned from the perspective of adolescents.

Compared to children and adults, adolescents are also characterised by greater differences between the duration of sleep on weekdays and weekends (Gradisar et al, 2011), as well as a shift in the overall activity cycle to the evening/night (including completing school homework, communicating with friends, schoolmates, using mobile phone, computer) side (Saxvig et al., 2012). In addition, it has been observed that insufficient sleep duration and other sleep disorders become more common with increasing age and class group of the adolescents (Paiva et al., 2015). Certain authors associate this phenomenon more with the onset of physiological processes of the puberty period, rather than adolescence as such. However, the fact remains that the shift to a later bedtime affects the biological mechanisms of the adolescent organism (Saxvig et al., 2012).

It is important to note that in addition to significant physiological changes, adolescence is characterised by new challenges, both in the social and educational fields. Thus, adolescents' well-being and sleep during this period are simultaneously influenced by psychosocial processes related to the home, school, peer environment and growing academic load (Owens, 2014; Bauducco et al., 2016; Bartel et al., 2015; Short et al., 2018).

The importance of sufficient sleep is emphasised in international policy planning documents, including the Sustainable Development Goals (SDGs) defined by the United Nations, which include sub-goals aimed at promoting well-being, including sufficient sleep (Skevington and Epton, 2018), as well as in national-level policy planning documents and recommendations, such as the Canadian 24-Hour Movement Guidelines for Children and Youth (Tremblay et al., 2016). The importance of sleep in the context of promoting mental and emotional health is also emphasised in the Public Health Guidelines of Latvia for 2021–2027 (Public Health Guidelines, 2022).

According to the 2017/2018 Survey of the Health Behaviour in School-aged Children (HBSC) Study, Latvia ranks second behind Poland with the shortest average sleep duration among adolescents (Garipey et al., 2020). Thus, taking into account the importance of sleep in promoting the well-being and health of adolescents, as well as the fact that research into insufficient sleep risk factors in Latvia, especially among children and adolescents, has been limited and insufficient so far, an in-depth study of the adolescents in Latvia is necessary in order to ascertain the factors associated with insufficient sleep (i.e., home / family environment, school environment, interpersonal relationships, etc.) which would allow (1) to assess the differences among factors affecting sleep duration compared to other countries, (2) explain the potential reasons why adolescents in Latvia have one of the shortest average sleep durations in Europe, (3) provide evidence-based recommendations and (4) develop appropriate interventions to improve adolescent sleep-related habits and sleep duration.

Data from the 2017/2018 Survey of the Health Behaviour in School-aged Children Study in Latvia were used in the development of the Thesis.

Aim of the Thesis

To investigate the relationship between demographic, social environment, free time organisation factors, as well as self-rated health and well-being with the insufficient sleep duration among adolescents in Latvia.

Objectives of the Thesis

The following objectives have been identified to achieve the aim of the Thesis:

1. To determine the distribution of sleep duration in the general adolescent population in relation to demographic factors.
2. To clarify the relationship between the factors of the respondents' family and home psychosocial environment and insufficient sleep duration.
3. To explore the relationship between the factors of the psychosocial environment of the respondents' school and insufficient sleep duration.
4. To clarify the relationship between respondents' self-rated health and insufficient sleep duration.
5. To explore the relationship between the respondents' leisure habits and insufficient sleep duration.
6. To study the relationship of the analysed factors with insufficient sleep duration in adolescents, by adjusting for sex and age and testing the interaction with sex and age.

Hypothesis of the Thesis

Insufficient sleep duration in adolescents is associated with poorer self-rated health and well-being.

Novelty of the Thesis

In order to achieve the goal of the Doctoral Thesis and to fulfil the defined tasks, the study includes the analysis of multiple factors shaping the well-being of adolescents and their relationship with the sleep duration of adolescents (see Figure 1). The factors affecting adolescent sleep are analysed through the prism of subjective health and well-being, thus depicting the importance of individual perception and interpretation of the experience regarding the sleep duration. For insufficient sleep, 7 hours was selected as the cut-off point, which in the existing different sleep duration recommendations is unequivocally considered as insufficient sleep duration, both for 11, 13 and 15-year-old adolescents, thus reducing the possible effect of individual differences in the duration of sufficient sleep. In addition, analysing the relationship of the mentioned factors with the sleep duration, possible interaction effects with adolescent age and gender were also analysed in order to identify subgroups of adolescents and factors whose combinations create greater odds of insufficient sleep duration (see Figure 1).

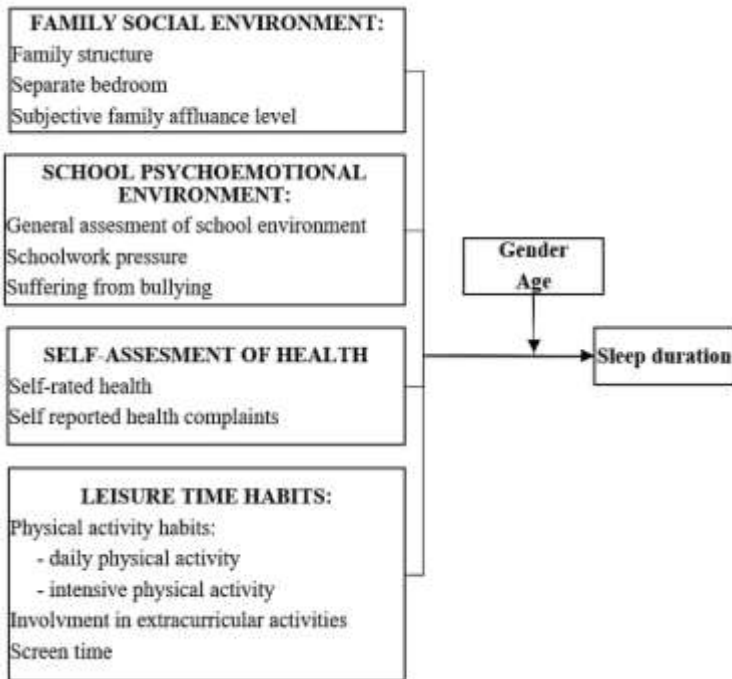


Figure 1 Conceptual model of the Doctoral Thesis

1 Material and methods

1.1 Data sources and extraction

Data from the 2017/2018 Survey of the Health Behaviour in School-aged Children Study in Latvia were used in the development of the Doctoral Thesis. The international study of adolescents' health habits is a cross-sectional study carried out according to a standardised methodology and study protocol in all the Member States of this study. The study instrument is a questionnaire in English developed, endorsed and validated by the research groups, which is translated and back-translated into Latvian and Russian (Inchley et al., 2017) in order to carry out the study in Latvia.

The target group of the Health Behaviour in School-aged Children Study is 11, 13 and 15-year-olds. In the Latvian education system, adolescents of grades 5, 7 and 9 correspond most precisely to the age groups of adolescents specified in the study.

A representative study sample is created by using the multi-stage cluster method. First, general education schools are selected from the Register of Educational Institutions of the Ministry of Education and Science of Latvia. Schools with the same probability are selected proportionally to their size (Probability Proportional to Size – PPS), meaning that the probability of schools entering the sample is proportional to the number of students in the school. This selection method provides the same probability for both numerically small and large schools and grades to enter the sample. Only general education schools are included in the initial selection, excluding schools for children with special needs and those whose basic teaching language is not Latvian or Russian. In the selected schools, grades 5, 7 and 9 are randomly selected, one of each class group at a time.

Permission to carry out the Health Behaviour in School-aged Children Study was received from the Ethics Committee for Medical and Biomedical Research at Riga East Clinical University Hospital (No. 11 – A/17, October 5, 2017, Riga, Latvia).

1.2 Characteristics of the study population

Overall, the 2017/2018 Survey of the Health Behaviour in School-aged Children Study in Latvia includes data on 4412 respondents, which is 74 % of the initial sample population.

107 respondents who did not provide information about their age ($n = 27$) and / or bedtime and / or wake-up time on school days or holidays ($n = 84$) were excluded from the further data analysis. The distribution of adolescents who did not report sleep duration was similar between age groups.

Thus, 4305 respondents were included in the data analysis of the Thesis (see Table 1.1).

Table 1.1

Distribution of the respondents by gender and age groups

Age group	Boys	Girls	Total
11 years	722	775	1497
13 years	756	724	1480
15 years	650	678	1328
Total	2128	2177	4305

Of these 4305 respondents, 4294 (2123 boys and 2171 girls) had reported their sleeping habits on school days, i.e., 99.7 % of the total number of respondents, and on holidays – 4232 respondents (2089 boys and 2143 girls), i.e., 98.3 % of the total number of respondents.

1.3 Variables and grouping

Dependent variable

Insufficient sleep duration of adolescents, separately on school days and on non-school days, was analysed as the dependent variable.

Sleep duration was measured using the questions “What time do you usually go to bed in the evening?” (separately on school and non-school days) and “What time in the morning do you usually get up?” (separately on school and non-school days). The total duration of sleep was estimated by calculating the difference between the time of getting up and going to bed (separately – on school days and non-school days). Total sleep duration of less than 7 h was classified as insufficient, while 7 and more hours of sleep was classified as sufficient.

Independent variables

1) **Demographic factors:**

- **gender** – boy or girl;
- **age group** 11, 13 and 15 years.

2) **Factors related to family and home environment:**

- to determine the **family structure**, the question “Please, answer this question for the home where you live all or most of the time and tick the people who live there” was used. For data analysis, the respondents' answers were categorised “Full family” if the respondent indicated living with both biological parents, and “Incomplete family”, which included respondents who indicated living in other family models than with both biological parents;

- **separate bedroom** – the question “Do you have your own room where, apart from you, no one else lives?” has been used. The possible answer options, used also in subsequent data analysis, were “No” and “Yes”;
 - **subjective level of family affluence** – the question “How well off do you think your family is?” has been used. For data analysis, respondents’ answers were grouped into categories “High” and “Low”.
- 3) **Factors related to the psychoemotional environment of the school:**
- **general subjective assessment of the school environment** – the question “How do you feel about school at present?” was used. For data analysis, respondents’ answers were combined into “Like” and “Dislike” categories;
 - **schoolwork pressure** – the question “How pressured do you feel by the schoolwork you have to do (both at school and at home)?” was used. For data analysis, respondents’ answers were combined into the categories “A lot”, “Some” and “Not at all”;
 - **suffering from bullying** was measured using the question “How often have you been bullied at school in the past couple of months?”. For data analysis, respondents’ answers were grouped into categories “Never”, “Sometimes” and “Regularly”.
- 4) **Factors related to health self-assessment:**
- **self-rated health** – the question “What do you think your health is?” has been used. For data analysis, respondents’ answers were grouped into categories “Good”, “Average” and “Bad”;

- **self-reported health complaints and self-reported medicine use** – for each type of self-reported health complaint analysed (headache, abdominal pain, back pain, nervousness and difficulty to fall asleep), a separate new variable was created with three categories of responses – “Specific health complaints present and medicines for specific health complaint used,” “Specific health complaint present and no medicine for specific health complaint used” and “No specific health complaints,” combining questions about the frequency of self-reported health complaints (“In the last 6 months: how often have you had the following.... (headaches, abdominal pain, backaches, nervousness and difficulty falling asleep)?”) and the use of medicine against specific health complaints (“In the last month: have you taken any medications against... (headaches, abdominal pain, backaches, difficulty falling asleep, nervousness or other complaints)?”).

5) **Physical activity and screen time:**

- **daily physical activity** was measured by the question “Over the past 7 days, on how many days were you physically active for a total of at least 60minutes per day?”. For data analysis, respondents’ answers were grouped into the categories of “Insufficient daily physical activity” and “Sufficient daily physical activity”;
- **the level of intensive physical activity** was measured by combining questions about the frequency of intensive physical activity (“Outside school hours: how often do you usually exercise in your free time so much that you get out of breath or sweat?”) with the total duration of intensive physical activity

during the week (“In your free time from school: How many hours a week during your free time do you typically engage in physical exercises that speed up your heart rate and breathing or cause sweating?”). A new variable was created with two categories: “Sufficient level of intensive physical activity” (adolescents who engaged in intensive physical activity at least 2–3 times a week and for a total of at least 60 minutes) and “Insufficient level of intensive physical activity” (adolescents who exercised less than 2–3 times per week and / or less than 60 minutes a week);

- **total daily screen time** was assessed by questions “How many hours a day, in your free time , do you usually spend watching TV, videos (including YouTube or similar services), DVDs, and other entertainment on screen?”, “How many hours a day, in your free time , do you usually spend playing games on computer, games console, tablet (like iPad), smartphone or other electronic device (not including moving or fitness games)?” and “How many hours a day, in your free time, do you usually spend using electronic devices such as computers, tablets (like iPad) or smartphones for other purposes, for example, homework, emailing, tweeting, Facebook, chatting, surfing the internet?”. The threshold value of excessively long screen time was determined summing up the total time spent at all kinds of screens. Then the hours spent at screens of the 1st tercile for school days (4 h) and non-school days (5 h) were determined in the total screen time value distribution. Arithmetic average

between these two values was selected as the threshold for excessive screen time – 4.5 h. Finally, a new variable was created for data analysis with two categories: “0–4 h” and “> 4,5 h”;

- in order to determine **involvement in organised extracurricular activities**, the question “In your leisure time, do you do any of these organised activities? Organised activities refer to those activities that are done in a sport or another club or organisation.” was used. Summing up the types of extracurricular activities indicated by the respondent, information was collected regarding the involvement in organised team sports, organised individual sports, music or art school or group, participation in youth organisation, involvement in a group of creativity and involvement in a religious organisation. A variable with three categories was created for data analysis: “No extracurricular activities”, “One type of extracurricular activities” and “2 or more types of extracurricular activities”.

1.4 Statistical analysis

Descriptive statistical methods were used to characterise the prevalence of factors related to sleep duration in the study sample: estimation of the proportion of the characteristic in the study sample subgroups, the Chi-Square test for comparing the subgroups (gender and age groups) of the sample in crosstabs, and comparison of confidence intervals of the proportions.

The confidence intervals for the proportions were calculated using *Sample Size-Net: Confidence interval for a proportion* (Kohn and Senyak, 2021) online-based software. To compare the significance of the differences between

subgroups in crosstabs, a z-test and pvalues adjustment according to the Bonerroni method were applied.

Odds ratios were calculated to determine the association between factors analysed and insufficient sleep duration in adolescents. 4 models of logistical regression were developed to analyse the association between each investigational factor and insufficient sleep duration:

- 1) unadjusted odds of insufficient sleep duration in association with the factor analysed (Model 1),
- 2) gender and age adjusted odds of insufficient sleep duration in association with the factor analysed (Model 2),
- 3) odds of insufficient sleep duration in association with the factor analysed and testing the multiplicative interaction with gender (Model 3),
- 4) odds of insufficient sleep duration in association with the factor analysed and testing the multiplicative interaction with age (Model 4).

If no interaction with age and /or gender was found, the results of Model 1 and Model 2 were interpreted in the analysis of the relationship between the factor analysed and insufficient sleep duration. If an interaction with gender and / or age was found, the results of Model 3 and / or Model 4 were interpreted in the analysis of the relationship between the factor studied and insufficient sleep duration, with an additional analysis stratified by gender and / or age to clarify the differences in the association between the factor studied and insufficient sleep duration in gender and / or age groups.

The significance level selected for all statistical tests was < 0.05 . MS Excel, IBM SPSS and SampleSizeNet were used for data processing.

2 Results

2.1 Insufficient sleep duration

In general, 19.3 % of adolescents on school days and 4.4 % on non-school days indicated that they usually spend less than 7 hours sleeping. On school days, the differences in the proportion of adolescents with insufficient sleep duration in gender groups were not statistically significant. However, with increasing age, the proportion of adolescents who sleeps less than 7 h increased in both gender groups, and the differences between the studied age groups are statistically significant ($p < 0.05$).

On non-school days, in general, there is a much lower proportion of adolescents who sleep less than 7 hours and the differences between age groups disappear. The proportion of boys with insufficient sleep duration is higher than that of girls in all age groups, but statistically reliable gender differences were observed for 13 y.o. ($p < 0.05$).

2.2 Family structure and insufficient sleep

Living in incomplete family statistically significantly increased the odds of insufficient sleep duration (< 7 h) both on school days and on non-school days almost twofold, moreover, the association remained statistically significant even when adjusted by gender and age. In the relationship between family structure and insufficient sleep duration, a statistically significant interaction was found between adolescent gender and family structure regarding insufficient sleep duration on holidays and between adolescent age and family structure regarding insufficient sleep duration on non-school days (see Annex 1).

After performing a gender-stratified age-adjusted analysis of the association between family structure and insufficient sleep duration, it was observed that boys from incomplete families had higher chances of insufficient

sleep duration compared to girls from incomplete families, both on school days and non-school days. Age-stratified gender-adjusted analysis of the relationship between family structure and insufficient sleep duration on school days revealed that both 13 and 15 y.o. adolescents from incomplete families had statistically significantly higher odds of insufficient sleep duration on school days compared to 11-year-olds.

2.3 Separate bedroom and insufficient sleep duration

Living in the same room together with someone else reduces the odds of insufficient sleep on school days ($p < 0.05$), regardless of the age and gender of the respondents. At the same time, no relationship was observed between living in the same room with someone else and insufficient sleep duration on non-school days (see Figure 2.1). No statistically significant interactions with adolescent age and / or gender were found for the relationship between own bedroom and insufficient sleep duration.

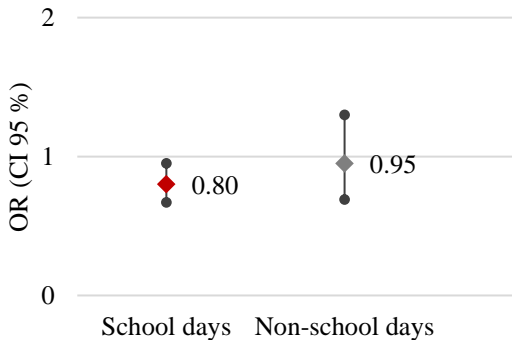


Figure 2.1 Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with shared bedroom *

* Ref. – adolescents with separate bedroom

2.4 Subjective level of family affluence and insufficient sleep

Statistically significantly higher odds of insufficient sleep (on school days) were found only for adolescents who rate their family's level of affluence as low ($p < 0.05$). However, after adjusting the results by age and gender, the relationship was no longer statistically significant (see Figure 2.2). No statistically significant interactions with adolescent age or gender were found.

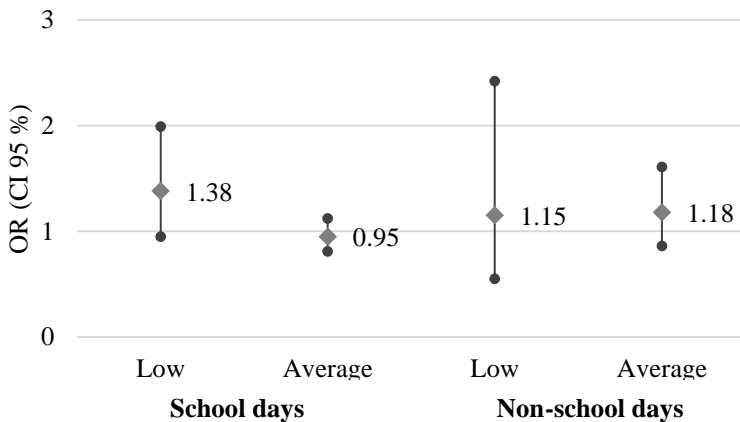


Figure 2.2 Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with self-reported family affluence level*

* Ref. – adolescents rated their family affluence level as high

2.5 General subjective assessment of the school environment and insufficient sleep duration

Statistically higher ($p < 0.05$) odds of insufficient sleep in both gender groups, both on school days and non-school days, were observed in adolescents who were not satisfied with their school. No interaction with adolescent gender was found for the association of overall subjective assessment of the school environment with insufficient sleep duration, but the interaction between school assessment and age for insufficient sleep duration on school days was statistically

significant (see Annex 2). After additional age-stratified and gender-adjusted analysis of the association between the subjective assessment of the school environment and sleep duration on school days, it was observed that although in all age groups dissatisfaction with school statistically significantly ($p < 0.05$) increased the odds of insufficient sleep, however, 11 y.o. adolescents had significantly higher odds of insufficient sleep (IA = 2.56, CI95 % 1.71–3.82) compared to 13 y.o. (OR = 1.33, CI95 % 1.00–1.76) and 15 y.o. (OR = 1.39, CI95 % 1.08–1.78).

2.6 Schoolwork pressure and insufficient sleep duration

High schoolwork pressure is associated with higher odds of insufficient sleep duration both – on school days and non-school days ($p < 0.05$). An interaction with adolescent age was observed in the relationship between schoolwork pressure and insufficient sleep duration on non-school days (see Annex 3). Additional age-stratified and gender-adjusted analysis of the relationship between schoolwork pressure and sleep duration on non-school days revealed, that statistically significantly ($p < 0.05$) higher odds of insufficient sleep were for 11 y.o. adolescents who reported feeling a lot of schoolwork pressure (OR = 2.50, CI95 % 1.24–5.05) compared to their peers who reported experiencing little or no schoolwork pressure at all.

No interaction with adolescent gender was observed in the association between self-reported schoolwork pressure and insufficient sleep duration.

2.7 Suffering from bullying and insufficient sleep duration

Victims of regular bullying have higher odds of insufficient sleep on school days ($p < 0.05$), but not on non-school days, compared to their peers who do not suffer from bullying at school, regardless of age and gender of the

respondents (see Figure 2.3). No interactions with adolescent age and gender were found in the association between bullying and insufficient sleep duration.

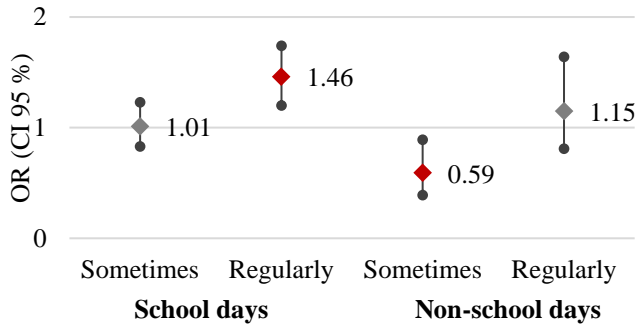


Figure 2.3 Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with suffering from bullying*

* Ref. – adolescents who have never suffered from bullying

2.8 Self-rated health and insufficient sleep duration

Both unadjusted and age and gender-adjusted odds of insufficient sleep in association with adolescent self-rated health show statistically significant trifold higher odds of insufficient sleep in adolescents with poor self-rated health and almost 2 times higher odds of insufficient sleep in adolescents with average self-rated health compared to adolescents with good or very good self-rated health on school days. No statistically significant associations were observed between students' self-rated health and insufficient sleep duration during holidays (see Figure 2.4).

No interactions with adolescent age and / or gender were found in the relationship between self-rated health and insufficient sleep duration.

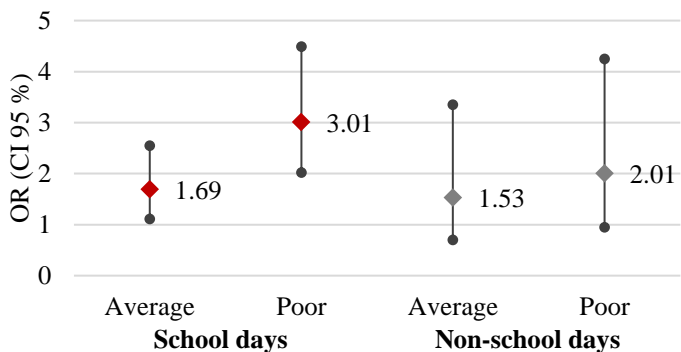


Figure 2.4 **Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with self-rated health***

* Ref. – adolescents rated their health as good / very good

2.9 Self-reported health complaints, self-reported medication use and insufficient sleep duration

This subsection analyses the associations of insufficient sleep duration with adolescent self-reported health complaints (headaches, stomachaches, backaches, difficulty sleeping and nervousness) in context with corresponding medicine use (medicine for headache, stomachache, backache, sleeplessness and against nervousness). The medicine use practice is analysed as an indicator of the intensity of the subjective feeling of discomfort caused by health complaints – the degree to which specific health complaints affect daily functioning and well-being of adolescents.

2.9.1 Headache and insufficient sleep duration

Adolescents with weekly headaches were twice as likely to have insufficient sleep duration on school days compared to adolescents who did not report weekly headaches in the past 6 months. In addition, adolescents who report weekly headaches but have not taken medicine for headaches are twice as likely

to have insufficient sleep even on weekends (see Figure 2.5). No interactions with adolescent age and / or gender were found in the associations between headache and insufficient sleep duration.

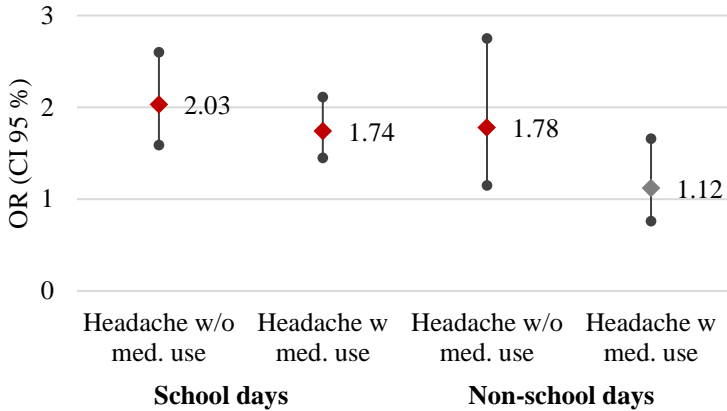


Figure 2.5 Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with headache and medicine use for headache*

* Ref. – adolescents without weekly headache

2.9.2 Stomachache and insufficient sleep duration

Adolescents with weekly stomachache (both in the group of adolescents who used medicine for stomachache and among those who did not) have up to twice the odds of insufficient sleep duration both on school days and non—school days compared to adolescents who did not report weekly stomachache in the last 6 months (Figure 2.6). No interactions with adolescent age and / or gender were found in the associations between stomachache and insufficient sleep.

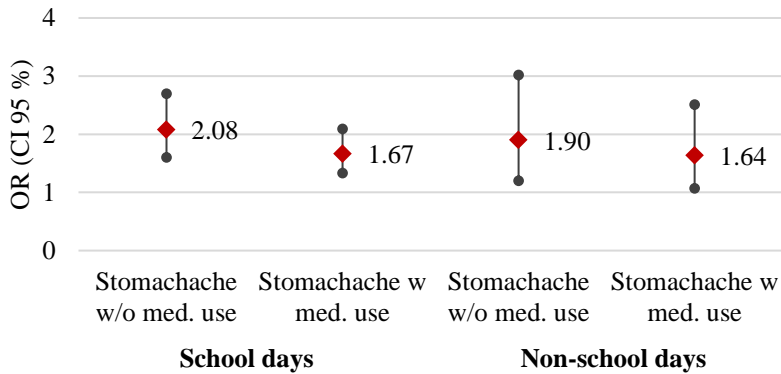


Figure 2.6 Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with stomachache and medicine use for stomachache*

* Ref. – adolescents without weekly stomachache

2.9.3 Back pain and insufficient sleep duration

Weekly back pain doubled the odds of insufficient sleep both on school days and non-school days, regardless of adolescent age and gender, compared to those who did not reported weekly back pain. This relationship was present both in the group of adolescents who used medicine for back pain, and – who did not (see Figure 2.7). No interactions with adolescent age and / or gender were found in the associations between weekly back pain and insufficient sleep duration.

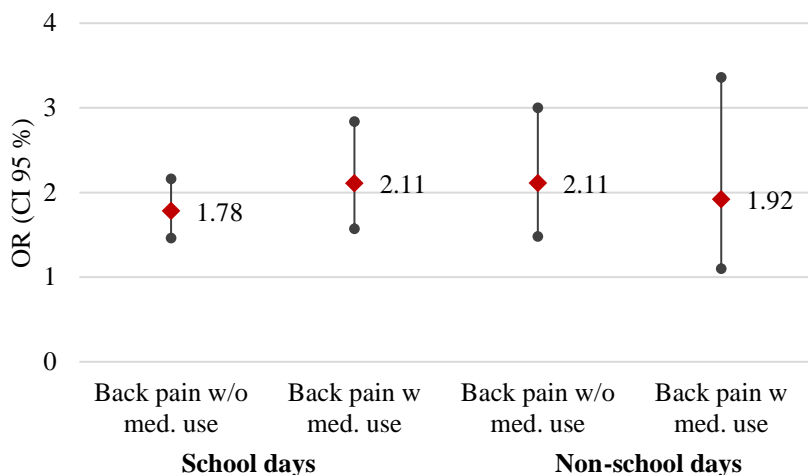


Figure 2.7 **Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with back pain and medicine use for back pain***

* Ref. – adolescents without weekly back pain

2.9.4 Difficulties falling asleep and insufficient sleep duration

Adolescents who reported weekly difficulties falling asleep but did not use medicine for sleep difficulties had statistically significantly higher odds of insufficient sleep both on school days and non-school days compared to adolescents who did not experience regular difficulties falling asleep, regardless of adolescent age and gender. Adolescents who reported weekly sleep difficulties and use of medicine for sleep difficulties had statistically significantly higher odds of insufficient sleep duration only on school days (see Figure 2.8). No interactions with adolescent age and / or gender were found for associations between weekly difficulties falling asleep and insufficient sleep duration.

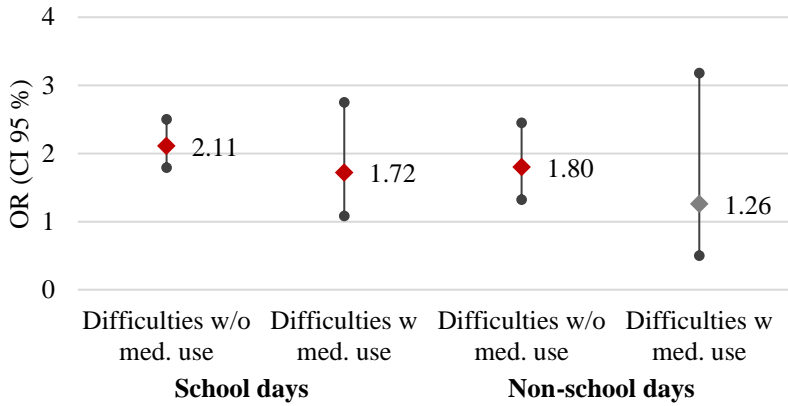


Figure 2.8 Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with difficulties falling asleep and medicine use for difficulties falling asleep*

* Ref. – adolescents without weekly difficulties falling asleep

2.9.5 Nervousness and insufficient sleep duration

Adolescents with weekly nervousness, regardless of medicine use status for nervousness, were twice as likely to have insufficient sleep on school days, regardless of their gender and age. The mentioned relationship was not observed on non-school days (see Figure 2.9). No interactions with adolescent age and / or gender were found in the associations between nervousness and insufficient sleep duration.

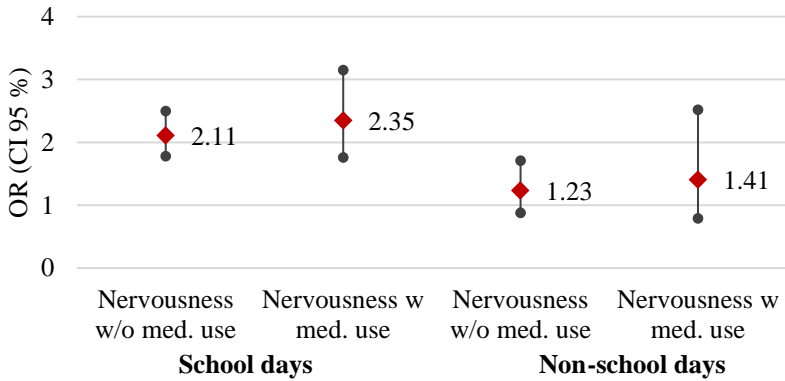


Figure 2.9 Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with nervousness and medicine use for nervousness asleep*

* Ref. – adolescents without weekly nervousness

2.10 Daily and intensive physical activity levels and insufficient sleep duration

Insufficient level of daily physical activity in adolescents was associated with lower odds of insufficient sleep duration on weekends but not on school days, regardless of adolescent gender and age, compared to adolescents with sufficient level of daily physical activity. On the other hand, adolescents with an insufficient level of intensive physical activity had higher odds of insufficient sleep on school days, regardless of their gender and age, compared to adolescents who had a sufficient level of intensive physical activity (see Figure 2.10). No statistically significant interaction was found in association between the level of daily and intensive physical activity and insufficient sleep duration with adolescent gender and / or age.

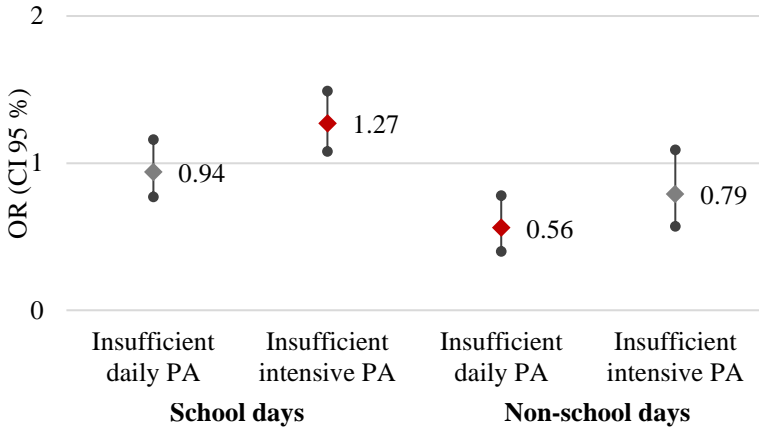


Figure 2.10 **Age and gender adjusted odds of insufficient sleep duration (< 7 h) associated with physical activity (PA) levels***
 * Ref. – adolescents with sufficient daily / intensive physical activity level

2.11 Screen time and insufficient sleep duration

Spending more than 4.5 hours in front of electronic device screens (TV, video games, computer) increases the odds of insufficient sleep by more than 2 times, both on school days and on non-school days. An interaction with age was found in the relationship between screen time and insufficient sleep duration, both on school days and on weekends (see Annex 4).

Additional age-stratified and gender-adjusted analysis revealed, that exceeding 4,5 h of screen time statistically significantly ($p < 0.05$) increases the odds of insufficient sleep duration in all age groups on school days: 11 and 13 y.o. adolescents had trifold higher odds, and 15 y.o. – almost twice higher odds of insufficient sleep, compared to adolescents who spent less time in front of screens. On holidays only in 11 y.o. were found statistically significant odds of insufficient sleep among adolescents who spend more than 4.5 h in front of screens of electronic devices. Thus, the association between prolonged use of

electronic devices and insufficient sleep duration is stronger and more persistent on a weekly basis among 11 y.o. adolescents compared to older adolescents.

2.12 Organised extracurricular activities and insufficient sleep duration

Adolescents not involved in any type of extracurricular activities were almost twice as likely to have insufficient sleep duration on school days, but not on weekends, compared to adolescents who were involved in one type of extracurricular activity. At the same time, higher odds of insufficient sleep were not observed for students involved in two or more types of extracurricular activities. This relationship was present both on school days and on non-school days (see Figure 2.11).

No interaction with adolescent age and /or gender was found for the relationship between the number of organised extracurricular activities and insufficient sleep duration.

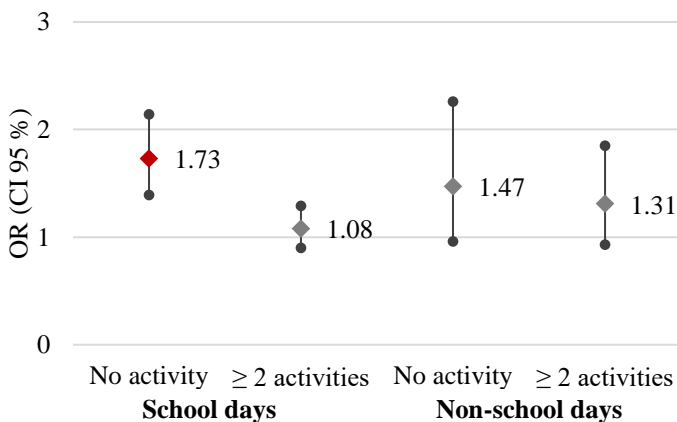


Figure 2.11 **Age and gender adjusted odds of insufficient sleep duration (< 7 h) in association with involvement in organised extracurricular activities***

* Ref. – adolescents engaged in 1 type of organised extracurricular activities

3 Discussion

3.1 Sleep duration

For the categorization of sleep duration, a threshold of 7 h was used in the Doctoral Thesis, stating that a shorter sleep duration is considered insufficient. In the literature, there are different approaches in defining insufficient sleep duration for adolescents of 11 to 15 years of age. Some sources indicate that 9–11 h of sleep is recommended for adolescents aged 5–13 years (Hirshkowitz et al., 2015; Tremblay et al., 2016) or 9–12 h of sleep for adolescents aged 6–12 years and 8–10 h sleep for 13 to 18 y.o. adolescents (Paruthi et al., 2016). Thus, many studies use a cut-off of 8 to 9 hours to define insufficient sleep duration (Chaput and Janssen, 2016; Patte et al., 2017). According to the data of a recent extensive cross-sectional comparative study of 24 European and North American countries, Latvian adolescents rank third with one of the lowest proportions of adolescents who achieve the recommended sufficient amount of sleep on school days – 37 %, followed by Greece with 35 % and Poland with only 32 % of adolescents sleeping enough on school days – 9 h for 5–13 y.o. and 8 h for the 14–17 y.o. (Garipey et al., 2020). However, it should be taken into account that there may be individual differences in optimal sleep duration, with individuals maintaining optimal daily functioning even with fewer hours spent sleeping at night (Chaput et al., 2016). Thus, according to the US National Sleep Foundation's recommendations 7 hours of sleep should be considered as shortest potentially sufficient sleep duration for adolescents 6 to 17 years old (Hirshkowitz et al., 2015).

The results of the Thesis reveal that almost one fifth of Latvian adolescents – 19.3 %, spend less than 7 h in sleep on school days. This is higher than reported in other studies with the same insufficient sleep cut-off point used (Leger et al., 2012). At the same time, researches can be found that in certain

populations up to 40 % of adolescents do not reach this minimum recommended sleep duration (Twenge et al., 2017) on a daily basis.

Similar to the data of other studies, there was a trend observed that proportion of adolescents who sleep insufficiently on school days increases with the age of adolescents (Garipey et al., 2020). According to literature, this relationship is explained both by the increasing independence of adolescents, as the parents' ability to determine and control bedtime decreases (Tashjian et al., 2019), and by the general shift of the adolescents' daily activity cycle towards the evening / night side, increase in the importance of communication with peers, staying awake for a longer period of time and communicating through the use of electronic devices, while wake-up time remains the same – related to the start of school (Saxvig et al., 2012). At the same time, no gender differences were found in the proportion of adolescents with insufficient sleep duration on school days, which contradicts the previously observed relationship that girls are more likely to sleep enough on school days than boys (Garipey et al., 2020).

On non-school days, the proportion of adolescents who sleep less than 7 hours was found to be generally much lower – 4.4 %, which is in line with the results from other studies stating, that a much lower proportion of such adolescents is observed on non-school days (Garipey et al., 2020, Gradisar et al., 2011). However, insufficient sleep duration was generally more common in boys than in girls, which is also consistent with the results of other studies (Olds et al., 2010b). At the same time, there are studies where significant gender differences in sleep duration have not been observed (Bartel et al., 2016; Chaput and Janssen, 2016). The above-mentioned gender differences in the results of Thesis were especially significant among 13 y.o., where up to 6.7 % of boys did not reach the recommended sleep duration, compared to 3.3 % of girls. This relationship differs from the results of study described previously, where the proportion of adolescents with insufficient sleep duration increased inversely proportional to

the age group, reaching the highest proportion of adolescents who sleep insufficiently among 15 y.o. (Garipey et al., 2020).

Differences between school days and non-school days may be explained by different daily rhythms and responsibilities (Yan et al., 2018), which allow adolescents to sleep indefinitely during non-school days, possibly in an attempt to compensate fatigue accumulated on school days. However, sleeping more during the holidays does not help restore cognitive functions or performance that has decreased due to sleep deprivation during the week. At the same time, extra hours of sleep on holidays are considered as an indicator of irregular sleep-wake cycle, marking a risk group for insufficient sleep and pointing to other risks associated with insufficient sleep duration (Lv et al., 2020). Accordingly, the observed relatively low proportion of adolescents with insufficient sleep duration on holidays in itself, without analysing the contextual conditions, should be evaluated positively with caution, as it can indicate a relatively large proportion of adolescents who sleep longer on holidays to compensate for insufficient sleep duration on school days. An additional analysis of the differences in sleep duration on school days and non-school days at the individual level would be necessary to determine the proportion of adolescents who sleep significantly longer on non-school days than on school days, thus representing a group of adolescents with a possible sleep deficit and related health risks. According to recent study on adult population the need to re-evaluate the interpretation of the relatively longer holiday sleep duration was emphasised, postulating that the holiday sleep duration cannot be considered as an extended sleep duration, but corresponds to the adequate sleep duration required by the individual (Putilov, 2021). In the context of this idea, it might be necessary to reassess the threshold of sufficient sleep – 7 h, because there is a possibility that even adolescents who reach the minimum adequate sleep duration, still do not sleep enough. Additional

research specifically in the adolescent population is needed to confirm the hypothesis.

3.2 Family and home environment and adolescent sleep duration

Family structure. Living in an incomplete family showed nearly twice the odds of insufficient sleep duration both on school days and non-school days. The odds were especially greater among 13 and 15 y.o. boys compared to girls, adolescents from full families and younger adolescents. Similar results are also found in the work of Ryan E. Rhodes and colleagues (2020), where boys from nuclear families had on average longer sleep duration than boys from single-parent families (Rhodes et al., 2020). In addition, younger adolescents more often live in a full family, which is a factor with beneficial effect on sleep duration. At the same time, other studies do not find differences between adolescent age or gender groups in the relationship between sleep duration and family structure (Schmeer et al., 2018). Considering that the incomplete family structure is an important, independent factor associated with adolescent sleep problems, more sleep problems in children from incomplete families can be explained by the sense of insecurity, a more unstable home environment, insufficient parental supervision, an irregular daily rhythm and generally lower household organisation level (Troxel et al., 2014; Billows et al., 2009; Herke et al., 2020). Although in previous studies girls report stronger parental control compared to boys (Fagan et al., 2011), with increasing age group, in general, parental control and influence in various areas of adolescent life decreases (Tashjian et al., 2019). Accordingly, a generally lower socially accepted level of control for boys, combined with possibly ineffective parental supervision in incomplete families (Troxel et al., 2014), may be associated with higher odds of insufficient sleep specifically among older boys.

Separate bedroom. The data analysis reveals that living in the same room together with someone else can be evaluated as a factor positively influencing sleep duration on school days both boys and girls in all age groups. But on holidays, such a relationship was not observed. Very few research data are available on the relationship between a separate bedroom and sleep duration. Among them, there is evidence that there is no relationship between the separate bedroom and the sleep onset time. However, the importance of quietness for shorter time to fall asleep is emphasised (Alexandru et al., 2006). At the same time, the relationship between separate bedroom and the ability to use various electronic devices without interruption is emphasised as a combination of factors negatively affecting sleep duration (Hale et al., 2018). Accordingly, when living in a room with someone else, such a practice of using electronic devices, as well as late bedtimes, may be limited by facing objections from the roommate, which could explain the association found in this study.

The subjective level of family affluence. Higher odds of insufficient sleep duration were found only in adolescents who rated their family's affluence as low compared to adolescents from medium and high affluence families, which is also consistent with the results of other studies (Felden et al., 2015). Moreover, this relationship was no longer present when adjusting for age and gender. Previous study results explain such a relationship by the direct effects of material conditions, such as insufficient availability of health promotion, treatment and prevention services (Adler and Snibbe, 2003; Diener et al., 1993; Mackenbach, 2012), lower quality house and level of household organisation, poorer knowledge about sleep hygiene (Jarrin et al., 2014; Holupka and Newman, 2011), and indirect psychological consequences – the stress arising from comparing one's situation and resources with that of others (Adler and Snibbe, 2003; Diener et al., 1993; Mackenbach, 2012). It is important to note, that there is no consensus in the literature on whether the health of adolescents is more

affected by the relative or absolute level of affluence (Elgar et al., 2010; Marmot, 2004). Moreover, the subjective assessment of family affluence analysed in this study can equally include both relative and absolute assessment of the level of affluence. Accordingly, adolescent health may be strongly associated with both absolute and relative levels of family affluence (Elgar et al., 2013).

3.3 School environment and adolescent sleep duration

General subjective assessment of the school environment.

Dissatisfaction with school was associated with higher odds of insufficient sleep for both sexes on both – school days and non-school days. In addition, the dissatisfied with school 11-year-olds were found to have a significantly higher odds of insufficient sleep on school days compared to 13 y.o. and 15 y.o. adolescents. It is possible that in younger adolescents the school-related discomfort leads to higher levels of stress with stronger effects on sleep duration. Additionally, an explanation for the observed association may be sought through the lens of adolescent behavioural problems, including health behaviours and sleep patterns. Aversion to school is more common in adolescents with various behavioural problems (Joyce et al., 2014; Langille et al., 2015), which can be combined with worse health habits, including sleep habits (Vogel et al., 2015; Rossen et al., 2016). On the other hand, both, internalising and externalising behavioural difficulties in boys are more common in younger age groups, and they decrease with age. At the same time, the prevalence of externalising difficulties in girls does not change significantly in age groups (Pudule et al., 2020). Thus, older adolescents are more likely to be better adapted to the school environment and the school-related events cause less stress and less impacts the sleep duration.

Schoolwork pressure. Higher schoolwork pressure level was associated with higher odds of insufficient sleep both, on school days and non-school days, regardless of adolescent gender. At the same time, 11 y.o. with a high level of schoolwork pressure can be considered as a group with increased risk of insufficient sleep on non-school days, compared to peers who experienced less or no schoolwork pressure. Considering that schoolwork pressure is closely related to satisfaction with school (Suldo et al., 2014), the relationship observed among 11 y.o., similarly like the association with satisfaction with school, can be explained both, by the younger adolescents' lower resilience to the school-related stress factors, and by the relatively higher prevalence of internalising and externalising behavioural difficulties in younger age groups. However, these considerations only partially explain the observed association with sleep duration on non-school days. It is possible that schoolwork pressure maintains a significant effect on sleep duration also on weekends, while the effect of school dissatisfaction is stronger on school days only.

Suffering from bullying. Victims of regular bullying had increased odds of insufficient sleep on school days, regardless of age and gender, compared to adolescents who did not suffer from bullying. Accordingly, analysing what happened and re-thinking the situation may be factors that negatively affect the sleep of the bullying victims (Hunter et al., 2014). More frequent self-reported sleep problems, including insomnia, anxiety, both at night and during the day, in bullying victims have been found also in the works of other authors. In addition, bullying victims with such disorders also have significantly higher self-rated scores of social inclusion problems and stress, compared to bullying victims without self-reported sleep and anxiety problems (Kubiszewski et al., 2014). This can create a seemingly never-ending cycle of social inclusion problems – bullying – sleep disturbances.

On the other hand, such a relationship was not observed on non-school days, which could be explained by the fact that physical contact with the offender(s) most often does not occur during the holidays. In addition, the impact of cyberbullying and its relationship with adolescent sleep should be analysed, as this form of bullying extends beyond the physical environment of the school and the time spent at school. However, it should be taken into account that the beginnings of cyberbullying are most often found in the school environment and in the relationships between pupils (Juvonen and Sandra, 2014).

3.4 Health self-assessment and adolescent sleep duration

Self-rated health. In Latvia, adolescents with a poor self-rated health were almost three times, and adolescents with an average self-rated health were almost twice as likely to have insufficient sleep duration on school days, regardless of their age and gender, compared to their peers who assessed their health positively. Similar conclusions are also described in other studies (Kosticova et al., 2019; Garmy et al., 2020). A partial explanation of the observed association can be sought with reference to the relatively common schoolwork pressure in the study sample and its negative impact on the self-rated health of adolescents (Ottova et al., 2012; Guo et al., 2014; Joyce et al., 2014; Langille et al., 2015). Accordingly, assuming that school-related stressors are less pronounced during the holidays, this partially explains why such a relationship was not observed on non-school days.

Self-reported health complaints and self-reported corresponding medicine use. A composite variable characterizing both, health complaint and medicine use status, was created to assess the association between health complaints and insufficient sleep duration, since adolescent medicine use can be considered as an indicator of the overall greater burden and discomfort caused by health complaints (Gobina et al., 2011; Levin et al., 2015).

A three-category composite variable was created for each type of health complains by combining self-reported health complaint and medicine use status against the corresponding health complaint to determine the odds of insufficient sleep. It is important to note that the medicines used by adolescents are most often over-the-counter, thus relatively easily available. Considering that the purpose of Health Behaviour in School-aged Children Study is not to specifically determine the type of medicine used by adolescents, the fact of their use itself is not related to a medically confirmed illness, but reflects the problem-solving approach of adolescents in case of health complaints occurred (Shehnaz et al., 2014; Gobina et al., 2015; Holstein et al., 2003). Therefore, also in this study medicine use was conceptualised as an indicator of the subjective burden of experienced health complaints, i.e., the degree to which health complaints affect an individual's daily well-being. A similar approach – the analysis of health complaints linked with corresponding medicine use status – can also be found in previously published studies (Klavina-Makrecka et al., 2020).

A nearly twice the odds of insufficient sleep on school days were observed in adolescents with any type of health complaints reported, compared to adolescents with health complaints rarer than weekly on never, regardless of medicine use status. In general, this relationship remained also on holidays with an exception – in the case of headaches and difficulty falling asleep, the chances of insufficient sleep were increased only among adolescents who did not used the corresponding medicine. At the same time, weekly nervousness increased the odds of insufficient sleep only on school days. Thus, it can be hypothesised that medication status does not have a significant impact on the strength of the relationship between health complaints and insufficient sleep.

These results lead to the conclusion that adolescents with weekly health complaints have a significantly higher risk of insufficient sleep. Furthermore, neither interaction with adolescent age nor gender were observed on the

associations between health complaints and insufficient sleep duration. Thus, regardless of the adolescent age and gender, the experience of various health complaints during adolescence generally negatively affects sleep duration.

Explaining the association between different types of pain and insufficient sleep duration, pain can maintain its effect on sleep in a direct and indirect way. For example, the sensation of the pain itself can be disturbing to the extent that it delays falling asleep or prevents from staying asleep during the night and / or contributes to premature awakening in the morning. At the same time, individual differences in pain threshold and pain perception should be taken into account, which may influence the individual's functioning and quality of life through interaction with psychological processes and emotional states (Valrie et al., 2013). Thus, the experience of pain in adolescents may increase anxiety and depressive symptoms, which, acting as mediating factors, sequentially affect sleep duration and quality (Vinnall et al., 2016). Accordingly, when studying health complaints, especially psycho-emotional complaints – nervousness, difficulties falling asleep, etc., and their relationship with sleep duration, it would be equally important to analyse aspects of both – quantity and quality of sleep, because sleep quality can be low despite quantitatively adequate sleep duration (El-Sheikh et al., 2019; Jiang et al., 2020; Tonetti et al., 2015).

There is probably a bidirectional relationship between health complaints and sleep duration. Pain or psychoemotional complaints can have a negative impact on sleep duration, while insufficient sleep can negatively affect mood and health the next day (Shochat et al., 2014; Norell-Clarke and Hagquist, 2018; Gregory and Sadeh, 2012). Research also suggests that insufficient sleep can induce pain (Badawy et al., 2019; Valrie et al., 2013) or lower the pain perception threshold through a dopamine secretory mechanism (Finan and Smith, 2013). At the same time, the relationship between health complaints and insufficient sleep can also be largely explained by emotional state and psychosocial functioning

(Shochat et al., 2014). The above may partly explain why the relationship between sleep duration and nervousness was not observed on non-school days. Many potential stress factors related to the school environment and the school week, like schoolwork, tension of school and extracurricular activities, aspects of interpersonal relationships, etc., are not present on non-school days.

When interpreting the observed associations between self-reported health complaints, corresponding medicine use, and adolescent sleep, the pharmacological effect of corresponding medicine may potentially improve adolescent sleep duration. However, this effect may be weak if the individual suffers from a generally higher burden of pain (Klavina-Makrecka et al., 2020) or more pronounced difficulties in falling asleep and nervousness, thus representing a specific subpopulation of adolescents, in which also the relationship between the experience of health complaints, corresponding medicine use and sleep duration may be different (Gobina et al., 2015).

3.5 Physical activity, screen time and adolescent sleep duration

Adolescent physical activity and screen time in the literature are often discussed as mutually substitutable activities. There is a noticeable relationship that with more time spent in front of screens, the overall level of physical activity of adolescents decreases (Auhuber et al., 2019).

Physical activity. The database used in the Thesis is part of the cross-national Health Behaviour in School-aged Children Study, so it should be taken into account that according to the protocol of the study, daily physical activity and intensive physical activity are analysed as two different concepts. This approach is also preserved in the data analysis of the Thesis. The level of moderate / daily physical activity provides information about the overall level of physical activity of adolescents and its compliance with current recommendations. Information on intensive physical activities allows to evaluate

the role of physical activities in the context of recreation, sports and hobbies (Bucksch et al., 2017), which are most often implemented as parent-initiated participation in organised team or individual training or other type of classes (Inchley et al., 2020). Moreover, the prevalence of these two types of physical activity in the daily life of adolescents does not always correlate and they may represent different behavioural patterns and different health outcomes (Motl et al., 2004).

Regardless of adolescent age and gender, insufficient daily physical activity reduced the risk of insufficient sleep duration on non-school days. The observed relationship could be explained by relatively later wake-up times on non-school days, which accordingly reduces the time available for any type of activity, including physical activity, in the rest of the day (Master et al., 2019). It is important to note that the data source used in this study does not provide an opportunity to analyse the level of physical activity of a given day and the duration of sleep in the following night. This is a limitation in the interpretation of the results described, as other studies have emphasised the importance of such an approach in data analysis (Master et al., 2019; Dolezal et al., 2017). At the same time, there is evidence for the potentially negative effect of physical activity on sleep, related to the timing of physical activity before bedtime. Physical activity performed less than 3 hours before bedtime increases heart rate, body temperature, and adrenaline levels, thereby prolonging sleep onset time (Driver and Taylor, 2000; King et al., 2008; National Sleep Foundation, 2021; Myllymaki et al., 2011).

At the same time, an insufficient level of intensive physical activity statistically significantly increased the odds of insufficient sleep on school days. Considering that the level of intensive physical activities is strongly related to participation in organised extracurricular sports and hobby activities (Inchley et al., 2020), which are most often organised on school days, the negative effect of the lack of such activities on sleep duration may be explained by lower levels of fatigue in the evenings of school days. This, in turn, may contribute to a later bedtime and / or engagement in other activities during the evening hours (e.g., using electronic devices, spending time with friends, etc.), resulting in shorter sleep duration on school days.

Similar to the findings of other authors (Kline, 2014; Master et al., 2019), the data analysis of this study also points to complex and multidirectional relationships between physical activity and sleep duration. Engaging in physical activities can improve sleep duration if they promote an earlier bedtime, and conversely, longer sleep can be a prerequisite for sufficient energy levels to engage more, both, in daily and intensive physical activities. At the same time, sleeping longer, for example on holiday mornings, can be the reason why physical activity is pushed out of the schedule of activities for the rest of the day.

Screen time. 4.5 and more hours of daily screen time increased the risk of insufficient sleep by more than 2 times, both on school days and on non-school days. The mentioned relationship was especially strong among 11 y.o., regardless of the day of the week, as well as among 13 y.o. on school days, compared to peers who spent less time in front of screens of electronic devices. Thus, younger adolescents with more daily screen time hours can be considered a high-risk group for insufficient sleep duration. In the literature, more frequent use of electronic devices is also associated with higher rates of psychological complaints (Husarova et al., 2015), which, through an increased level of stress and cognitive arousal, can partially explain the observed more negative effect on

sleep duration among younger and thus less psychologically mature adolescents. At the same time, despite the higher level of parental control over bedtime in younger adolescents described in other studies (Tashjian et al., 2019), sleep duration may still be negatively affected if the availability and use of electronic devices in the bedroom before sleep is not limited (National Sleep Foundation, 2006; Calamaro et al., 2009). Differences between screen time and sleep duration among 11 and 13 y.o. observed on holidays may be explained by the larger variety between school day and non-school day sleep duration among older adolescents (Gariepy et al., 2020). Thus, older adolescents may more successfully compensate the sleep deficit, accumulated through the school week, with longer sleep on non-school day mornings, while younger adolescents keep to wake up earlier also on non-school days because of the biological sleep-wake cycle regulation (Randler et al., 2017; Crowley et al., 2007).

3.6 Engagement in organised extracurricular activities and adolescent sleep duration

In the Thesis, involvement in organised extracurricular activities (both, physical activity related and other) was conceptualised as an indicator of additional increased workload, which can potentially negatively affect the sleep duration of adolescents in a direct way – by restricting the time that is left for homework, hobbies, communication with friends, etc. daily activities and possibly resulting in an overall later bedtimes; and through higher stress levels related to the desire to succeed in the specific activity and at the same time still achieve good academic results, maintain relationships with friends and family, devote time to meaningful activities and hobbies (Luthar and Shoun, 2006; Luthar and Sexton, 2004; Luthar and Latendresse, 2005).

Adolescents who were not involved in any form of organised extracurricular activity showed almost twice the risk of insufficient sleep duration on school days compared to those who were engaged in at least one form of organised extracurricular activity, regardless of adolescent age and gender. The relationships found among adolescents not involved in any activities can be explained through the prism of alternative activities in which these adolescents might be involved and which become more and more relevant with increasing age, for example, various unorganised leisure activities, such as spending time with friends (Auhuber et al., 2019), using electronic devices (Inchley et al., 2020; Garmy et al., 2020; Wu et al., 2015; Melkevik et al., 2010) etc. Research also shows that adolescents who are not involved in any form of organised activities have a higher risk of substance abuse and the development of antisocial behaviour patterns (Farb and Matjasko, 2012), which can affect overall sleep duration through sleep-wake rhythm shifts and later average bedtimes (Sivertsen et al., 2015). It is important to note that adolescents who are not engaged in any form of organised extracurricular activities are also observed to have lower levels of general well-being (Badura et al., 2021).

The data analysis of the Thesis also shows that the involvement of adolescents in two or more types of organised extracurricular activities did not increase the odds of insufficient sleep either on school days or on non-school days. Similar conclusions have been reached by other authors, at the same time emphasizing the importance of the parents' determined and controlled bedtime than the total workload in ensuring sufficient sleep duration for adolescents. At the same time, lack of parental control over bedtime combined with a higher workload in extracurricular activities can have a significant negative impact on adolescent sleep duration (Short et al., 2013).

3.7 Strengths and limitations of the study

In the Health Behaviour in School-aged Children Study and, accordingly, in the Thesis, the calculations of sleep duration were based on self-reported data – the self-reported bedtime and wake-up time. Previous studies reveal that the answers to the question “What time do you usually go to bed on school days / holidays?” can include any time point from getting ready to go to bed, for example, washing, brushing the teeth in the evening, changing for bed, etc., to lying in bed while still awake, and finally to actually falling asleep, which is a time point actually impossible to determine by adolescent himself. Likewise, the answers to the question “What time in the morning do you usually get up on school days / holidays?” can include any time point from waking up while still in bed to getting out of bed (Matricciani et al., 2013). Thus, the described differences in the interpretation of bedtime and wake-up time can lead to an overestimation of the actual sleep duration, i.e., calculating a longer sleep duration from the given initial data than it actually was. Taking into account the specificity of the data mentioned, it is possible that even a larger proportion of adolescents actually sleep less than the minimum number of hours considered as adequate – 7 hours. At the same time, self-reported sleep duration has demonstrated its effectiveness and validity in epidemiological studies to study sleep duration at the population level (Combs et al., 2019).

It should also be noted that the Thesis is a cross-sectional study. Thus, it is not possible to make precise conclusions about the causal direction of the associations observed. For example, with regard to self-reported health complaints and their association with insufficient sleep duration, increasing evidence suggests that insufficient sleep duration may induce pain (Badawy et al., 2019; Valrie et al., 2013) or increase pain sensitivity via dopaminergic pathways (Finan and Smith, 2013). Thus, a bidirectional effect between pain and sleep duration may exist here.

A significant advantage of this study is the representative sample of the target population, which was studied according to the standardized protocol of the cross-national Health Behaviour in School-aged Children Study by using validated instruments (Inchley et al., 2017).

It is important to note that additional, composite variables were created for the data analysis in the Thesis in order to more successfully reveal the nature of certain phenomena and their connection with insufficient sleep duration. For example, a composite variable of self-reported health complaints was created that was combined with corresponding medicine use status for the specific health complaint, thereby also viewing medication use as an indicator of subjective health complaint severity. A composite variable was also created to determine the level of intensive physical activities in order to analyse the data of the study in accordance with the WHO recommendations for the sufficient level of intensive physical activities.

Additional analysis of the insufficient sleep risk factors identified in the Thesis and the quantitative characteristics of sleep (like sleep duration, bedtime and wake-up time, differences of these parameters between days of the week, social jet-lag) and qualitative characteristics of sleep (like sleep structure and functional outcomes, i.e., whether sleep provided refreshment, daytime sleepiness, etc.) in longitudinal studies would be beneficial to clarify the causal direction and mechanism of the observed associations. At the same time, it should also be considered to supplement the Latvian questionnaire of the Health Behaviour in School-Age Children Study with a question package characterising the quality of sleep.

Conclusions

1. Almost every fifth teenager does not sleep enough during school days, i.e. less than 7 hours, without significant differences in gender groups, but with increasing age, the proportion of adolescents who spend less than 7 h in sleep increased in both gender groups. On weekends, insufficient sleep duration was found in 4.4 % of adolescents without significant differences in age groups, but showing a slightly higher proportion of boys with insufficient sleep duration compared to girls.
2. Among the family and home psychosocial environment factors analysed in the work, the chances of insufficient sleep are increased by an incomplete family structure (not living with both biological parents), especially for 13- and 15-year-old boys. Also having separate bedroom increased the chances of not getting enough sleep during school days.
3. General subjective assessment of the school environment and greater academic pressure increase the chances of insufficient sleep, especially for 11-year-olds. Similarly, regularly suffering from bullying increases the odds of insufficient sleep, but only on school days.
4. The odds of insufficient sleep both on school days and on non-school days increase significantly for teenagers who report weekly complaints of headaches, stomachaches, backaches and difficulty falling asleep. At the same time, worse self-rated health and complaints about nervousness increase the chances of insufficient sleep only on school days.
5. Adolescents' sleep duration is influenced by leisure time habits. More than 4.5 hours of screen time every day increases the chances of insufficient sleep, especially for 11-year-olds. Insufficient levels of vigorous physical activity and non-involvement in any form of organised extracurricular activities increase the odds of insufficient sleep on school days, while

sufficient levels of daily physical activity increase the odds of insufficient sleep on weekends.

6. Statistically significant associations with insufficient sleep duration are shown by all health and well-being related factors studied, except for the subjectively assessed level of family affluence of teenagers, thus generally confirming the hypothesis of the work.

Practical recommendations

According to the results of the study, the following factors / groups of factors related to health and well-being contributing to insufficient sleep duration among adolescents were identified (see Figure 2):

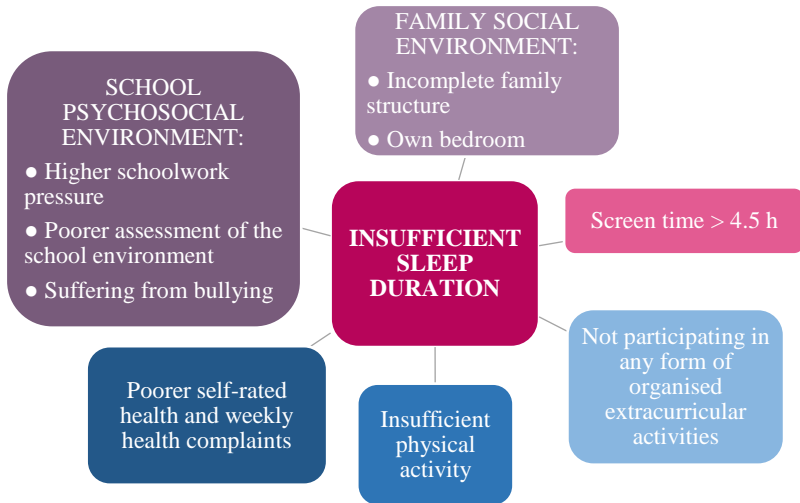


Figure 2 **Insufficient sleep risk factors**

The colouring of the factor / groups of factors affecting the sleep duration used in the picture is further used to highlight the association of each recommendation with the particular factor / group of factors.

Recommendations for adolescents:

- assessment of one's state of health, taking into account that regular complaints of headaches, stomachaches, backaches, nervousness and difficulties falling asleep may be the cause of insufficient sleep;

- balancing of time spent for doing homework and the time spent in extracurricular activities (including organised extracurricular activities), leaving enough time for night sleep – no less than 7 hours;

- limiting the use of electronic devices outside the school homework to 2 h, not using them in the bedroom before going to sleep;

- regular engagement in daily physical activities – at least 60 minutes of moderate-intensity physical activity daily (including active mode of commuting as possible), and in intensive physical activities – at least 2–3 times a week and for a total of at least 60 minutes, while avoiding intensive physical activity several hours before going to sleep;

- consideration of involvement in some form of organised extracurricular activities;

- help should be sought in the family and / or school (school psychologist, teachers, etc.) if psycho-emotional, peer relationship, including teasing, related situations or problems in learning occur;

Recommendations for parents / guardians / family:

- together with the adolescent agree on a specific bedtime on school days and non-school days, follow this time to ensure sufficient time for night sleep, not less than 7 hours;

- help the adolescent to plan study work, free time activities and rest time in order to promote a balanced time planning on a daily and weekly basis;

- reviewing the factors of the physical environment of the home that affect sleep, ensuring conditions that promote falling asleep in the evening and support the maintenance of sleep at night (for example, a quiet, well-ventilated room, appropriate temperature regime), including evaluation whether and how falling asleep is affected by whether the adolescent sleeps in the room alone or with another family member (for example, sisters, brothers, etc.);

- attention should be paid to the adolescent's health complaints (including complaints of regular pain, nervousness, difficulty falling asleep), as they may be the cause of insufficient sleep;

- if possible, encourage the choice of an active mode of commuting (e.g., going to school by foot or by bicycle, scooter, skateboard, etc.);
- monitor and limit the use of electronic devices for up to 2 hours outside of school work, limit their use in the bedroom before going to bed;
- involve the adolescent in some organised form of extracurricular activities, including physical activity related organised extracurricular activities;
- create and maintain a supportive family environment in order to ensure a safe environment for the adolescent to discuss his concerns, problems and causes of tension, to receive support and encouragement, as well as ensure appropriate involvement of parents / family members in solving problem situations, if necessary (e.g., responding to bullying situations at school, in the extracurricular environment, problems in the learning process, etc.);

Recommendations for specialists working with adolescents on a daily basis (teachers, management of educational institutions, general practitioners, psychologists, psychotherapists, psychiatrists, social educators, etc.)

- attention should be paid to adolescents who show signs of increased fatigue, sleepiness, difficulty concentrating, irritability, aggression, as well as regularly complain of various somatic symptoms (for example, various types of pain), which may be the causes of insufficient sleep, if necessary, inform the parents about the observed;
- planning the school start times, taking into account the average time students have to spend on the way to school;
- planning the study workload so that it is balanced with the amount of tasks to be done at home, assuring that the adolescents have time also to engage in extracurricular activities, spend time with friends and family, and have time for a sufficiently long night's sleep during the school week;

- encouraging pupils' involvement and active participation in sports / physical education classes;

- meaningful and organised out-of-school time should be promoted by offering an appropriate range of extracurricular activities;

- building a supportive, inclusive and positive school and classroom environment (including anti-bullying programmes) in order to create a safe environment for the adolescents to discuss their concerns, problems and causes of tension, gain support and encouragement, as well as ensure appropriate involvement of relevant school staff in problem solving, if necessary (e.g., responding to bullying situations at school, problems in the learning process, etc.);

Recommendations for policy makers in public health, well-being and other sectors involved:

- questions about healthy sleep habits should be included and additionally emphasized in the health education module to be learned both at the general basic and secondary education levels, emphasizing the risk factors of insufficient sleep and mechanism of their action;

- education of parents, custodians, specialists who work with adolescents on a daily basis (educators, management of educational institutions, family doctors, psychologists, psychotherapists, psychiatrists, social pedagogues, etc.) about

- adolescent sleep issues,
- the major risk factors affecting sleep duration and the most vulnerable groups of adolescents,
- indicators of insufficient sleep, and
- simple techniques to promote sufficient sleep duration in adolescents;

- planning the start time of school, the scope of educational programs and learning dynamics in balance with the need of adolescents for sufficient rest and time for activities outside of school work;

- promotion of the offer of organised extracurricular activities, including physical activity related, in educational institutions or in the wider framework of the municipality, that is interesting for adolescents and available financially, in terms of time planning and logistics;

- creation and implementation of anti-bullying programmes in educational institutions.

Publications and thesis

Publications included in international databases (Web of Science, SCOPUS):

1. Gariépy, G., Danna, S., Gobina, I., Rasmussen, M., Gaspar de Matos, M., Tynjälä, J., Janssen, I., Kalman, M., Villerusa, A., Husarova, D., Brooks, F., Elgar, F. J., Klavina-Makrecka, S., Šmigelskas, K., Gaspar, T., Schnohr, C. 2020. How Are Adolescents Sleeping? Adolescent Sleep Patterns and Sociodemographic Differences in 24 European and North American Countries. *Journal of Adolescent Health*. 66(6S): S81–S88. Doi: 10.1016/j.jadohealth.2020.03.013. PMID: 32446613.
2. Klavina-Makrecka, S., Gobina, I., Pulmanis, T., Pudule, I., Villerusa, A. 2020. Insufficient sleep duration in association with self-reported pain and corresponding medicine use among adolescents: a cross-sectional acquisition-based study in Latvia. *International Journal of Public Health*. 65(8), 1365–1371. Doi: 10.1007/s00038–020–01478–0.
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Thesis and presentations in international conferences:

1. Klavina-Makrecka, S., Gobina, I., Villerusa, A. 2019. Sleep duration in 11, 13 and 15 aged adolescents in Latvia by age and sex. In: *International Conference on Medical and Health Care Sciences Knowledge for Use in Practice: Abstracts*. Rīga: Riga Stradins University. 661.
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3. Klavina-Makrecka, S., Villerusa, A., Gobina, I., Pudule, I., Velika, B., Grinberga, D. 2020. Insufficient sleep duration and negative emotional states among adolescents in Latvia. *Cogent Medicine*. 7: 1848781, p. 99. <https://doi.org/10.1080/2331205X.2020.1848781>
4. Klavina-Makrecka, S., Gobina, I., Pudule, I., Grinberga, D., Velika, B., Villerusa A. 2021. Poor self-reported health in association with sleep duration and health complaints among adolescents in Latvia. *RSU the 8th International Multidisciplinary Research Conference "Society. Health. Welfare."* p. 38.

5. Gobina, I., Villerusa, A., Klavina-Makrecka, Boniel-Nissim, M., Tynjälä, J., Furstova, J., Villberg, J., Lahti, H. 2021. Adolescent use of social media and associations with sleep patterns Across 18 European and North American countries. Thesis in: *13th Excellence in Pediatrics Conference*. Amsterdam.

Other types of publications:

1. Pudule, I., Velika, B., Grīnberga, D., Gobiņa, I., Villeruša, A., Kļaviņa-Makrecka, S., Bezborodovs, Ņ. 2020. Latvijas skolēnu veselības paradumu pētījums 2017./2018. mācību gada aptaujas rezultāti un tendences. Slimību profilakses un kontroles centrs. Available from: https://www.spkc.gov.lv/sites/spkc/files/data_content/latvijas-skolenu-veselibas-paradumu-petijums-05.10.2020_1.pdf [viewed 21.04.2021].

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Annexes

Odds of insufficient sleep duration (< 7 h) in association with family structure

	Model 1		Model 2		Model 3		Model 4	
	School days	Non-school days	School days	Non-school days	School days	Non-school days	Non-school days	Non-school days
	OR (CI 95 %)	OR (CI 95 %)	OR (CI 95 %)	OR (CI 95 %)	OR (CI 95 %)	OR (CI 95 %)	OR (CI 95 %)	OR (CI 95 %)
Family structure								
Incomplete family	1.58* (1.36–1.84)	1.74* (1.30–2.34)	1.41* (1.20–1.65)	1.7* (1.26–2.30)	1.6* (1.27–2.01)	1.73* (1.19–2.51)	1.41 (0.96–2.06)	1.58 (0.91–2.73)
Ref. = Full family	1	1	1	1	1	1	1	1
Family structure × sex								
Incomplete family × girls	–	–	–	–	1.09 (0.86–1.38)	0.52* (0.33–0.81)	–	–
Ref. = Incomplete family × boys	–	–	–	–	1	1	–	–
Full family × girls	–	–	–	–	1.38* (1.12–1.70)	0.54* (0.35–0.83)	–	–
Ref. = Full family × boys	–	–	–	–	1	1	–	–
Family structure × age								
Incomplete family × 15 years	–	–	–	–	–	–	4.56* (3.22–6.43)	0.98 (0.55–1.73)
Incomplete family × 13 years	–	–	–	–	–	–	2.76* (1.93–3.94)	1.46 (0.86–2.47)
Ref. = Incomplete family × 11 years	–	–	–	–	–	–	1	1

	Model 1		Model 2		Model 3		Model 4	
	School days	Non-school days	School days	Non-school days	School days	Non-school days	Non-school days	Non-school days
	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)
Full family × 15 years	-	-	-	-	-	-	5.03* (3.80-6.65)	1.11 (0.66-1.87)
Full family × 13 years	-	-	-	-	-	-	2.44* (1.82-3.26)	1.09 (0.67-1.80)
Ref = full family × 11 years	-	-	-	-	-	-	1	1

Model 1 – unadjusted odds ratios;

Model 2 – age and gender adjusted odds ratio;

Model 3 – testing interaction with gender;

Model 4 – testing interaction with age.

* Statistically significant result ($p < 0.05$).

Odds of insufficient sleep duration (< 7 h) in association with general subjective assessment of school environment

	Model 1		Model 2		Model 3		Model 4	
	School days	Non-school days	School days	Non-school days	School days	Non-school days	Non-school days	Non-school days
	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)
General subjective assessment of the school environment								
Dislikes	1.72* (1.46–2.03)	1.86* (1.37–2.53)	1.51* (1.28–1.79)	1.82* (1.33–2.48)	1.46* (1.14–1.86)	1.57* (1.06–2.32)	2.65* (1.78–3.95)	2.88* (1.63–5.08)
Ref. = Likes	1	1	1	1	1	1	1	1
General subjective assessment of the school environment × sex								
Dislikes × girls	–	–	–	–	1.07 (0.76–1.5)	1.49 (0.79–2.82)	–	–
Ref. = Likes × boys	–	–	–	–	1	1	–	–
General subjective assessment of the school environment * age								
Dislikes × 15 years	–	–	–	–	–	–	0.50* (0.32–0.83)	0.56 (0.25–1.25)
Dislikes × 13 years	–	–	–	–	–	–	0.49* (0.30–0.81)	0.49 (0.23–1.05)
Ref. = Likes × 11 years	–	–	–	–	–	–	1	1

Model 1 – unadjusted odds ratios;

Model 2 – age and gender adjusted odds ratio;

Model 3 – testing interaction with gender;

Model 4 – testing interaction with age.

* Statistically significant result ($p < 0.05$).

Odds of insufficient sleep duration (< 7 h) in association with school pressure

	Model 1		Model 2		Model 3		Model 4	
	School days	Non-school days	School days	Non-school days	School days	Non-school days	Non-school days	Non-school days
	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)
Learning strain								
A lot	2.02* (1.63–2.50)	1.33 (0.90–1.97)	1.55* (1.24–1.93)	1.33 (0.94–2.08)	1.46* (1.06–2.0)	1.68* (1.03–2.73)	1.93* (1.18–3.16)	2.50* (1.24–5.04)
Some	1.25 (0.92–1.37)	0.79 (0.54–1.16)	0.98 (0.76–1.20)	0.80 (0.54–1.17)	0.89 (0.66–1.19)	0.73 (0.44–1.18)	1.02 (0.66–1.59)	0.98 (0.49–1.94)
Ref. = Not at all	1	1	1	1	1	1	1	1
Learning stress × sex								
A lot × girls	–	–	–	–	1.13 (0.72–1.75)	0.58 (0.25–1.34)	–	–
Some × girls	–	–	–	–	1.20 (0.79–1.82)	1.24 (0.57–2.73)	–	–
Ref. = Not at all × boys	–	–	–	–	1	1	–	–
Self-assessment of health × age								
A lot × 15 years	–	–	–	–	–	–	0.63 (0.34–1.14)	0.49 (0.17–1.36)
Some × 15 years	–	–	–	–	–	–	0.71 (0.41–1.22)	0.68 (0.24–1.91)

	Model 1		Model 2		Model 3		Model 4	
	School days	Non-school days	School days	Non-school days	School days	Non-school days	Non-school days	Non-school days
	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)
A lot > 13 years	-	-	-	-	-	-	0.93 (0.5-1.73)	0.37* (0.14-0.96)
Some > 13 years	-	-	-	-	-	-	1.26 (0.71-2.21)	0.75 (0.30-1.83)
Ref. = Not at all * 11 years	-	-	-	-	-	-	1	1

Model 1 – unadjusted odds ratios;
 Model 2 – age and gender adjusted odds ratio;
 Model 3 – testing interaction with gender;
 Model 4 – testing interaction with age.
 * Statistically significant result ($p < 0.05$).

Odds of insufficient sleep duration (< 7 h) in association with daily screen time

	Model 1		Model 2		Model 3		Model 4	
	School days	Non-school days	School days	Non-school days	School days	Non-school days	Non-school days	Non-school days
	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)	OR (CI95 %)
Screen time								
> 4.5 h	3.18* (2.65–3.81)	1.74* (1.19–2.56)	2.66* (2.20–3.21)	1.60* (1.08–2.37)	2.74* (2.04–3.69)	1.97* (1.13–3.45)	3.78* (2.51–5.70)	2.33* (1.21–4.49)
Ref. = 0–4 h	1	1	1	1	1	1	1	1
Screen time × sex								
> 4.5 h × girls	–	–	–	–	0.94 (0.64–1.38)	0.63 (0.29–1.38)	–	–
Ref. = 0–4 h × boys	–	–	–	–	1	1	–	–
Screen time × age								
> 4.5 h × 15 years	–	–	–	–	–	–	0.52* (0.31–0.85)	0.35* (0.13–0.93)
> 4.5 h × 13 years	–	–	–	–	–	–	0.80 (0.47–1.35)	0.71 (0.28–1.80)
Ref. = 0–4 h × 11 years	–	–	–	–	–	–	1	1

Model 1 – unadjusted odds ratios;

Model 2 – age and gender adjusted odds ratio;

Model 3 – testing interaction with gender;

Model 4 – testing interaction with age.

* Statistically significant result (p < 0.05).