Adolescents, Sleep Deprivation and Externalizing Behaviour - Is There a Connection?

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Abstract

Adolescent adjustment is an area of great interest for parents, schools and not the least for adolescents themselves. Adolescence is a period of avid development in many areas, two of which are critical for youths’ healthy adjustment; sleep and externalizing behaviour. Therefore, the goal of this study was to investigate whether there is a link between these two areas, and if so, what this looks like. This study is part of the “Three City Study”, a large 5-year longitudinal-experimental study conducted at Örebro University. Pupils from junior high schools and high schools in three cities - Örebro, Karlskoga, Köping – were recruited. This study uses data from two measurement points including only pupils from 8th grade (N=1553) with a 1 year follow up. Results show that about half of adolescents sleep too little and circa a quarter have clinical levels of insomnia. Boys tend to sleep less and girls tend to have poorer quality sleep. Clinical levels of insomnia significantly predicted several of the externalizing outcome variables such as delinquency, drinking and emotional reactivity. Sleep amount only predicted drinking and insomnia predicted drinking in boys. These results suggest that sleep is indeed implicated in externalizing behaviour among adolescents. Sleep should therefore be targeted in intervention and promotion efforts regarding adolescent healthy development.

Keywords: Sleep, externalizing behaviour, adolescents, cross-sectional longitudinal study, regression analysis.
Sammanfattning


Nyckelord: Sömn, externaliserande beteende, ungdomar, longitudinell tvärsnitts studie, regressions analys.
Introduction

Adolescents’ sleep habits continually worsen during adolescence (Maslowsky & Ozer, 2014; Dahl & Lewin, 2002), causing many parents to worry about their children's social adjustment during this critical period of their lives. Their concerns about whether their children will manage to cope with school, and not fall behind in their classes, are not entirely unfounded. Some studies that have investigated the significance of sleep, have shown that pupils that sleep less than the National Sleep Foundation’s (2015) recommendations of 8-10 hours per night, have lower grades in school (Hysing, Harvey, Linton, Askeland & Sivertsen, 2016). This is furthermore associated with worse mental health (McKnight-Eily, Eaton, Lowry, Croft, Presley-Cantrell & Perry, 2011).

At the same time, adolescence is also a period of experimenting with social roles. For many adolescents, this means exploring different kinds of identities until late adolescence or young adulthood where they reach a more stable maturation (Meeus et al., 2010). To many parents’ concern, this period is indeed a turmoiled one. Research does show that there exists a normative peak in risk taking behaviors (Spear, 2000) and delinquency (Loeber & Farrington, 2014; Stolzenberg & D’Alessio, 2008).

However, something that is not fully explored in the literature is whether adolescents’ sleep habits affect this dramatic increase of externalizing behavior. This might be the case considering some research suggesting a connection between lack of sleep, impulsivity and sensation seeking behavior (Peach & Gaultney, 2013).

Sleep

Adolescence, in contrast to adulthood, is characterized by an increasing need for sleep (Dahl & Lewin, 2002). Despite of this, indications exist (Keyes, Maslowsky, Hamilton & Schulenberg, 2015; Kronholm et al., 2015) that adolescents not only don’t get enough sleep, but also get
poorer quality of it in today's society. Nevertheless, changes in their sleep patterns between 10 years old to the beginning of their 20s, are common during adolescence. These changes occur due to both biological and psychosocial developments that are typical of this time period (Maslowsky & Ozer, 2014). However, such changes as sleepiness during the day and difficulties falling asleep stabilize in the beginning of the 20s and adolescents start to sleep longer periods of time again.

Even though sleep problems can be temporary and normal, they still entail both short and long term consequences that have serious effects on their academic, psychosocial and physical functioning (Gregory & Sadeh, 2012). Adolescents who sleep poorly relative to both quality and quantity have been shown to be more depressed, anxious, aggressive and engage more in risk behaviors (e.g., suicidal ideation, substance use, and unprotected sex) (Schochat, Cohen-Zion & Tzischinsky, 2014). Furthermore they have worse physical health and worse achievement in school (Gregory & Sadeh, 2012).

Despite that sleep patterns seem to generally become worse during this period as part of a normal development, there is evidence that adolescents’ sleep patterns during the last few decades have worsened (Keyes, Maslowsky, Hamilton & Schulenberg, 2015; Kronholm et al., 2015). Societal factors such as access to entertainment media (Przybylski, Murayama, DeHaan & Gladwell, 2013), increasing demands to perform in school (Keyes et al., 2015) and competing activities with sleep (Cassoff, Knäuper, Michaelsen & Gruber, 2013) seem to contribute to the negative trend of less and poorer quality of sleep in adolescents. With these societal factors in mind, we can now turn our attention to the biology of sleep to understand what's going on.
The Biology of Sleep

Sleep is regulated by the interaction of two biological processes, the circadian rhythm and the homeostatic process (Carskadon, 2011). The circadian rhythm is an internal 24 hour clock that regulates our sleep-wake cycle mainly by the environmental daylight. The process occurs in the hypothalamus by the release of the hormone melatonin at night time, inducing relaxation and sleepiness (Dahl & Lewin, 2002). Meanwhile, the homeostatic pressure builds up during our waking hours creating a pressure to sleep. In turn, the pressure is reduced when we sleep thus experiencing rest (Crowley, Acebo & Carskadon, 2007).

Interestingly, something different occurs in adolescence, resulting in a delayed sleep timing (DST) by approximately 1-2 hours. The sleepiness is delayed and adolescents stay alert for longer during evenings and wake up later at mornings. Suggesting that the homeostatic pressure and the release of melatonin is slowed down during puberty (Carskadon, Acebo & Jenni, 2004).

However, this period is not entirely unproblematic for adolescents staying awake later. They still have to meet the demands of school obligations with early schedules and activities requiring them to wake up early during weekdays. For many adolescents, this means that they consistently receive less sleep for a longer period of time (Carskadon, 2011). Taken together, there are different kinds of sleep disruptions that might occur. Some of the more common sleep disruptions will be briefly examined in the next section.

Sleep disruptions

There are several ways for sleep to get disrupted, and there seems to be no single factor that is more important than any other. Many adolescents might cope well with the biological changes brought on by puberty. But perhaps adolescents don’t cope as well with societal changes like higher academic demands and growing social responsibilities, or environmental factors such as
constantly being available for social interaction on electronic media/devices. For some adolescents, these disruptions result in different sleep disorders e.g. Delayed Sleep-Wake Phase Disorder (DSWPD) and Insomnia.

With account for the biological changes previously explained, DSWPD is diagnosed when adolescents are unable to fall asleep/wake up with societal times (American Psychiatric Association, 2013). This happens because of a misalignment between the internal circadian clock and desired time to fall asleep/wake up (Magee, Marbas, Wright, Rajaratnam & Broussard, 2016). However, if the adolescents were to set up individual sleep/wake times they would have a normal sleep pattern and sleep quality, merely somewhat delayed (Crowley, Acebo & Carskadon 2007).

Insomnia on the other hand has a more irregular pattern and is not as predictable as DSWPD. Adolescents with insomnia can't fall asleep at a specific bedtime, and they have difficulties maintaining sleep and/or waking up too early. Criteria for diagnosis is met when these troubles persist at least 3 times a week over a period of 3 months’ time and significantly impair daily functioning (American Psychiatric Association, 2013). Roughly 7-24% of all adolescents struggle with insomnia (Johnson, Roth, Schultz & Breslau, 2006)

**Operationalization of Sleep**

Taken together, these sleep disruptions result in a sleep deprivation that affects how much sleep adolescents get and their experienced sleep quality. The National Sleep Foundation (2015) has done research on how much sleep adolescents need and they concluded that 8 hours of sleep is a good recommendation for an adequate amount of sleep. However, adolescents can be satisfied with their sleep even if they sleep less than 8 hours or they can experience troubles with their sleep even though they sleep 8 hours or more. Defining sleep deprivation purely on the basis of the amount of sleep they get we might overlook important individuals with different sleep
patterns. Sleep deprivation must therefore also include how adolescents experience the quality of sleep they receive. One way of doing so is by screening for insomnia. This way, sleep does not only have a quantitative aspect but also a qualitative one.

**Impact of sleep on health**

Research suggests that sleep is an important factor for good health and daily functioning. For instance, in an experimental study (Beebe et al., 2008), sleep restrictions of 6.5 hours sleeptime during weekdays over 3 weeks were given to 20 adolescents. Both the adolescents and their parents reported increased daytime sleepiness, inattention, oppositional behaviour and reduced metacognition. Consequently, we have seen that adolescents who sleep less than their counterparts have higher school absenteeism (Bauducco, Tillfors, Özdemir, Flink & Linton, 2015; Hysing, Haugland, Stormark, Boe & Sivertsen, 2014) and poorer academic achievement (Hysing, Harvey, Linton, Askeland & Sivertsen, 2016).

However, it seems that the effects of sleep deprivation on cognitive abilities are reversible. In an experimental study (Cohen-Zion, Shabi, Levy, Glasner & Wiener, 2016) sleep restrictions prescribed as 6.5 hours sleep for 4 consecutive days were given to 45 adolescents. They performed poorer on information processing and executive functioning compared to the control group with no sleep restrictions. When the experimental group had their sleep restrictions removed and the control group received them, the performance was the other way around. This finding suggests that the effects of sleep deprivation on cognitive functioning can be reversed when adolescents get enough sleep. In fact, getting adequate sleep is important for consolidating learning and facilitating recovery (Curcio, Ferrara & De Gennaro, 2006).

Sleep deprivation seems to even affect different structural parts of the brain, such as the prefrontal cortex (Peach & Gaultney, 2013) and the amygdala (Yoo, Gujar, Hu, Jolesz, & Walker, 2007). Some functions located in the prefrontal cortex region are decision making
and inhibition, implicating that sleep might influence sensation-seeking behaviour (Peach & Gaultney, 2013). Other functions, such as responsivity to negative stimuli, are heightened when the amygdala is sleep deprived (Yoo et al., 2007). With this in mind, it seems that there is a biological link between sleep and externalizing behaviour such as sensation-seeking and emotional reactivity. Indeed, this link seems to receive some support from research (Baum, Desai, Miller, Rausch & Beebe, 2014) where sleep deprivation due to sleep restrictions increased self-rated and observed irritability, oppositional behaviour and poorer emotional regulation.

Furthermore, sleep deprivation seems to a certain degree affect social adjustment. Some research indicates that alcohol use in young adulthood is linked to being overtired in childhood, and persistent trouble with sleep in childhood is linked to drug use in young adulthood (Wong, Brower, Nigg & Zucker, 2010). Even delinquent behaviour seems to be affected by sleep deprivation (Backman, Laajasalo, Saukkonen, Salmi, Kivivouri & Aronen, 2015). This means that sleep might be an important, but overseen factor in the development of externalizing behavior.

In summary, current research on the effects of sleep deprivation on health emphasizes the importance of sleep. Sleep seems not only to be important for proper functioning and judgmental skills but also to play a role for social adjustment and externalizing behavior e.g. emotion regulation and norm breaking behaviour. However, this link needs more exploration. So far, current research has independently examined the role of sleep on few but different factors of externalizing behaviour.

**Gender differences in sleep**

We have so far summarized how sleep changes during adolescence and what psychosocial and biological markers that might be in play. We also reviewed how sleep deprivation might impact
different domains in adolescents’ lives. One aspect that has not been mentioned yet is the role of gender differences. Looking into these, we might get a deeper understanding whether and how sleep deprivation affects girls and boys differently.

Research on how girls and boys sleep differently is ambiguous in their findings. One difference that seems to emerge early on is that boys at the age of 13-14 are more frequently morning birds than girls who prefer evenings (Hysing, Pallesen, Stormark, Lundervold & Sivertsen, 2013; Mateo, Díaz-Morales, Escribano, Delgado & Randler, 2012).

However, this difference diminishes when boys get older, suggesting that this difference might be due to girls reaching puberty before boys (ibid.). Even though that is the case, girls still wake up approximately 7 to 30 minutes earlier than boys during weekdays. This accumulated sleep debt seem to be recovered during weekends when girls sleep half an hour more than boys (Bauducco, Flink, Jansson- Fröjmark & Linton, 2016; Lee, Mcenany & Weekes, 1999; Natal et al., 2009).

Another interesting difference was found in a study (Guedes, Abreu, Rodrigues, Teixeira, Luiz & Bloch, 2016) where 37 adolescents estimated their sleep duration and had their actual sleep time monitored by a actigraphy during a period of one week. The results were striking; boys overestimated how much they slept by 1.9 hours while girls had a more accurate estimation by 0.5 hours. Considering the small sample these findings should be interpreted with caution until replicated. Still this could mean that boys’ self-reports are not so accurate.

Other differences were also seen in bedtimes with girls going to bed earlier than boys but also having greater sleep onset latency (Hysing et al., 2013). Several studies also reported girls sleeping more than boys (Hysing et al., 2013; Mateo et al., 2012). However, results from other research (Bauducco et al., 2016) contradict these findings, reporting that boys slept more than girls. Nonetheless, in a large Norwegian sample (n = 9846) girls were found to
be almost twice as likely as boys, 23.6% vs 12.5%, to report clinical levels of insomnia according to DSM-V criteria (Hysing et al., 2013).

Examining these differences in sleep, a mixed picture of gender differences in sleep quantity emerges. On the other hand, girls seem to get poorer quality of sleep. If there are gender differences in sleep, the next interesting and logical step is to examine whether differences exist in externalizing behaviours.

**Externalizing behaviour**

Externalizing behaviour is a broad construct and no simple clear cut definition is available in the literature. Hence, the definition we use in this study is based on a biopsychosocial theoretical framework, operationalized into a range of concrete behaviours. The framework suggests that there are similar biological pathways to various forms of externalizing behaviours (Krueger, Markon, Patrick & Iacono, 2005). It proposes that these behaviours lie on a dimension and are fundamentally correlated with each other on an Externalizing Behaviour Spectrum. This is also supported by the fact that meeting criteria for one form of externalizing disorder predicts meeting criteria for another.

A central feature of the externalizing spectrum is impulsivity (Liu, 2004), a trait that can be operationalized by behaviours an individual has trouble resisting or later regretting. Other central features of externalizing behaviour are defiance and norm breaking (ibid.). Frick (1993) proposes a model capturing these factors of the externalizing spectra based on oppositional defiant disorder and conduct disorder. His findings resulted in four constructs: status violation, property violation, oppositional and aggression.

*Defiance* is captured in the construct *Oppositional* with minor aggressive behaviours typically overt and self-directed such as temper, angry, stubborn and touchy. *Norm breaking behaviour* on the other hand is a much broader construct that is captured by both not
so harmful covert behavior (*Status violation*) like runaways, breaking rules and substance use, but also by more aggressive forms that involve hostile confrontation with another individual (*Aggression*) or property damage (*Property violation*) e.g. vandalism and firesetting. The four constructs are organized in two distinct yet related dimensions - destructiveness to others and covert/overt behaviour (Table 1.). These constructs have been validated and supported longitudinally (Bongers, Koot, van der Ende & Verhulst, 2004).

In sum, impulsivity, defiance and norm breaking behaviour are key contributors to the externalizing behaviour spectrum. These constructs will therefore be in focus in this study.

**Table 1.** Frick’s model containing the four externalizing behaviour constructs.

<table>
<thead>
<tr>
<th></th>
<th>Non-Destructive</th>
<th>Destructive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covert</td>
<td>Status violation:</td>
<td>Property violation:</td>
</tr>
<tr>
<td></td>
<td><em>Swears, Runaways, Break rule, Truancy, Substance Use.</em></td>
<td><em>Cruel to animals, vandalism, steals, firesetting, lies</em></td>
</tr>
<tr>
<td>Overt</td>
<td>Oppositional:</td>
<td>Aggression:</td>
</tr>
<tr>
<td></td>
<td><em>Temper, defies, annoys, argues, angry, stubborn, touchy</em></td>
<td><em>Assault, spiteful, cruel, blames others, fights, bullies</em></td>
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</table>

**Gender differences in externalizing behaviour**

In a 1-year longitudinal study with 460 adolescents from the United States Leadbeater et al. (1999) investigated the effects of specific protective, risk and vulnerability factors in predicting changes in externalizing problems in boys and girls. Externalizing problems were measured using latent variables from scores on the Youth Self-Report. After computing the scores two syndromes indicative of externalizing problems emerged, aggressive behaviour and delinquent
behavior. The results showed that boys reported more aggression and delinquency even though delinquency increased for both genders longitudinally.

In another study conducted by Bask (2015), material from 3095 ninth grade pupils from a region in central Sweden was used. Externalizing behaviours were measured using variables such as alcohol use, alcohol related fighting, alcohol related trouble with police, smoking and bullying. The aim was to investigate whether these externalizing problem behaviours were more common among boys than girls, as previous studies suggested. The results were surprising in that no sex differences were found with regard to the above mentioned variables. However, the same was not true for internalizing problems, where girls tended to experience these more often. This is an interesting finding in that girls and boys, at least in the externalizing domain, seem to have become more equal. This is also in line with other research in Sweden that points to evaporated gender differences with regard to smoking and drinking (Hagquist, 2009).

The abovementioned studies give somewhat inconclusive answers regarding whether there are gender differences in externalizing behaviours. The more current evidence could point to decreasing of differences in levels of externalizing problem behaviours between girls and boys. Perhaps, the inconsistency with previous research showing clear gender differences may be explained by societal changes. However, they could also be due to different measurements used to measure externalizing behaviour across studies. Given the possibility of gender differences in externalizing behaviours, as well as in sleep variables, it is important to consider the role of gender in this study.

**This Study**

Externalizing behaviour inflicts large costs to society in the form of used health care,
substance abuse and crime (Barlow & Durand, 2014). In addition, it has large consequences for the adolescents themselves, their immediate environment and society in large. Because of this, it is important and relevant to investigate what factors may make adolescents more vulnerable to externalizing behaviour. We argue that sleep may play an important role. 

We hypothesize, based on previous research on risk taking and sensation seeking behaviours (Luna, Paulsen, Padmanabhan & Geier, 2013) and sleep deprivation, that poor sleep can affect the degree of externalizing behaviour in adolescents. Risk taking and sensation seeking behaviour is part of the dual system model suggesting that there is a heightened reactivity during adolescence of the socioemotional system that seeks rewards and excitement (Strang, Chein & Steinberg, 2013; Steinberg, 2010). The model poses that, at the same time, adolescents’ cognitive control system is yet to mature. This cognitive control system, functions to inhibit responses to competing stimuli in order to coordinate thoughts and actions toward a goal. This could make that adolescents, for example, are more vulnerable to impulsive behaviours, but also to emotional dysregulation.

Sleep quantity and quality may be of importance to regulate this system. It could be that this vulnerability to be impulsive and emotionally reactive and sleep affect each other bidirectionally. For instance, the heightened reactivity towards incentives might delay sleep onset by the use of multimedia, but also, poor sleep might influence cognitive and emotional control leading to - reduced impulse control and heightened emotional reactivity. It is therefore important to gather empirical evidence on the role of sleep in the development of externalizing behaviours.

**Aim and research questions**

The aim of this study is to examine the relationship between sleep and externalizing behaviours prospectively amongst adolescents in 8th grade. We hypothesize that sleeping less than 8 hours
and/or clinical levels of insomnia influence the degree of externalizing behaviours. We also aim to investigate whether gender moderates this hypothesized relationship. Thus our aim can be summarized and divided into three research questions:

1. Are there gender differences in levels of sleep and externalizing behaviours or in their interrelations?
2. Does insufficient sleep quantity and/or clinical levels of insomnia predict higher levels of externalizing behaviours in adolescents in 8th grade over a 1 year follow up?
3. Does gender moderate the effects of insufficient sleep quantity and/or clinical levels of insomnia on externalizing behaviours?

Method

Design

This study is part of the “Three City Study”, a large study conducted at Örebro University. It is a 5 year longitudinal-experimental study with the aim of identifying risk and protective factors in the development and prevention of mental health problems in adolescents. The participants were recruited from junior high schools and high schools in three cities - Örebro, Karlskoga, Köping - involving over 3000 students. Our study uses data from two measurement points including only pupils from 8th grade with a 1 year follow up when they reached 9th grade.

Participants and procedure

Our sample is based on the “Three City Study”, however limited to pupils in 8th grade at time point 1, and 1 year later at time point 2 these pupils were in 9th grade. Our sample included a
total of 1553 students. They were recruited from 17 public schools in 3 cities. For participating in this study students had to give active consent and caregivers gave passive consent by having the opportunity to refuse their childrens’ participation.

The questionnaires were administered during class hours by trained test leaders. The teachers were asked to leave for the sake of integrity and confidentiality. The trained test leaders informed the students about the study and that participation was confidential, that their participation is voluntary and that they may withdraw at any time. If students needed help, with for example understanding difficult questions, they could turn to the test leaders for help. The students were given 180 minutes to answer the survey with a break where they received some snacks. Afterwards, the test leaders collected the questionnaires. The same procedure was done for the 1 year follow up.

**Measurements**

The survey consisted of several instruments, most of them established but a few created specifically for this study. One instrument, Anger Dysregulation, was initially split into three subscales through a factor analysis, however later only 1 of the subscales was used.

**Sociodemographics**

Standard items including gender, age, school and country of birth.

**Independent variables**

In our study, we define sleep deprivation as adolescents who sleep less than 8 hours, according to the National Sleep Foundation’s (NSF) guidelines (2015) who recommend 8-10 hours of sleep. We also include clinical levels of insomnia as part of our definition of sleep deprivation.
By doing so, we will not only have a quantitative measure of sleep deprivation but also a qualitative measure of experienced troubles with sleep.

**Total Sleep Time (TST)**

Youths’ sleep duration on weekdays was estimated by asking them at what time they went to sleep for weekdays, and at what time they woke up at weekdays. Additionally, we subtracted sleep onset latency by asking how long does it usually take for you to fall asleep on school days. We then created two groups of individuals, those sleeping less than 8 hours became group 0, and those sleeping 8 hours or more became group 1.

**Insomnia**

Insomnia was measured with the scale Insomnia Severity Index (Bastien, Vallières & Morin, 2001). It consists of 7 items with responses ranging from 1 “Very satisfied” to 5 “Very dissatisfied”. The minimum to maximum points range is 7-35 with cut-offs ranging from 0-14 for subclinical insomnia and ≥ 15 clinical level insomnia. A typical item from this scale is e.g. “To what extent do you consider your sleep problem to interfere with your daily functioning (e.g., daytime fatigue, concentration, memory, mood, etc.)?”. This instrument has been found valid with an excellent Cronbach's alpha $\alpha = 0.83$ (Chung, 2011). Cronbach’s alpha in this study was $\alpha = 0.83$ and also an optimal inter-item correlation of $r = 0.42$.

**Dependent variables**

Our operationalized externalizing variables were measured using the following instruments.

**Impulsivity**
Impulsivity was measured with the subscale “urgency” of the Impulsive Behavior Scale. It consists of 12 items with responses ranging from 1 “Don’t agree at all” to 4 “Agree completely”. The minimum to maximum points range is 11-44. A typical item from this scale is e.g. “Sometimes I do things on impulse that I later regret”. Item 10 “I am always able to keep my feelings under control.” was inverted for the purpose of a coherent data analysis of the scale. This instrument has been found valid with a excellent Cronbach’s alpha $\alpha = 0.86$ (Whiteside & Lynam, 2001). Cronbach's alpha for internal consistency in this study was $\alpha = 0.852$.

**Delinquency**

Norm-breaking behaviour was measured with the Delinquency scale taken from Kerr & Stattin’s (2000) adolescent adjustment scales. It consists of 13 items with responses ranging from 1 “No, it has not happened” to 4 “Yes, it has happened 10 times or more”. The minimum to maximum points range is 13-65. A typical item from this scale is e.g. “Have you snuck away without paying (e.g., from the movies, a café, the train or bus, or somewhere else)– during the last year?” The responses were categorized with a cut-off at 13 signifying ‘no delinquent behaviors’ and $>13$ ‘delinquent behaviors’. Cronbach's alpha was excellent at $\alpha = 0.83$.

**Drinking**

Drinking was measured using 1 item inspired from Magnusson, Dunér & Zetterblom’s (1975) longitudinal study about adjustment. The item asked “Have you had so much beer, liquor, or wine that you got drunk - during the past 6 months?”. The response ranged from 1 “No, it has not happened” to 5 “More than 10 times”. The responses were categorized with a cut-off at 1 for ‘no drinking’ and $\geq 2$ ‘drinking’.
Anger dysregulation

Anger dysregulation was measured through a scale that was constructed for the three cities study. Factor analysis yielded 3 subscales whereof one subscale of 4 items was relevant for our study. The subscale was labelled *Emotional Reactivity* and a typical item from this scale is e.g. “Feel that I’m lacking control over myself”. Items were scored on a scale ranging from 1 “Don’t agree at all” to 4 “Agree completely”. The minimum to maximum points range is 4-16. Cronbach’s alpha was good at $\alpha = 0.80$ and inter-item correlation excellent at $r = 0.501$.

Ethics

Ethical principles that could be relevant in this study are the requirements for Information, Informed consent, Confidentiality and Utilization. Both adolescents and caregivers have been informed in advance regarding the study’s aim, that participation is voluntarily and that they have the right to withdraw their participation if they would want to.

This naturally leads to the requirement of Informed consent where passive consent was obtained regarding caregivers and active consent regarding the adolescents. Caregivers had the possibility to take contact and cancel adolescents’ participation if they wanted to. During the administration of the surveys the pupils were informed that participation is voluntarily. The fact that passive consent limits sampling bias (Shaw, Cross, Thomas, & Zubrick, 2015) and that it increases sample size (Pokorny, Jason, Schoen, Townsend, & Curie, 2001) are reasons for using this approach. A limitation with this procedure is that we have no way of knowing if some of the caregivers, for various reasons, may have not received information about their child’s participation.

As motivation to participate the pupils were offered treats. According to the requirement about Confidentiality and Utilization information about professional secrecy, secure safe keeping of sensitive material and that the information obtained through the surveys
only is used for the purpose of the research has been conveyed to the pupils and the caregivers. However we do not think that these last 2 requirements will be a problem in our study considering that the surveys were anonymous.

Nonetheless there is a certain sensitive aspect in asking adolescents about their mental health. The questions might trigger difficult memories and/or feelings that might negatively impact them. To attend to this we have instructed the test leaders to be observant about how the pupils seem to feel when they hand in the surveys. If the need would arise the test leaders also had the possibility to take contact with the student health.

Data analysis

The data was analyzed using IBM SPSS version 24. The data had some missing values for most measures. We compared whether the means were significantly different when the missing values were excluded or adjusted by imputing a mean value. We found no significant differences and therefore chose to exclude missing values by using the option exclude cases pairwise. Checking the variables for kurtosis and skewness we found that the outcome variables drinking and delinquency were highly skewed and therefore split into categorical output of ‘drinking’ and ‘no drinking’ respectively ‘delinquent’ and ‘no delinquent behaviour’.

Reliability Analysis was used to produce inter-item reliability coefficients for the instruments. Inter-item correlations were used instead when Cronbach’s alphas were deemed to low. One instrument had incoherent reliability and thus Factor analysis was used to examine and finally create a subscale of the Anger Dysregulation scale named Emotional Reactivity.

First, to establish the sample’s characteristics on the independent and dependent variables, we used ANOVA and frequency analysis. The frequency analyses ANOVA yielded results about the percentage of all participants, girls and boys in our categorical variables; TST, Insomnia, Delinquency and Drinking. Means and standard deviations were calculated for the
continuous variables; Impulsivity and Emotional Reactivity. Furthermore independent samples t-test and Chi square were used to test for potential gender differences.

Second, the data was then analyzed for cross-sectional and longitudinal correlations among the variables using Pearson R Correlation Analysis. To examine whether there were significant differences in the correlation coefficients between girls and boys we used Fisherman’s r-to-z transformation to conduct Z-tests.

Finally, by using Multiple Standard Linear Regression we conducted analyses to examine the predictive ability of our independent variables, Insomnia and Total Sleep Time (TST), on our continuous dependent variables Impulsivity and Emotional reactivity. moderation analysis (Figure 1.) was used to investigate the influence of gender in the predictions.

Figure 1. Moderation analysis
Binary Logistic Regression Analysis was used to examine the predictive ability on our categorical dependent variables *Drinking* and *Delinquency*. 
Results

Sample characteristics

A total of 1238 participants finished the surveys of which 47 % were girls. 20.3 % did not complete the surveys at both time points, had partial response rates or had no responses at all and were therefore excluded from the sample. Descriptive statistics of our main variables from time point 1 are reported in Table 2, including mean scores, standard deviations, t-tests and chi-square tests.

The descriptive statistics in Table 2 show that 54.6% of adolescents receive less than 8 hours of sleep during weekdays and 25.1% report having clinical levels of insomnia. There are also significant gender differences when it comes to total sleep time (TST) and insomnia. Boys more frequently report sleeping less than 8 hours, $\chi^2 (1, n = 1238) = 36.50, p < 0.001, \phi = 0.18$, while girls more frequently report clinical symptoms of insomnia than boys, $\chi^2 (1, n = 1238) = 44.23, p < 0.001, \phi = -0.19$.

Table 2. Descriptive statistics

<table>
<thead>
<tr>
<th>Main variables</th>
<th>All</th>
<th>Girls (584)</th>
<th>Boys (654)</th>
<th>$t/\chi^2$</th>
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Figure 2. Flowchart of participants
Sleep Variables

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<th>%</th>
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<tbody>
<tr>
<td>TST weekdays (Less than 8 hours of sleep)</td>
<td>54.6</td>
<td>45.3</td>
<td>62.9</td>
<td>0.18***</td>
</tr>
<tr>
<td>Insomnia (Clinical level symptoms)</td>
<td>25.1</td>
<td>34</td>
<td>17.1</td>
<td>-0.19***</td>
</tr>
</tbody>
</table>

Insomnia (Clinical level symptoms)

<table>
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<th>Externalizing variables, mean (SD)</th>
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<tbody>
<tr>
<td>Impulsivity (11-43)</td>
<td>20.51 (6.32)</td>
<td>21.38 (6.69)</td>
<td>19.72 (5.86)</td>
<td>4.51**</td>
</tr>
<tr>
<td>Delinquency (Delinquent behavior)</td>
<td>31.3%</td>
<td>29.7%</td>
<td>32.6%</td>
<td>0.03</td>
</tr>
<tr>
<td>Drinking (Drinking)</td>
<td>9.7%</td>
<td>11.1%</td>
<td>8.5%</td>
<td>-0.04</td>
</tr>
<tr>
<td>Anger dysregulation</td>
<td>13.27 (3.63)</td>
<td>13.28 (2.82)</td>
<td>13.25 (2.75)</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Significance level *** p<0.001, ** p<0.01.
χ² Chi-square test for independence (with Yate’s Continuity Correction).
t Independent-samples t-test, two-tailed.

Girls and boys also differ in the degree of impulsivity with girls being significantly more impulsive than boys. The magnitude of the differences in the means (mean difference = 1.66, 95% CI: 0.94 to 2.38) was very small (eta squared = 0.02 0.017) according to Cohen’s guidelines. There are no significant gender differences in regard to the outcome variables delinquency, drinking and emotional reactivity.

In summary about half of the adolescent’s sleep less than the recommended 8 hours and circa a quarter have clinical levels of insomnia. Boys more frequently report sleeping less than 8 hours amount of total sleep while girls more frequently report clinical symptoms of insomnia. With the exception of impulsivity, where girls scored significantly higher, there are no significant gender differences in regards to the other outcome variables.

**Cross Sectional and Longitudinal Correlations**

Results from Pearson correlation analysis are shown in two tables both for cross-sectional and longitudinal correlations amongst the variables. Table 2.1 includes girls and table 2.2 includes boys. The cross-sectional data for time point 1 is found in the two first columns, while longitudinal data for time point 2 is found in the remaining columns.
Cross-sectional correlations show that all variables are significantly correlated. Correlations for girls are somewhat stronger than for boys. Looking closer on the differences we see that girls have a moderate association ($r = 0.43$) between insomnia and impulsivity while boys have a small correlation ($r = 0.27$). Using the Fisher r-to-z transformation for comparing correlation coefficients we obtained a statistically significant result, $Z$-score = 3.02, $p < 0.01$, two-tailed. This means that the difference between the correlation of girls and boys is 3.02 SD.

Insomnia and emotional reactivity differed also between girls and boys with girls having a moderate correlation ($r = 0.32$) and boys a small correlation ($r = 0.21$). The correlation differences are significant with the $Z$-score = 2.02, $p < 0.05$. This means that the difference between the correlation of girls and boys is 2.02 SD.

Our last finding in the cross-sectional analyses showed that correlations of insomnia and delinquency was significantly different between girls ($r = 0.24$) and boys ($r = 0.10$) with a $Z$-score of 2.46, $p < 0.05$. There were no significant gender differences between TST and the outcome variables.

Continuing with the longitudinal correlations we can see that all variables, besides TST and delinquency for boys, were significant. Girls have a moderate correlation between insomnia and impulsivity ($r = 0.34$) and emotional reactivity ($r = 0.33$). Boys’ correlations...
however were small for both insomnia and impulsivity ($r = 0.19$) and emotional reactivity ($r = 0.22$).

In summary, cross-sectional correlations for both groups were significant. The largest correlation was found between impulsivity and insomnia for girls. Furthermore, the correlation between insomnia and emotional reactivity for girls stood out with a moderate correlation. Longitudinally, all but one correlation between the variables was significant. Larger correlations were found between insomnia and impulsivity and insomnia and emotional reactivity for girls.

**Regression Analysis**

Standard Multiple Regression Analyses were conducted for the outcome variables impulsivity (Table 3.1 & 3.2) and emotional reactivity (Table 4.1 & 4.2). The analyses include gender as a moderator. Furthermore Logistic Regression Analyses were conducted for delinquency (Table 5.1, 5.2 & 5.3) and drinking (Table 6.1, 6.2 & 6.3). Separate analyses were done to explore gender differences.

**Predicting Impulsivity**

As can be seen in Table 3.1, multiple regression analysis was used to assess if total sleep time (TST) predicts impulsivity. The total variance explained by the model as a whole was 38% $F(4, 1096) = 166.84, p < 0.001$. The results show that impulsivity at T1 but not TST is a significant predictor of impulsivity at T2. Gender was not a significant moderator in the model as can be seen in a non-significant interaction effect.

<table>
<thead>
<tr>
<th>Table 3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B (S.E.)</strong></td>
</tr>
<tr>
<td><strong>Lower</strong></td>
</tr>
</tbody>
</table>
Moving on to table 3.2 we assessed if insomnia predicts impulsivity. The total variance explained by the model as a whole was 38% $F(4, 1092) = 166.44$, $p < 0.001$. The results show that impulsivity at T1 predicted impulsivity at T2. Insomnia is not a significant predictor of impulsivity. Gender was not a significant moderator in the model as can be seen in the non-significant interaction effect.

### Table 3.2

<table>
<thead>
<tr>
<th></th>
<th>B (S.E.)</th>
<th>t</th>
<th>C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Constant</td>
<td>10.32 (0.96)</td>
<td>10.7***</td>
<td>8.43</td>
</tr>
<tr>
<td>TST_{T1}</td>
<td>-1.87 (1.04)</td>
<td>-1.80</td>
<td>-3.91</td>
</tr>
<tr>
<td>Gender</td>
<td>-1.14 (0.49)</td>
<td>-2.34*</td>
<td>-2.1</td>
</tr>
<tr>
<td>Impulsivity_{T1}</td>
<td>0.62 (0.03)</td>
<td>23.64***</td>
<td>0.57</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.43 (0.65)</td>
<td>0.65</td>
<td>-0.86</td>
</tr>
</tbody>
</table>

Significance level *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

$t_{T1}$ = Time point 1

### Predicting Emotional reactivity

In table 4.1 we assessed if insomnia predicts the outcome variable emotional reactivity. The total variance explained by the model as a whole was 30% $F(4, 1159) = 124.36$, $p < 0.001$. The results show that insomnia was a significant predictor of emotional reactivity over and above the variance explained by emotional reactivity at T1. Gender was not a significant moderator in the model as can be seen in the non-significant interaction effect.

### Table 4.1

<table>
<thead>
<tr>
<th></th>
<th>B (S.E.)</th>
<th>t</th>
<th>C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insomnia_{T1}</td>
<td>1.78 (1.16)</td>
<td>1.54</td>
<td>-0.50</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.87 (0.38)</td>
<td>-2.33*</td>
<td>-1.61</td>
</tr>
<tr>
<td>Impulsivity_{T1}</td>
<td>0.62 (0.03)</td>
<td>21.1***</td>
<td>0.57</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.51 (0.77)</td>
<td>-0.66</td>
<td>-2.02</td>
</tr>
</tbody>
</table>

Significance level *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

t_{T1} = Time point 1
In the final table of multiple regression analysis we assessed if total sleep time (TST) predicts the outcome variable emotional reactivity. The total variance explained by the model as a whole was 29% $F(4, 1170) = 121.44, p < 0.001$. The results show that TST is not a significant predictor of emotional reactivity. There was no significant interaction effect of gender and TST.

Table 4.2

<table>
<thead>
<tr>
<th></th>
<th>B (S.E.)</th>
<th>t</th>
<th>C.I.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Constant</td>
<td>5.58 (0.48)</td>
<td>11.6***</td>
<td>4.63</td>
<td>6.52</td>
</tr>
<tr>
<td>TST$_{T1}$</td>
<td>0.38 (0.48)</td>
<td>0.78</td>
<td>-0.57</td>
<td>1.32</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.18 (0.22)</td>
<td>-0.8</td>
<td>-0.61</td>
<td>0.26</td>
</tr>
<tr>
<td>Emotional Reactivity $_{T1}$</td>
<td>0.57 (0.03)</td>
<td>25.19***</td>
<td>0.51</td>
<td>0.62</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.11 (0.30)</td>
<td>0.37</td>
<td>-0.48</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Significance level *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

In the final table of multiple regression analysis we assessed if total sleep time (TST) predicts the outcome variable emotional reactivity. The total variance explained by the model as a whole was 29% $F(4, 1170) = 121.44, p < 0.001$. The results show that TST is not a significant predictor of emotional reactivity. There was no significant interaction effect of gender and TST.

Table 4.2

<table>
<thead>
<tr>
<th></th>
<th>B (S.E.)</th>
<th>t</th>
<th>C.I.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Constant</td>
<td>5.58 (0.48)</td>
<td>11.6***</td>
<td>4.63</td>
<td>6.52</td>
</tr>
<tr>
<td>TST$_{T1}$</td>
<td>0.38 (0.48)</td>
<td>0.78</td>
<td>-0.57</td>
<td>1.32</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.18 (0.22)</td>
<td>-0.8</td>
<td>-0.61</td>
<td>0.26</td>
</tr>
<tr>
<td>Emotional Reactivity $_{T1}$</td>
<td>0.57 (0.03)</td>
<td>25.19***</td>
<td>0.51</td>
<td>0.62</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.11 (0.30)</td>
<td>0.37</td>
<td>-0.48</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Significance level *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Summarizing the standard multiple regression analyses we find that only insomnia has a significant predictive value for emotional reactivity. TST was not found to predict impulsivity or emotional reactivity. Gender did not moderate these relations.

*Predicting Delinquency*

Results of logistic regression analysis of delinquency for all participants are presented in table 5.1. We assessed if insomnia and TST predict delinquent behaviour. The results show that insomnia is a significant predictor of delinquency $F(2, 1150) = 164.24, p < 0.001$, Hosmer test Chi = 1.38, $p = 0.50$. The variance explained by the model was 13.3%. There was an increased likelihood by 1.54 for adolescents who report having clinical levels of insomnia at time point 1 to report delinquent behaviour in time point 2 compared to adolescents who did not report having clinical level insomnia in time point 1. TST however, was not a significant predictor of
delinquent behavior. In table 5.1 we can also see that adolescents who report being delinquent in time point 1 are over 5 times as likely to report being delinquent in time point 2 compared to adolescents who reported no delinquent behaviour at time point 1.

Table 5.1

<table>
<thead>
<tr>
<th>Delinquency</th>
<th>B</th>
<th>S.E</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
<th>Odds Ratio</th>
<th>95% C.I. for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insomnia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>0.43</td>
<td>0.15</td>
<td>7.80</td>
<td>1</td>
<td>0.005</td>
<td>1.54</td>
<td>1.14-2.08</td>
</tr>
<tr>
<td>DelinquencyT1</td>
<td>1.66</td>
<td>0.14</td>
<td>137.1</td>
<td>1</td>
<td>0.000</td>
<td>5.23</td>
<td>3.97-6.9</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.54</td>
<td>0.10</td>
<td>246.8</td>
<td>1</td>
<td>0.000</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>TST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>-0.17</td>
<td>0.14</td>
<td>1.56</td>
<td>1</td>
<td>0.211</td>
<td>0.84</td>
<td>0.64-1.10</td>
</tr>
<tr>
<td>DelinquencyT1</td>
<td>1.71</td>
<td>0.14</td>
<td>149.6</td>
<td>1</td>
<td>0.000</td>
<td>5.54</td>
<td>4.21-7.28</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.37</td>
<td>0.12</td>
<td>133.5</td>
<td>1</td>
<td>0.000</td>
<td>0.25</td>
<td></td>
</tr>
</tbody>
</table>

T1 = Time point 1

Girls and boys

Exploring gender differences we did separate analyses for girls and boys. The results for girls are presented in table 5.2. We assessed if insomnia and TST predicts delinquent behaviour among girls. The results show that insomnia is a significant predictor of delinquency for girls F(2, 553) = 77.84, p < 0.001, Hosmer test Chi = 0.12, p = 0.943. The variance explained by the model was 13.1%. There was an increased likelihood by 1.53 for girls who report having clinical symptoms of insomnia in time point 1 to report any kind of delinquent behaviour in time point 2 compared to girls who reported not having clinical level insomnia. TST however, was not a significant predictor of delinquent behaviour among girls. Girls who were delinquent at time point 1 were also over 5 times as likely to report being delinquent in time point 2 compared to girls who reported no delinquent behaviour.

Table 5.2

<table>
<thead>
<tr>
<th>Delinquency</th>
<th>B</th>
<th>S.E</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
<th>Odds Ratio</th>
<th>95% C.I. for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insomnia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>0.42</td>
<td>0.21</td>
<td>4.06</td>
<td>1</td>
<td>0.044</td>
<td>1.53</td>
<td>1.01-2.31</td>
</tr>
<tr>
<td>DelinquencyT1</td>
<td>1.63</td>
<td>0.21</td>
<td>60.61</td>
<td>1</td>
<td>0.000</td>
<td>5.1</td>
<td>3.38-7.68</td>
</tr>
</tbody>
</table>
The results for boys are presented in table 5.3. We assessed if insomnia and TST predicts delinquent behaviour amongst boys. The results are similar to those of girls and show that insomnia is a significant predictor of delinquency for boys $F(2, 597) = 77.675$, $p < 0.001$, Hosmer test Chi = 4.14, $p = 0.13$. The variance explained by the model was 13.7%. There was an increased likelihood by 1.76 for boys who report having clinical levels of insomnia in time point 1 to report any kind of delinquent behavior in time point 2 compared to boys who reported not having clinical level insomnia. TST was not a significant predictor of delinquent behavior amongst Boys. Boys were also 5 times more likely to be involved in delinquent behaviour in time point 2 if they reported any delinquent behaviour in time point 1 compared to boys who reported no delinquent behaviour.

**Table 5.3**

<table>
<thead>
<tr>
<th>Delinquency</th>
<th>B</th>
<th>S.E</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
<th>Odds Ratio</th>
<th>95% C.I. for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insomnia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>0.56</td>
<td>0.24</td>
<td>5.47</td>
<td>1</td>
<td>0.019</td>
<td>1.76</td>
<td>1.10-2.82</td>
</tr>
<tr>
<td>Delinquency1</td>
<td>1.67</td>
<td>0.19</td>
<td>74.63</td>
<td>1</td>
<td>0.000</td>
<td>5.3</td>
<td>3.63-7.74</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.48</td>
<td>0.13</td>
<td>125.18</td>
<td>1</td>
<td>0.000</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>TST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>0.09</td>
<td>0.20</td>
<td>0.19</td>
<td>1</td>
<td>0.665</td>
<td>1.09</td>
<td>0.74-1.60</td>
</tr>
<tr>
<td>Delinquency1</td>
<td>1.72</td>
<td>0.19</td>
<td>79.8</td>
<td>1</td>
<td>0.000</td>
<td>5.61</td>
<td>3.84-8.18</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.48</td>
<td>0.18</td>
<td>65.60</td>
<td>1</td>
<td>0.000</td>
<td>0.23</td>
<td></td>
</tr>
</tbody>
</table>

In summary, our results show that clinical level insomnia is a significant predictor of self-reported delinquent behaviour. When analysing girls and boys separately we see a somewhat greater odds ratio for boys than for girls. The amount of sleep adolescents had during weekdays was not found to predict delinquent behaviour in this sample.
Predicting Drinking

Results of logistic regression analysis of drinking for all participants are presented in table 6.1.

We assessed if insomnia and TST predicts drinking. The results show that insomnia is a significant predictor of drinking $F(2, 1189) = 165.65, p < 0.001$, Hosmer test Chi = 0.034, $p = 0.86$. The variance explained by the model was 13%. There was an increased likelihood by 1.6 times for adolescents who report having clinical symptoms of insomnia in time point 1 to report drinking in time point 2 compared to adolescents who reported not having clinical level insomnia at timepoint 1.

TST was also a significant predictor of drinking for all participants $F(2, 1201) = 165.49, p < 0.001$, Hosmer test Chi = 0.10, $p = 0.755$. The variance explained by the model was 12.9%. There was an increased likelihood by 1.9 times for adolescents who report sleeping less than 8 hours in time point 1 to drink alcohol in time point 2 compared to adolescents who reported sleeping more than 8 hours during weeknights at timepoint 1. In table 6.1 we can also see that adolescents who report drinking alcohol in time point 1 are over 11 times more likely to report drinking in time point 2 compared to adolescents who reported not drinking alcohol at timepoint 1.

Table 6.1.

<table>
<thead>
<tr>
<th></th>
<th>Drinking</th>
<th>B</th>
<th>S.E</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
<th>Odds Ratio</th>
<th>95% C.I. for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Insomnia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td></td>
<td>0.47</td>
<td>0.18</td>
<td>7.22</td>
<td>1</td>
<td>0.007</td>
<td>1.60</td>
<td>1.14-2.26</td>
</tr>
<tr>
<td>Drinking$t_1$</td>
<td></td>
<td>2.59</td>
<td>0.22</td>
<td>133.4</td>
<td>1</td>
<td>0.000</td>
<td>13.35</td>
<td>8.60-20.72</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td>-1.93</td>
<td>0.10</td>
<td>358.7</td>
<td>1</td>
<td>0.000</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td>TST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td></td>
<td>0.64</td>
<td>0.16</td>
<td>15.95</td>
<td>1</td>
<td>0.000</td>
<td>1.9</td>
<td>1.39-216</td>
</tr>
<tr>
<td>Drinking$t_1$</td>
<td></td>
<td>2.47</td>
<td>0.22</td>
<td>126.9</td>
<td>1</td>
<td>0.000</td>
<td>11.86</td>
<td>7.71-18.24</td>
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<tr>
<td>Constant</td>
<td></td>
<td>-2.11</td>
<td>0.12</td>
<td>287.3</td>
<td>1</td>
<td>0.000</td>
<td>0.12</td>
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</tr>
</tbody>
</table>

$t_1 =$ Time point 1

Girls and Boys

Here too, we examine gender differences by doing separate analyses of girls and boys. In table 6.2. we assessed if insomnia and TST predicts drinking amongst girls. The results show that
insomnia is not a significant predictor of drinking. TST on the other hand, was a significant predictor of drinking for girls $F(2, 566) = 82.88, p < 0.001$, Hosmer test Chi $= 0.00$, $p = 0.99$. The variance explained by the model was 13.6%. There was an increased likelihood by 1.66 times for girls who report sleeping less than 8 hours in time point 1 to drink alcohol in time point 2 compared to adolescents who reported sleeping more than 8 hours during weeknights at timepoint 1. In table 6.2 we can also see that girls who report drinking alcohol in time point 1 are over 11 times as likely to report drinking in time point 2 compared to girls who reported not drinking alcohol at timepoint 1.

Table 6.2

<table>
<thead>
<tr>
<th>Drinking</th>
<th>B</th>
<th>S.E</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
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<tbody>
<tr>
<td>Insomnia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>0.16</td>
<td>0.23</td>
<td>0.51</td>
<td>1</td>
<td>0.474</td>
<td>1.18</td>
<td>0.76-1.82</td>
</tr>
<tr>
<td>DrinkingT1</td>
<td>2.57</td>
<td>0.32</td>
<td>63.77</td>
<td>1</td>
<td>0.000</td>
<td>13.04</td>
<td>6.94-24.49</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.52</td>
<td>0.14</td>
<td>122.5</td>
<td>1</td>
<td>0.000</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>TST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>0.51</td>
<td>0.22</td>
<td>5.31</td>
<td>1</td>
<td>0.021</td>
<td>1.66</td>
<td>1.08-2.55</td>
</tr>
<tr>
<td>DrinkingT1</td>
<td>2.47</td>
<td>0.31</td>
<td>61.89</td>
<td>1</td>
<td>0.000</td>
<td>11.81</td>
<td>6.39-21.86</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.76</td>
<td>0.18</td>
<td>100</td>
<td>1</td>
<td>0.000</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

The results for boys are presented in table 6.3. We assessed if insomnia and TST predicts drinking amongst boys. Our findings show that insomnia is a significant predictor of drinking for boys $F(2, 627) = 79.68, p < 0.001$, Hosmer test Chi $= 0.045$, $p = 0.832$. The variance explained by the model was 11.9%. There was an increased likelihood by 1.92 for boys who report having clinical symptoms of insomnia in time point 1 to report drinking alcohol in time point 2 compared to boys who reported not having clinical level insomnia at timepoint 1.

TST was also a significant predictor of drinking for boys $F(2, 635) = 76.10, p < 0.001$, Hosmer test Chi $= 0.22$, $p = 0.64$. The variance explained by the model was 11.3%. There was an increased likelihood by 1.84 times for boys who report sleeping less than 8 hours in time point 1 to drink alcohol in time point 2 compared to boys who reported sleeping more than 8 hours during weeknights at timepoint 1. In table 6.3 we can also see that boys who report...
drinking alcohol in time point 1 are over 12 times as likely to report drinking in time point 2 compared to boys who reported not drinking alcohol at timepoint 1.

Table 6.3

<table>
<thead>
<tr>
<th>Drinking</th>
<th>B</th>
<th>S.E</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
<th>Odds Ratio</th>
<th>95% C.I. for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insomnia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>0.65</td>
<td>0.30</td>
<td>4.89</td>
<td>1</td>
<td>0.027</td>
<td>1.92</td>
<td>1.08-3.42</td>
</tr>
<tr>
<td>Drinking(_{t1})</td>
<td>2.71</td>
<td>0.32</td>
<td>70.59</td>
<td>1</td>
<td>0.000</td>
<td>14.97</td>
<td>7.96-28.14</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.32</td>
<td>0.16</td>
<td>221.3</td>
<td>1</td>
<td>0.000</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td><strong>TST</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>0.61</td>
<td>0.25</td>
<td>6.17</td>
<td>1</td>
<td>0.013</td>
<td>1.84</td>
<td>1.14-2.98</td>
</tr>
<tr>
<td>Drinking(_{t1})</td>
<td>2.52</td>
<td>0.31</td>
<td>64.48</td>
<td>1</td>
<td>0.000</td>
<td>12.40</td>
<td>6.71-22.93</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.4</td>
<td>0.18</td>
<td>180.3</td>
<td>1</td>
<td>0.000</td>
<td>0.09</td>
<td></td>
</tr>
</tbody>
</table>

\(t_1\) = Time point 1

In summary, both having clinical symptoms of insomnia and sleeping less than 8 hours are significantly related to drinking for all adolescents. However, separate analyses for boys and girls suggest that insomnia has greater predictive value for boys than for girls. The odds ratio for boys was also somewhat greater than for girls.

**Summary**

A summary of our findings suggest that the results are mixed. Our analysis suggest that insomnia has a significant predictive value for several of the outcome variables. Specifically insomnia seems to predict emotional reactivity, delinquency and drinking while TST only predicts drinking. Examining gender differences and interaction effects, we found no evidence for this except for separate logistic regression analysis of drinking suggesting that insomnia predicts drinking amongst boys but not girls.
Discussion

This study aimed to examine whether sleep was related to externalizing behaviour. More specifically, we examined whether sleep less than 8 hours and/or clinical levels of insomnia could predict increases in impulsivity, emotional reactivity, delinquency and drinking amongst 8th grade students 1 year later. Our results were conclusive, sleep deprivation mainly in the form of poor sleep quality rather than quantity explained variance in the development of emotional reactivity, delinquency and drinking across a 1 year period.

In today's society many adolescents have sleep difficulties. In our study, adolescents who had problems with sleep also had externalizing behaviour in general. Interestingly, it can be seen that this association looked different for girls and boys. Girls for example had stronger correlations between clinical level insomnia and externalizing behaviours than boys did.

We could also see that it was more likely for adolescents who experienced poor sleep quality, to report more externalizing behaviour one year later. This seemed to be true for both girls and boys, but boys reported an increase in drinking alcohol, when they experienced poor sleep quality and girls did not. The amount of sleep, on the other hand, was not as important as the quality of sleep adolescents got. This variable only predicted drinking, for both genders, one year later.

What do the findings say?

First research question. Our first research question aimed to examine whether there were gender differences in sleep and externalizing behaviours and their interrelations. Part of our significant results on gender differences in sleep behaviour was that, even though boys more frequently reported sleeping less than 8 hours, girls had almost twice as much clinical levels of insomnia. This might sound contradicting, how can boys, who report sleeping more
often less than 8 hours still manage to have better sleep quality? One possibility is that boys are not as accurate as girls to estimate how many hours of sleep they received during the night (Guedes et al., 2016). It might also be that our sample is not the same as in other research where boys sleep more than girls (Bauducco et al., 2016).

Other possible explanations for this might be that girls and boys have different demands in society or different coping strategies. One such strategy could be that girls ruminate, i.e. worry more and thereby maybe indirectly affect their sleep quality. It may also be that girls wake up earlier than boys because they are more stressed than boys are to work on their appearance. For some reason, even though girls go to bed 1 hour earlier than boys (Hysing et al., 2013) they still more frequently report experiencing clinical symptoms of insomnia than boys. Whether this depends on coping strategies, sleep hygiene or social demands remains to be explored.

Gender differences regarding externalizing behaviours have evaporated as evidenced by our results. We found no differences between girls and boys regarding reports of drinking habits, delinquency and emotional reactivity. Our findings are also supported elsewhere (Galambos, Barker, & Almeida, 2003; Snyder, & Sickmund, 2006; Hagquist, 2009; Bask, 2015). Somewhat surprisingly, our findings even show that girls tend to be significantly more impulsive than boys are, in contradiction to previous research.

Besides this, what could be causing the above mentioned diminishing differences? Goodkind et al. (2009) came to the conclusion that most of the diminishing gender gap may not be due to girls’ heightened externalizing behaviours but due to boys’ decreasing levels. At the same time Bask (2015) argues that the diminishing gap, at least in Sweden, could be a byproduct of the ongoing gender equality promotion in Swedish society as a whole. Girls are being taught to “take more space” and be more unrelenting with their wishes leading to equality in
externalizing behaviours as well. Indeed, our era is a different socio historical one with developments in many areas, not the least in gender roles.

The possibility exists that a combination of both above mentioned processes are under play. Regardless of the mechanism the end result is the same, gender differences are diminishing.

Continuing with our results, they show that all our variables are correlated. Girls, who report clinical levels of insomnia, have significantly stronger correlations with externalizing behaviour than boys do. More specifically, girls have stronger correlations with impulsivity, emotional reactivity and delinquency than boys do. This is in line with our theoretical framework for how we expect that sleep affects sensation seeking and risk taking behavior. That is, adolescents who experience poorer sleep also should report more externalizing behaviour.

Interestingly, the amount of sleep did not seem to correlate as high as insomnia did with the outcome variables. These results may seem counterintuitive and are exciting in that they could imply that the main focus when discussing sleep difficulties maybe should be quality and not quantity. Also noteworthy, is for girls in general the correlations were stronger between externalizing behaviours and sleep difficulties. This is an intriguing finding, maybe sleep difficulties are interrelated with externalizing behaviours in girls in a different manner than in boys. Further studies, maybe of qualitative nature could explore possible reasons for this.

Second research question. Our second research question aimed to examine whether sleep quantity and/or clinical levels of insomnia at time point 1 predicted higher levels of externalizing behaviour amongst adolescents one year later. We found that it was foremost the quality of sleep and not quantity that predicted externalizing behaviour. In fact, less than 8 hours of sleep predicted only drinking, whereas insomnia predicted drinking, emotional reactivity and delinquency.
Why sleep quality is a better predictor than sleep quantity is hard to say. Our theoretical framework for understanding how sleep affects externalizing behaviour is built upon that sleep deficits on structural parts of the brain increase sensation-seeking and risk-taking behaviour. One crucial aspect for this framework to be valid, is to have an agreement on what sleep deprivation really is. It seems that in our study, with a large sample, sleep quality takes into account individual variations of experienced sleep deprivation better than sleep quantity does. It could thus be that insomnia is a better representative of sleep deprivation than sleeping less than 8 hours per night on weeknights is.

Nonetheless, our findings support the notion that sleep deprivation, however experienced or objectively measured, may affect the socioemotional and cognitive control system. This is in line with experimental research on the adult population that shows a link between risk taking behavior and sleep deprivation (Ferrara, Bottasso, Tempesta, Carrieri, Gennaro, & Ponti, 2014).

In conclusion, adolescents who experienced poor sleep also reported more externalizing behaviour. To calm parents, our results show that it’s not the amount of sleep that appears most important, but rather it seems it is the quality of sleep that their children get that is important for proper daily functioning. Instead of worrying about how much sleep or how late adolescents are awake, parents should simply ask their children how well they slept to get a sense of their children's well-being and risk for developing externalizing problems.

**Third research question.** Our final research question aimed to investigate whether gender acted as a moderator in the effects sleep deprivation had on externalizing behaviour. Our findings show that this is not the case. The relation between sleep and developing externalizing behaviours across time is by and large similar for boys and girls. The only difference found was that clinical levels of insomnia predicted increased drinking in boys.
but not in girls. For some reason, boys seem to report increases in drinking if they experience poor quality sleep. It might be that the dual system model (Strang, Chein & Steinberg, 2013; Steinberg, 2010) previously mentioned is in play. The cognitive control system might be negatively affected by poor quality sleep leading to worse control of the socioemotional system.

Still, our results point to the fact that there no remarkable gender differences between how sleep and externalizing behaviours are related. This is also supported by other research pointing to a more equal society (Bask, 2015). With this in mind, other factors might mediate the links resulting in for example insomnia predicting drinking in boys.

**Strengths and limitations**

This study has both strengths and limitations. One of the strengths of this study is its research design. As established in the literature, causality cannot be inferred from a cross-sectional design. However a longitudinal design can not only measure variables but also establish the direction of change over time (Caruana, Roman, Hernandez-Sanchéz & Solli, 2015), thus allowing us to make predictions about our variables. However, predictions might also be bi-directional in nature or non-measured confounders may be in play, and these can only be controlled for with an experimental research design. Therefore, while a strength in this longitudinal design is its ability to investigate predictive validity, it cannot fully control for confounding variables.

Another common weakness for longitudinal designs is the attrition rate of losing participants over time. It can seriously threaten internal and external validity if the attrition exceeds 20-30% (Marcellos, 2004). In our study, about 79.7 % of the participants successfully completed the study, thus falling within the limits of acceptable attrition loss.

Furthermore, a strength of the sample is that it is large and includes adolescents from different socioeconomic and cultural backgrounds, increasing the generalizability of the
findings. However, the sample consisted of only 8th graders and therefore the findings may only be applicable for this age group in general. This might be the case, since research shows that sleep patterns change with onset of puberty. For instance, boys wake up earlier than girls in 7th grade, but not in 8th (Hysing et al., 2013; Mateo et al., 2012). Considering that girls reach puberty before boys do, this might be an important factor for generalizability.

There are pros and cons in using self-report surveys in studies. Limitations such as response bias, social desirability and pure inaccuracy are important issues to address (Fan et al., 2006). Nevertheless, there were reversed items included in the surveys to control for eventual unserious answers. Not having objective measures, there is always the chance for over and underestimation of sleep. However, the accuracy of self-reports answered by adolescents have been established when validated with objective sleep measures (Short, Gradisar, Lack, Wright & Carskadon, 2012; Wolfson & Carskadon, 2003).

Advantages of our sleep measures were that they captured both quantitative and qualitative aspects of sleep. More exactly, they include items such as time in bed, sleep onset latency and subjective items such as difficulty falling and staying asleep. This can be considered to give our predictive measures more accuracy and weight.

On the other hand, a limitation amongst our variables might exist among the constructs of impulsivity, as measured by the Impulsive Behavior Scale, and defiance, as measured by the Emotional Reactivity Scale. There exists some similarities in these instruments as is evident by the high correlation (r = 0.50). However, a major distinction is that emotional reactivity includes a core item of “Behave aggressively even though I don’t want to”. Since our study is part of a larger study, we could not use a validated instrument for defiance, still our regression analyses were significant for emotional reactivity but not impulsivity. This suggest that these instruments captured different constructs. Furthermore, reliability analysis showed excellent reliability and inter-item correlations in all of the measures used.
Some analytical limitations that are up for discussion is the fact that we split several of our variables from continuous to categorical ones. The variables TST and insomnia were split into categories because there was theoretical support to do so. National sleep foundation’s (2015) recommendations of 8-10 hours of sleep for adolescents were found to be appropriate guidelines for categorization of TST. While established clinical cut-off scores of insomnia (Yang, 2009) seemed appropriate to distinguish between adolescents with sleep quality difficulties. One consequence of this might be that this study misses out on considering if variations in the amount of sleep or levels of insomnia have a potential effect on externalizing behaviours.

Our outcome variables of drinking and delinquency had no other theoretical explanation for being categorical other than that the responses were highly skewed and not normally distributed. To interpret the responses in a meaningful way we split these variables into “drinking/no drinking” and “delinquent/no delinquent behaviour”. This leaves a broader definition of engaging in these behaviours ranging from “once” to “several times in the past six months” that needs to be considered when interpreted. This means that when sleep quantity and quality predicts drinking/delinquency one year later it does not predict the frequency of drinking, merely the occurrence of drinking. Still, considering how only 10% report drinking in 8th grade, drinking at that age would then be a norm-breaking behaviour.

Another aspect of this study that might be both a limitation but also a strength is its theoretical underpinning. As we reviewed the literature on externalizing behaviour, we concluded that there was no uniform perspective on externalizing behaviour. This reflects the complexity of the concept and how vast the subject is. Even though this study is a master thesis, we were encouraged by the gap in the literature to operationalize this concept.

Starting off to explore its core components, we found theoretical support for externalizing behaviours to be considered as parts of a spectrum (Liu, 2004). Very recent
research in this field suggest that the externalizing spectrum stem from the trait impulsivity with biological links to Hyperactivity, ODD, CD, SUD and ASPD (Beuchaine, Zisner & Sauder, 2017). Compared to our operationalization, which we developed from meta-reviews and factor analyses (Frick, 1993; Bongers, Koot, van der Ende & Verhulst, 2004), we included constructs of impulsivity, defiance, and norm-breaking behaviour (e.g. drinking and delinquency). As can be noted, our model seems to be supported by current research in the field suggesting that our theoretical framework might be a valid model for capturing externalizing behaviours.

**Implications and future research**

This study is unique in the sense that it gives a theoretical framework over how the dual system model could be affected by sleep. It offers a model for why there might be a norm-breaking peak in the age-crime curve during adolescence and why externalizing behaviour increases during a period of changing sleep patterns. Contemporary changes in society suggest that gender differences in externalizing behaviour are diminishing and thus that externalizing behaviour is more than a pubertal roller-coaster of testosterone.

Considering that the findings of this study suggest that sleep is related to externalizing behaviour, there are benefits to gain from sleep interventions in junior high school and high school. Many adolescents struggle in school to stay alert and learn. Several factors are probably involved here and this study suggest that sleep may be one of the factors that affect emotional turmoil and risk-taking behaviour. This study also emphasizes that girls have as much to gain as boys do from sleep interventions regarding externalizing behaviour.

An intriguing question that is not in the scope of our study is why sleep quality seems to better predict externalizing behaviours than sleep quantity. Future research in this area could help to illuminate why this seems to be the case and thereby help to tailor promotion and interventions even better.
Limiting use of media devices (Przybylski, Murayama, DeHaan & Gladwell, 2013) in homes to prevent and/or mitigate sleep difficulties helps to improve sleep hygiene. There is a connection between sleep and emotional and behavioral problems as shown by our and previous research. Increasing demands (Keyes et al., 2015) might also affect adolescents’ emotional well being in the form of stress and anxiety, in turn affecting sleep.

Sleep interventions might not only help adolescents to better cope with externalizing behaviour in the future, but also to perform better in school (Hysing et al., 2016) and not miss classes (Bauducco et al., 2015; Hysing et al., 2014). Indeed, some of the effects that sleep deprivation has on cognitive abilities seem to be reversible (Cohen-Zion et al., 2016). Schools and parents should therefore pay attention to the sleep quality that adolescents get and help them sleep better.

Our findings suggest that there exist a link between sleep and externalizing problems. What our findings cannot tell us is whether this link is better explained by a confounding variable. To further explore this link and determine if there exists causality, we suggest conducting experimental research in this field as an important next step in understanding the development of externalizing behaviour among adolescents. Such a finding might have valuable implications for keeping adolescents in school and helping them to better cope in our society.
References


