The transition to adolescence:

Changes in chronotype and behavioral/emotional problems.

Bart van Gent
Leiden University
Everything takes me longer than I expect. It's the sad truth about life.

Donna Tartt

So what?

George M. Whitesides
Abstract

The transition to adolescence is linked to behavioral and/or emotional problems, and to a change of circadian phase preference towards evening chronotype. Recent studies showed that eveningness in adolescence is associated with behavioral and emotional problems and with shorter sleep duration, poor sleep quality, and daytime sleepiness. Studies on chronotype, sleep and behavioral/emotional problems in preadolescents are scarce. The current study examined: 1) whether there is association between chronotype and behavioral/emotional problems in healthy 9, 10, and 11-year-old preadolescents, and 2) whether the hypothesized correlation is mediated by sleep quality, sleepiness, and/or sleep duration. Parents of 98 Dutch children aged 9 to 11 filled out the Strengths and Difficulties Questionnaire (SDQ), Children’s Chronotype Questionnaire (CCTQ), Sleep Disturbance Scale for Children (SDSC), and a sleep diary. The hypothesized association between eveningness and behavioral and/or emotional problems was not found. However, eveningness was significantly correlated to poor sleep quality and daytime sleepiness. Furthermore, poor sleep quality was significantly correlated to externalizing problems, and daytime sleepiness was significantly correlated to internalizing problems. To conclude, eveningness does not increase the risk of behavioral/emotional problems, but is related to poor sleep quality and increased daytime sleepiness. These results suggest that evening types are particularly vulnerable to behavioral/emotional problems when they experience poor sleep quality/daytime sleepiness. Moreover it might mean that other children, who are not considered evening types but do experience poor sleep quality/daytime sleepiness, may also be vulnerable to behavioral/emotional problems.

Keywords: Preadolescents; Sleep; Chronotype; Emotional/behavioral problems
Introduction

Preadolescents face many challenges as they experience their last days of unconcerned childhood. Not the least of them is the safe haven of sleep (Shakespeare, 1598), which is so important in youth (Sadeh, Gruber, & Raviv, 2002). While we all know how nourishing sleep can be, and how a single night of insufficient sleep can influence our functioning, a more radical change in sleeping patterns is associated with the transition to adolescence: the possible change of chronotype. In cases where children could generally be regarded as morning types, the incidence of reported eveningness in (the transition to) adolescence increases (Randler, Bilger, & Díaz-Morales, 2009).

This possible change of chronotype is of interest as extensive recent research has demonstrated an association between eveningness and behavioral/emotional problems among adolescents (Gau et al., 2007; Lange & Randler, 2011; Susman et al., 2007) and (to a lesser extent) young adults (Mecacci & Rocchetti, 1998). Behavioral and emotional problems in children and adolescents can have an enormous impact on many aspects of their lives (Dahl, 2004).

In a very recent review research (2012), Gregory and Sadeh point out the apparent association between sleep difficulties and behavioral as well as emotional problems. They report an association between sleep difficulties and inter alia: anxiety, depression, hyperactivity, and conduct problems in children and adolescents. This research aims to investigate the relationship between chronotype and behavioral/emotional problems in a non-clinical group of 9-11 year old children. This is in accordance with Gregory and Sadeh’s suggestion to regard sleep as a phenotype rather than a secondary symptom of other problems.
Transition to adolescence

Literature on childhood has described every step in child development. Research over the last two decades concerning the changes associated with adolescent development has, however, mainly addressed the atypical development such as problem behavior (Steinberg & Sheffield Morris, 2001). According to Dahl (2004) it is a period of vulnerabilities (and opportunities). The current research will focus on the presence of problem behavior in healthy individuals that accompanies the transition from childhood to adolescence.

The transition to adolescence involves visible physical/biological changes (Dahl, 2004). In addition, however, there is evidence for psychological (Lengua, 2006), as well as neurological (Moore et al., 2012), and social changes (Levitt et al., 2005); all of which have been linked to behavioral and/or emotional problems. When investigating behavioral/emotional problems within the framework of externalizing and internalizing problems (as done by Achenbach (1991), and Goodman (2001)); Van den Akker, Deković, & Prinzie (2010) conclude that, apart from the initial level of problem behavior, the mere transition to adolescence can cause a change in behavior.

The development of a delayed sleep phase is a major change in the transition to adolescence (Hagenauer, Perryman, Lee, & Carskadon, 2009; Russo, Bruni, Lucidi, Ferri, & Violanti, 2007). This can be related to both psychosocial and biological changes. Psychosocial changes, such as better social opportunities (e.g. more independence regarding activities after school, staying out at night) and more academic responsibilities (e.g. homework), can lead to a delay in the timing of sleep (Russo et al., 2007). Biological changes, in this case changes in the homeostatic and circadian regulation, can result in a better resistance to sleep pressure (Hagenauer et al., 2009), and a change of circadian phase preference.
Sleep-wake rhythm

Circadian phase preference (reflected in chronotype) concerns the time-of-day at which one functions at their best. People can be divided into either morning or evening types, although most people (60-70%, Natale & Cicogna 2002) would be labeled as neither of these extremes (the intermediary category). The circadian rhythm is connected to the suprachiasmatic nucleus, a part of the hypothalamus that is also known as the biological clock (Saper, Scammell, & Lu, 2005). Daily obligations (e.g. early start of school) can change, or interfere with, chronotype (Roenneberg, Wirz-Justice, & Merrow, 2003). Chronotype can also change during a lifetime (Lee, Kim, Kim, Wang, & Duffy, 2011). Children whose chronotype was indicated as the intermediate category have a higher probability to change chronotype later in life compared to children that are either morning or evening types (Lee et al., 2011). Earlier research shows a change from higher reported morningness in children (Kim, Dueker, Hasher, & Goldstein, 2002) to an increased level of reported eveningness in adolescence (Díaz-Morales & Sorroche, 2008; Hagenauer et al, 2009; Randler & Frech, 2009). This change seems to reverse in the transition to adulthood (Paine, Gander, & Travier, 2006; Taillard, Philip, & Bioulac, 1999), which eventually results in a clear preference for morningness in elderly people (Monk et al., 1991).

Morning types wake up early in the morning and go to bed early at night. The personality domains of morning types can be categorized as more conscientious and less neurotic than evening types (Tonetti, Fabbri, & Natale, 2009). Morningness in adolescence is associated with a positive attitude towards life, physical health, mental health, self esteem, better familial relationships and school functioning as compared to evening types (Randler, 2011). Furthermore morningness is associated with pro social behavior (Lange & Randler, 2011), and has been linked to better school achievement (Randler & Frech, 2009). When
compared to evening types, morning types are less likely to use substances (e.g. alcohol and tobacco) and are more involved in physical activity (Urbán, Magyaródi, & Rigó, 2011).

Evening types go to bed and wake up later than morning types. When getting up late is not possible because of obligations such as school attendance or work, they try to make up for lack of sleep by sleeping longer on weekends, or by taking naps during the day (Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002). In general, evening types when compared to morning types will more often report psychological as well as psychosomatic complaints. Aside from later bedtimes and longer sleep on weekend days, eveningness in adolescence is associated with inattention (Gau et al., 2007; Giannotti et al., 2002; Goldstein, Hahn, Hasher, Wiprzycka, & Zelazo, 2007), emotional problems (Giannotti et al., 2002), aggressive behavior (Goldstein et al., 2007), delinquent behavior (Gau et al., 2007; Susman et al. 2007), thought problems (Gau, et al. 2007), social problems (Gau et al., 2007; Goldstein et al., 2007) and habitual substance use (Urbán et al., 2011). At bedtime evening types are more alert compared to morning types, whereas they are sleepier after waking (Baehr, Revelle, & Eastman, 2000).

Shorter sleep duration, poor sleep quality, and daytime sleepiness are all associated with eveningness. Sleep duration during weekdays is often shorter than desired, which is not seldom compensated by extending weekend sleep duration (Russo et al., 2007). Shorter sleep duration (less than 7.7 hours per night) has been associated with externalizing behavioral problems in general and attention problems in particular amongst healthy 8-year-old children (Pesonen et al., 2010). Concerning preadolescents (9-13 years of age) Meijer (2008) found evidence for emotional instability and negative effects on school achievement as a result of chronic sleep reduction. Paavonen et al. (2010) found sleep quality in healthy 8-year-olds to be related to a lower performance in cognitive tests. In a longitudinal research of Israeli
children during their transition to puberty (Soffer-Dudek, Sadeh, Dahl, & Rosenblath-Stein, 2011), a relation to emotional information processing was found. Finally, Fallone, Owens, & Deane (2002) ascribe the augmentation of behavioral problems (e.g. attention problems), as well as emotional problems (like decreased positive mood) to increased daytime sleepiness.

**Behavioral/emotional problems**

Many behavioral/emotional problems have been associated with sleep problems and abnormal sleep-wake rhythms (Astill, Van der Heijden, Van IJzendoorn, & Van Someren, 2012). This link is likely to be bidirectional (Gregory & Sadeh, 2012). Behavioral and emotional problems can be roughly divided into externalizing and internalizing problems (Eisenberg et al., 2001).

Examples of externalizing (behavioral) problems are conduct problems like delinquent and aggressive behavior, as well as hyperactivity (attention problems). All are associated with eveningness in adolescents (Gau et al., 2007). O’Brien et al. (2003) found that sleep-disordered breathing can lead to hyperactivity and concentration problems; even to a level were the behavior meets the criteria for ADHD.

The internalizing (emotional) problems consist of e.g. anxiety and depressed mood. Gau et al. (2007) found a significant correlation between internalizing problems and eveningness as compared to morningness, but not when compared to the intermediate category. Paavonen, Solantaus, Almqvist, & Aronen (2003) found a relationship between poor sleep quality and anxiety, as well as depressed mood in preadolescents.

Internalizing and externalizing problems often coincide (comorbidity). To our knowledge, the connection between chronotype and behavioral/emotional problems in preadolescence has not yet been the subject of research.
Current research

The current research aims at gaining more insight into the specific role of chronotype in described behavioral/emotional problems. To do so the following questions are asked: (1) Is there association between chronotype and behavioral/emotional problems in healthy 9, 10, and 11-year-old preadolescents? It is hypothesized that a connection between eveningness and behavioral/emotional problems does exist, as it does in adolescents (Gau et al., 2007; Lange & Randler, 2011; Susman et al., 2007) and (to a lesser extent) young adults (Mecacci & Rocchetti, 1998). (2) Is the hypothesized correlation between eveningness and behavioral/emotional problems mediated by factors earlier associated with behavioral/emotional problems such as: sleep duration (Pesonen et al., 2010), poor sleep quality (Paavonen, Porkka-Heiskanen, & Lahikainen, 2009; Pesonen et al., 2010), and daytime sleepiness (Fallone, Owens, & Deane, 2002)? All proposed mediators were previously related to eveningness (Giannotti et al., 2002).

Most people belong to neither the morning type, nor the evening type category. As this study is a pilot with only a limited amount of participants, and reported eveningness in children is low (Kim et al., 2002) we will regard chronotype as a continuous scale on which the degree of eveningness/morningness can be indicated. This has been previously done by Natale and Cicogna (2002). In this way a distinction can be made between children who, although belonging to the intermediary category, tend more to either morningness or eveningness.

Eveningness increases in adolescence. When, as hypothesized, a connection between eveningness and behavioral/emotional problems is seen in preadolescent children, it is important to take notice of the children who tend to eveningness in their transition to adolescence. Interventions to reduce eveningness could be considered in those cases.
Method

Participants

The subject of this study were 98 Dutch children aged 9 to 11 (M=10.01, SD=.79, 45% boys, 96% born in the Netherlands), that took part in a Leiden University and Netherlands Institute for Neuroscience study concerning the relationship between sleep characteristics and learning. The participating children lived in rural as well as urban areas throughout the Netherlands. All of them attended regular schools. Families consisted in most cases of the biological mother and father (90%), and two or three children (79%). Of the parents, 53% completed some form of higher vocational education, and another 33% some form of higher secondary education.

Procedures

The participants were recruited by students of Leiden University. Schools throughout the Netherlands were approached and approval letters were given to the children to take home. In some cases (approximately 10%) students approached parents directly. Of 50 schools that were approached, 28 granted permission to send a request, and 12 thereafter agreed to participate. Subsequently 1187 letters were sent directly to the parents or through the school. The letter explained the goal of the research and the contribution that would be required from both parents (an estimated 25 minutes for completing questionnaires) and the child (an estimated 25 minutes for completing questionnaires and two computer tests at home, and 30 minutes for three computer tests at school). The letter also contained an attached consent form which emphasized anonymous processing of the results and the right to withdraw the child from the project at all time without further explanation.
In consultation with the participating schools, dates were chosen to carry out the computer tests (these computer tests were not part of the current research). The week prior to the chosen date was classified as test week. Participating parents were asked to fill out several questionnaires in this week, of which the Strengths and Difficulties Questionnaire (SDQ), Children’s Chronotype Questionnaire (CCTQ), and Sleep Disturbance Scale for Children (SDSC) were used for the current research, as well as a questionnaire concerning background information, and a sleep diary parents were asked to keep for their child during eight days. The children were asked to complete two questionnaires of which only the Puberty Development Scale (PDS) was used in the current research in order to be able to exclude children that were already in puberty. Before, during, and after the test week a total of four emails were sent to remind parents to complete the questionnaires. The last two emails contained specific indications of the questionnaires that needed completing. All questionnaires were available via an online account, and a login name and password were provided to the parent(s) in the second email a few days before the test week. Some parents (5%) preferred to use paper versions, they were provided to them by mail and the results were digitized by the recruiting student.

**Instruments**

Demographic characteristics were obtained by a self-composed questionnaire that contained questions concerning the child’s age, the place of residence, family composition, school type, illnesses, and parental education and occupational class. This questionnaire was to be filled out by a parent.

Chronotype was measured using a Dutch version of the CCTQ (Werner, LeBourgeois, Geiger, & Jenni, 2009). The CCTQ is a 27-item parent report questionnaire that
enables to measure chronotype in three distinctive ways of which the “midsleep point on free days” was not used in this research. The morningness/eveningness scale consists of ten questions with possible scores ranging from 10 to 49 (representing extreme morningness to extreme eveningness). Questions concerned inter alia the times at which children would get up or go to bed if they could decide themselves, alertness after waking up, and assumed performance in an athletic activity in the morning. A single five-category-question concerning chronotype concluding the questionnaire enabled parents to indicate which chronotype matched their child best (response options ranged from definitely, to rather or neither one of the types). Both the morningness/eveningness scale and the chronotype question showed a high test-retest reliability of respectively $r = .94$ and $r = .84$ (Werner et al., 2009). When compared to actigraphic estimates, both measures showed significant correlations to bedtime, sleep start, and sleep end (ranging from $r = .30$ to $r = .65$). The internal consistency of the morningness/eveningness scale in this dataset was good ($.75$ Chronbach’s α) and the results of the scale were significantly correlated to those of the chronotype question, $r(84) = .75, p<.001$.

Internalizing and externalizing problems were both measured using subscales of the Dutch parent report version of the SDQ (Goodman, 2001; Van Widenfelt, Goedhart, Treffers, & Goodman, 2003). The SDQ is a brief questionnaire (25 items) that enables to indicate possible psychopathology in children. There are five different scales (emotional symptoms, conduct problems, hyperactivity-inattention, peer problems, and prosocial behavior) that each consists of five items and has a score range of 0 to 10. Possible responses are (respectively): “Many worries or often seems worried”, “Often fights with other children or bullies them”, “Easily distracted, concentration wanders”, “Picked on or bullied by other children”, and “Considerate of other people’s feelings”. Answers are to be given on a 3-point Likert scale
and include: “not true”, “somewhat true”, and “certainly true”. The statements are formulated positively as well as negatively. The Dutch parent report version of the SDQ showed acceptable internal consistency (.66 Chronbach’s $\alpha$) and strong correlation with the Child Behavior Checklist (CBCL). The correlation between emotional symptoms (SDQ) and internalizing problems (CBCL) was good ($r = .70$). For conduct problems and hyperactivity-inattention (SDQ) the correlation with externalizing problems (CBCL) was respectively $r = .72$, and $r = .50$ (Van Widenfelt et al., 2003). The internal consistency of the scales used in this research was .73 Chronbach’s $\alpha$ for internalizing (the SDQ emotional symptoms scale), and .77 for externalizing problems (a combination of the SDQ conduct problems and hyperactivity-inattention scales).

Poor sleep quality and daytime sleepiness were measured using a Dutch translation of the SDSC (Bruni et al., 1996). The SDSC is a 26-item parent report questionnaire which has shown a high internal consistency of .79 Chronbach’s $\alpha$. The total score is the sum of the 26 items that can be rated between one and five, and ranges between 26 (absence of sleep disturbances) and 130. Poor sleep quality was measured by using the total score of the SDSC. Possible statements were: “The child has nightmares which he/she doesn’t remember the next day”, “The child has difficulties in breathing during the night”, and “The child grinds teeth during sleep”. Possible answers to all questions excluding the first two were: “1 never, 2 occasionally (once or twice per month or less, 3 sometimes (once or twice per week), 4 often (3 or 5 times per week), and 5 always (daily)”. Internal consistency for the used dataset was .85 Chronbach’s $\alpha$. Daytime sleepiness was measured by a 5-item factor score “disorders of excessive somnolence” (DOES). This factor contained statements like: “The child awakes in the morning feeling tired”, and “The child is sleepy during the day”. The possible score ranges between 5 (absence of somnolence) and 25 and the internal consistency of the
subscale was .64 Chronbach’s α. In order to measure sleep duration the mean sleep duration was taken from seven nights that had been tracked by a sleep diary completed by the child’s parent(s). Sleeping diaries are commonly used in larger survey researches. Despite its restriction that nighttime awakenings are often not accounted for by parents, the agreement rates with actigraphy are acceptable for assumed sleep, as well as time in bed, sleep start, and sleep end (Werner, Molinari, Guyer, & Jenni, 2008).

Pubertal stage was measured using a Dutch version of the PDS (Petersen, Crockett, Richards, & Boxer, 1988). PDS is a self-report measure of pubertal changes that can easily be used in nonclinical settings and correlates satisfactorily with basal hormonal development (Shirtcliff, Dahl, & Pollak, 2009). It has been widely used in large-scale researches where a rough estimate of pubertal status is sufficient. PDS enables to classify five levels of pubertal status (pre-pubertal, early pubertal, mid-pubertal, late pubertal, and post-pubertal). It consists of three generic items: growth spurt, body hair, and skin change (e.g. pimples). Subsequently there are two questions for boys (voice change and facial hair), and two for girls (breast change and menarche). The total score can vary from 5 to 20. All questions except the one on menarche (yes (4) or no (1), and “if yes at which age?”) are on a 4-point scale marking development as not yet started (1), just started (2), clearly in progress (3), and seems to be completed (4). In longitudinal assessment (5 times in 3 years) for both boys and girls, the internal consistency was always between .68 and .83 Chronbach’s α (Petersen et al., 1988). In this study the internal consistency of the scale was acceptable for girls (.71 Chronbach’s α) but not for boys (.16 Chronbach’s α), data inspection revealed that 40% of the boys showed no sign of puberty what so ever (all questions answered with 1, not yet started) and the other 60% scored between 1 (not yet started) and 2 (just started). This can explain the lack of internal consistency.
**Statistical analyses**

For statistical analyses the Statistical Package for Social Sciences (SPSS) was used. Sleep duration was calculated as the interval between sleep onset (time lights out + sleep latency) and time of awakening, assessed over a week by a sleep diary. The correlation between all used variables supplemented with the variables age and gender has been computed using the Pearson’s correlation test. For all tests a .05 p value was used to assume significance.

The connection between eveningness and behavioral/emotional problems was primarily checked by the Pearson’s correlation test. For measuring the potential mediating effects of sleep quality, sleep duration, and daytime sleepiness, a non-parametric bootstrapping method with \( n = 1,000 \) resamples was used (Preacher & Hayes, 2008). Beside the total effect (Figure 1a), this method shows the direct effect (path \( c' \), Figure 1b) of the independent variable \( X \) on the dependent variable \( Y \). Furthermore it enables to detect an indirect effect of \( X \) on \( Y \) through a mediator \( M \). The indirect effect (Figure 1b) is the product of an effect of \( X \) on \( M \) (path \( a \)) and an effect of \( M \) on \( Y \) (path \( b \)). This way it’s possible to display whether the total effect (path \( c \), Figure 1a) of \( X \) on \( Y \) is just determined by \( X \) or that it’s partially or totally determined by \( M \) (in the current research multiple \( M \)’s were considered).

Prior to data analysis, the data were inspected to rule out incorrect data entry, outliers and extreme values, and to make sure that the conditions of statistical techniques were met. For response variables, predictor variables, and background information the descriptive statistics: mean (M), standard deviation (SD), minimum (Min), maximum (Max), skewness, and kurtosis were examined.

*Figure 1a Total effect*

*Figure 1b Direct and indirect effect*
Results

Data screening

Missing data was found for the variable sleep duration as measured by the sleeping diary. The sleeping diary entries did not correspond with the total-sleep-time-question from the SDSC as this one-question-item was not sensitive enough. On weekdays the mean sleep duration was 9-11 hours for most of the children (94%, n=51), which was one of five possibilities in the SDSC-question (all others assumed less sleep). Therefore the diary entry had to be used even though this part of the diary was not filled out completely by many participants. We took the mean of sleep duration for two weekdays, in order to save as many subjects as possible and still have a reliable measure of sleep duration (correlation with mean sleep duration of all weekdays was $r(52) = .88, p<.001$). Statistical analyses were therefore undertaken with 70 of the original 98 subjects.

The dataset was thoroughly checked for outliers and extreme values. All outliers and extreme values were reviewed using univariate as well as bivariate analysis. This way it was possible to ascertain that the deviant values were not related to a more advanced stage of puberty and to rule out that they were due to a psychiatric disorder, therefore none of the participants was removed from the dataset. Distributions were also checked for incorrect data entry. This was only the case for sleep duration and could be manually changed.

Descriptive statistics of the variables used as well as age are shown in Table 1. The distribution of the data was normal for age, chronotype, and sleep duration. The other mediating variables used in the data analyses (sleep quality and sleepiness), as well as the dependent variables (internalizing and externalizing problems) were not normally distributed (standardized skewness score was above three in all cases).
Table 1 Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Z-Skew.</th>
<th>Z-Kurt.</th>
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<tr>
<td>Age</td>
<td>70</td>
<td>10.00</td>
<td>0.82</td>
<td>8 - 12</td>
<td>0.00</td>
<td>-1.14</td>
</tr>
<tr>
<td>Chronotype</td>
<td>70</td>
<td>27.12</td>
<td>4.72</td>
<td>18 - 41</td>
<td>0.70</td>
<td>0.22</td>
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<tr>
<td>Sleep quality</td>
<td>69</td>
<td>39.27</td>
<td>8.86</td>
<td>26 - 67</td>
<td>3.08</td>
<td>1.31</td>
</tr>
<tr>
<td>Sleep duration*</td>
<td>70</td>
<td>602.22</td>
<td>43.78</td>
<td>520 - 732</td>
<td>1.51</td>
<td>0.41</td>
</tr>
<tr>
<td>Sleepiness</td>
<td>69</td>
<td>7.22</td>
<td>2.01</td>
<td>5 - 14</td>
<td>3.84</td>
<td>2.50</td>
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<tr>
<td>Internalizing pr</td>
<td>70</td>
<td>1.46</td>
<td>1.52</td>
<td>0 - 8</td>
<td>5.85</td>
<td>6.99</td>
</tr>
<tr>
<td>Externalizing pr</td>
<td>70</td>
<td>3.86</td>
<td>3.21</td>
<td>0 - 13</td>
<td>3.43</td>
<td>0.52</td>
</tr>
</tbody>
</table>

* measured in minutes (602.22 is 10 hours and 2 minutes)

Correlation of chronotype and emotional/behavioral problems

First of all a Pearson’s correlation test was carried out to reveal the correlations between used variables (Table 2). Secondly it enabled the hypothesis that eveningness as measured by the CCTQ (higher score meaning more evening orientated) was connected to emotional/behavioral problems to be tested. The results (Table 2) showed a correlation to neither internalizing problems, nor externalizing problems.

Table 2 Correlation between main variables

<table>
<thead>
<tr>
<th></th>
<th>gender</th>
<th>age</th>
<th>chrono</th>
<th>int. pr.</th>
<th>ext. pr.</th>
<th>quality</th>
<th>sl. ness</th>
<th>sl. dur.</th>
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<tr>
<td>Gender</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>.336**</td>
<td>.084</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Chronotype</td>
<td>.297*</td>
<td>.019</td>
<td>.108</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Intern. pr.</td>
<td>-.059</td>
<td>-.052</td>
<td>.049</td>
<td>.296*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extern. pr.</td>
<td>.032</td>
<td>-.069</td>
<td>.449**</td>
<td>.200</td>
<td>.362**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep quality</td>
<td>.233</td>
<td>-.024</td>
<td>.584**</td>
<td>.346**</td>
<td>.192</td>
<td>.662**</td>
<td></td>
<td></td>
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<tr>
<td>Sleepiness</td>
<td>.131</td>
<td>-.063</td>
<td>-.044</td>
<td>.214</td>
<td>.012</td>
<td>-.339**</td>
<td>-.055</td>
<td></td>
</tr>
<tr>
<td>Sleep duration*</td>
<td>.098</td>
<td>-.063</td>
<td>-.044</td>
<td>.214</td>
<td>.012</td>
<td>-.339**</td>
<td>-.055</td>
<td></td>
</tr>
</tbody>
</table>

* significant at the <.05 level ** significant at the <.01 level

Mediating factors

In the absence of correlation between the independent and dependent variables there would be no total effect that could be mediated by other factors. However, as recommended by Rucker, Preacher, Tormala, & Petty (2011), the proposed mediating effects were explored nonetheless as the hypothesized effects were theoretically substantiated, and could be present even though there was no direct effect of chronotype on emotional/behavioral problems.
Mediating effects for internalizing problems

The Preacher and Hayes (2008) model was used to measure mediating effects. In the normal theory test (Figure 2), significant effects were found for chronotype on sleep quality and daytime sleepiness, and for sleepiness and sleep duration on internalizing problems. After applying the bootstrapping method, using 1,000 bootstrap samples, the mediating effect of daytime sleepiness remained (Table 3). To avoid multicollinearity the analyses were done for each mediator individually.

![Figure 2 Normal theory test for indirect effects on internalizing problems](image)

**Table 3 Bootstrap results for indirect effects on internalizing problems**

<table>
<thead>
<tr>
<th>Indirect effects</th>
<th>Product of coefficients</th>
<th>Bootstrapping BC 95% CI</th>
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</thead>
<tbody>
<tr>
<td>Sleep quality</td>
<td>0.0266</td>
<td>0.0202</td>
</tr>
<tr>
<td>Sleepiness*</td>
<td>0.0786</td>
<td>0.0292</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>-0.0031</td>
<td>0.0086</td>
</tr>
<tr>
<td>Total</td>
<td>0.1021</td>
<td>0.0303</td>
</tr>
</tbody>
</table>

*Mediator since its 95% CI does not contain zero.
Mediating effects for externalizing problems

For the mediation effects concerning externalizing problems a separate calculation was made. In the normal theory test (Figure 3), additional significant effects were found for poor sleep quality on externalizing problems. After applying the bootstrapping method, the mediating effect for poor sleep quality was still seen (Table 4). To avoid multicollinearity the analyses were done for each mediator individually.

![Diagram](image)

*Figure 3 Normal theory test for indirect effects on externalizing problems*

**Table 4** Bootstrap results for indirect effects on externalizing problems

<table>
<thead>
<tr>
<th>Indirect effects</th>
<th>Point estimate</th>
<th>Product of coefficients</th>
<th>Bootstrapping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SE</td>
<td>Z</td>
</tr>
<tr>
<td>Sleep quality*</td>
<td>0.1310</td>
<td>0.0496</td>
<td>2.6434</td>
</tr>
<tr>
<td>Sleepiness</td>
<td>0.1005</td>
<td>0.0603</td>
<td>1.6670</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>-0.0004</td>
<td>0.0038</td>
<td>-0.1149</td>
</tr>
<tr>
<td>Total</td>
<td>0.2311</td>
<td>0.0648</td>
<td>2.0907</td>
</tr>
</tbody>
</table>

*Mediator since its 95% CI does not contain zero.
Discussion

This study aimed at gaining insight in the connection between chronotype and behavioral/emotional problems in healthy 9 to 11 year old children. As eveningness is associated with behavioral/emotional problems in adolescence it is important to know whether this association could be a continuation of an already existing relation in childhood or not. If so, this could mean that these children are more susceptible to problems in (the transition to) adolescence; if not, there could be other factors that predict problems in adolescence more than eveningness.

It was hypothesized that a connection between eveningness in children and behavioral/emotional problems exists, as it does in adolescents (Gau et al., 2007; Lange & Randler, 2011; Susman et al., 2007). Besides that, shorter sleep duration, poor sleep quality, and daytime sleepiness were considered possible mediating factors in this connection. These factors have all been shown to be related to eveningness (Gianotti et al., 2002).

The hypothesized connection between eveningness and behavioral and/or emotional problems was not found. However, poor sleep quality and daytime sleepiness were found to be significantly correlated to chronotype (children with a higher degree of eveningness had poorer sleep quality and experienced more daytime sleepiness). Furthermore poor sleep quality was significantly correlated to externalizing problems (behavioral problems) and daytime sleepiness was significantly correlated to internalizing problems (emotional problems). Sleep duration was not correlated to either chronotype or emotional and behavioral problems.
Chronotype and behavioral/emotional problems

This was, to our knowledge, the first study that looked into chronotype and behavioral/emotional problems in preadolescents. The hypothesized relation was not found. This is contrary to results in previous researches on adolescents (Gau et al., 2007; Lange & Randler, 2011; Susman et al., 2007).

In the above mentioned studies, chronotype was measured with variant instruments. It is unlikely that the use of instruments can be the reason for this difference. The Children’s Chronotype Questionnaire (CCTQ) that was used in this research is developed for children (adapting measures used in adolescents) and shows good psychometric results (Werner, LeBourgeois, Geiger, & Jenni, 2009). To measure behavioral/emotional problems Gau et al. (2007) and Susman et al. (2007) used the Child Behavioral Checklist (CBCL), and Lange & Randler (2011) used the Strengths and Difficulties Questionnaire (SDQ) as we did in the current research. Notable however, is the mean of the problem scores that differed. Lange & Randler (2011) reported a mean of 2.71 for internalizing problems and 6.11 for externalizing problems as to a mean of 1.46 and 3.86 in the current research. Reported problems in this study were much lower. This could be due to a difference in behavioral characteristics between children and adolescents, but it could also be a specific characteristic of the current sample.

The absence of a connection between eveningness and emotional/behavioral problems in preadolescent children was not hypothesized but is of considerable value for research and practice in the subject. As stressed before, the connection between eveningness and behavioral/emotional problems is demonstrated in several researches. The question could be raised whether eveningness as such is a predictor for problems in adolescence or that other factors are more important. We found that poor sleep quality and daytime sleepiness were connected to chronotype and also to behavioral/emotional problems.
Poor sleep quality and behavioral/emotional problems

A correlation was found between chronotype and poor sleep quality. Poor sleep quality in its turn predicted externalizing (behavioral) problems, but not internalizing (emotional) problems. This result suggests that evening types are particularly vulnerable to behavioral problems when they experience poor sleep quality. Moreover it might mean that other children, who are not considered evening types but do experience poor sleep quality, may also be vulnerable to behavioral problems.

Earlier research reports divergent results. Paavonen, Porkka-Heiskanen, & Lahikainen (2009) report a significant relation of poor sleep quality with parent-reported internalizing and externalizing problems, and teacher-reported externalizing problems in 5 and 6 year olds. Carvalho Bos et al. (2009) reported no connection between poor sleep quality in children between 6 and 11 and internalizing or externalizing problems. The reliability and validity of their instrument to measure sleep quality, however, was unclear. In a longitudinal study concerning sleep and problem behavior Meijer, Reitz, Deković, Van den Wittenboer, & Stoel (2010) found a relationship between poor sleep quality and internalizing and externalizing problems in adolescents. The relationship of eveningness with poor sleep quality was also found in adolescents by Gianotti et al. (2002).

With regards to research that linked eveningness to behavioral problems but did not measure other sleep parameters, it could be questioned whether this connection is indeed accounted for by eveningness. The problem behavior might as well have been a result of poor sleep quality. Focusing on sleep quality in children with and without the evening chronotype may decrease behavioral problems in preadolescence and maybe in adolescence as well. It may prove a better solution than to focus on eveningness alone.
Daytime sleepiness and behavioral/emotional problems

Daytime sleepiness was correlated with chronotype. Furthermore it predicted internalizing (emotional) problems, but not externalizing (behavioral) problems. Comparable with the connection between poor sleep quality and behavioral problems the result suggests that evening types are vulnerable to emotional problems, but especially when they experience daytime sleepiness. Here again, other children that are not considered evening types but do experience daytime sleepiness, may have a vulnerability to emotional problems as well.

In their meta-analytic review Dewald, Meijer, Oort, Kerkhof, & Bögels (2010) urged sleepiness to be treated as a separate sleep domain as this was only seldom done. Therefore there are few comparable results. Two recent studies investigated the relationship between behavioral/emotional problems and excessive daytime sleepiness in 508 children aged 6 to 12. The first reported association between daytime sleepiness and emotional problems (Calhoun et al., 2011), and the second between daytime sleepiness and behavioral problems (Calhoun et al., 2012). As with sleep quality, it would be wise to attend to reducing the level of sleepiness in children, regardless of the child’s chronotype.

Sleep duration and behavioral/emotional problems

No correlation was found between sleep duration and chronotype, and sleep duration did not predict either internalizing or externalizing problems. Notable is the relatively high mean sleep duration of 10 hours per night with a minimum of 8 hours and 40 minutes. This suggests that sleep duration in this group of children might have been a moderating factor. Behavioral/emotional problems that might normally occur due to eveningness, poor sleep quality, or daytime sleepiness might have been masked or even prevented by a sufficient amount of sleep.
The mean sleep duration measured in this research is comparable with that in another Dutch study (Meijer, 2008) on 9 to 13 year old children where sleep duration was measured by a sleep diary. Other researches however, report much shorter sleep duration. Holley, Hill, and Stevenson (2011) report a mean sleep period of 9½ hours (sleep onset to morning awakening measured by a sleep diary) with actual sleep duration of 8 hours, measured by actigraphy, in 6 to 12 year old children. Fallone, Acebo, Seifer, & Carskadon (2005) report a mean time in bed, measured by daily phone reports, of 9½ hours, and a mean sleep period, measured by actigraphy, of 9 hours in 6 to 12 year old children. Sadeh, Gruber, & Raviv (2003) report an 8½ hour sleep period measured by a sleep diary, and 8 hours sleep time measured by actigraphy in 9 to 12 year old children.

Both the Fallone et al. (2005) and the Sadeh et al. (2003) study were experimental designs in which the effect of sleep restriction was measured. Sadeh et al. report effects of neuropsychological functioning, e.g. behavioral inhibition, due to moderate changes in sleep duration. Fallone et al. report academic difficulties and attention problems rated by teachers. Holley et al. (2011) suggest that children who sleep an hour less than average are at risk of developing conduct problems. These studies substantiate the presumption that high mean sleep duration might have precluded behavioral/emotional problems in our study sample.

Limitations

There are some limitations to this study that have to be acknowledged. The first limitations concern the research design. It is cross-sectional research; even in the case of demonstrated connections between variables, this kind of research design leaves the question of causality unanswered. Besides that, all used instruments, except the Pubertal Development Scale, were parent-reported questionnaires.
Other limitations concern some of the unpredicted correlations of variables. Gender differentiation for example, was not accounted for. Analyses of the main variables, however, revealed a correlation between chronotype and gender; more girls were evening types in this sample. Influence of gender is something that has to be taken into account in research on morningness/eveningness, although in general there is no connection found (Gianotti et al., 2002; Kim et al., 2002; Russo et al., 2007). Gender was also correlated to internalizing problem, more girls experienced these problems.

Concerning the composition of the sample in this research it has to be noted that the education of the parents was much higher than average. Furthermore, the vast majority of the families consisted of both the biological parents and two or three children. This is not a representation of the average family composition and makes the results less applicable on the mean population. In particular, lower socioeconomic status in young adolescents is associated with poorer timing and consistency and shorter duration of sleep (Marco, Wolfson, Sparling, & Azuaje (2012).

Regarding daytime sleepiness and sleep duration should be stressed that daytime sleepiness was measured by a subscale of the questionnaire that assessed sleep quality. Although the psychometric properties of the subscale were acceptable, it would be better to avoid merging of two variables. Sleep duration was, as recommended by Astill et al. (2012), not measured as time in bed, but as the interval between sleep onset (time lights out + sleep latency) and time of awakening. It’s still likely however that the actual sleep duration was not as long as indicated by our parent-reported sleep diaries, as earlier mentioned researches all showed differences between results obtained by sleep diaries and results obtained by actigraphy.
Implications

Despite the above-mentioned limitations, there are several conclusions to be drawn from the obtained results. In the children that were subject of this research, chronotype did not predict behavioral/emotional problems. The identified problems did, however, correlate to other aspects of sleep. That implies that, regardless the chronotype, attention should be paid to these sleep related problems. Parental knowledge of good sleep hygiene will help to obtain better sleep quality and decrease daytime sleepiness. Concerning the transition to adolescence, the high sleep duration in the current sample is of interest. Evening types in adolescents experience a lack of sleep as was shown by Gianotti et al. (2002). The sleep duration of evening types in this sample did not deviate from the other children’s sleep duration. Securing adequate sleep in children that make the transition to adolescence might save them a lot of trouble.

This is not the first time that the problem is pointed out easily where the solution is likely to require more effort. Adolescents, especially young ones (Crone & Van der Molen, 2007) are not necessarily known for their well considered decision making, nor for their receptivity to suggestions made by their parents. That said parents do have an important role in their adolescents’ development. An Australian study on parent-set bedtimes (Short et al., 2011) showed that adolescents with parent-set bedtimes had, despite their biological clock changes, no longer sleep onset latency, and consequently obtained more sleep. Especially for the stage of early adolescence (between 12 and 14 years), when it’s most difficult for the adolescent to reason what’s best, this seems like a simple means to improve night time sleep and daytime functioning. Parent set bedtime also marks the time before bed more clearly and thus grants the opportunity to fill this time with activities that allow unwinding before going to bed.
A school-based program that addressed sleep problems in adolescents realized improvements in students’ sleep knowledge (Cain, Gradisar, & Mosely, 2011). The students attending the classes on sleep became more motivated to change their sleeping patterns in order to increase their average sleep time to 9 hours. The impact of the program did not last. Tracking the students showed that they did not succeed in maintaining these changes after the program had ended. Besides that, it is legitimate to question whether or (rather) not schools should be deployed in addressing these kinds of social issues (Furedi, 2009).

Recommendations

The findings in this research lead us to two recommendations concerning eveningness and parenting. Eveningness and its startling side effects was the starting point of this research. We would recommend however not to emphasize eveningness, but rather the inability to obtain enough sleep as a risk factor. Being an evening type does not necessarily lead to negative outcomes. There is, for example, also research suggesting that evening types are more intelligent (Kanazawa & Perina, 2009). And it is not even an impediment to holding the highest office; while the former President of the United States was considered an extreme morning type, his successor is said to be the opposite.

To conclude, parental awareness of their adolescent’s development might be the key to addressing issues like the ones at stake. Knowledge is acquirable through easily readable books (e.g. Crone 2008). Parents should tend to their children’s sleep need by regulating sleep during weekdays. In weekends they would do well on thinking back 10 years or so, when the mornings on which their baby slept long were cherished as it was so important for both the parent and child. It remains important, so do not bother them with quotes like “early to rise, makes a man healthy wealthy and wise”. Let them sleep…
Conflicts of interest:
The author reports no conflicts of interest, he considers himself neither morning type nor evening type.

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