



**Utrecht University**

**Unraveling the bidirectional relationship between sleep problems and externalizing  
problem behavior in adolescence**

Louise ten Harmsen van der Beek

2400618

Supervisor: Dr. Margot Peeters

Youth Studies

9 June 2023

Word count: 4811

This thesis has been written as a study assignment under the supervision of a Utrecht University teacher. Ethical permission has been granted for this thesis project by the ethics board of the Faculty of Social and Behavioral Sciences, Utrecht University, and the thesis has been assessed by two university teachers. However, the thesis has not undergone a thorough peer-review process so conclusions and findings should be read as such.

## **Abstract**

### ***English***

There is a well-established effect of sleep problems on externalizing problem behavior in adolescence, but whether this relationship is bidirectional remains unclear. Furthermore, the mechanisms driving this relationship are not fully understood. Hence, this study aimed to elucidate the bidirectional relationship between sleep problems and externalizing problem behavior in adolescence and to explore the potential moderating role of socioeconomic status (SES) and mediating role of effortful control in the pathway from sleep problems to externalizing problem behavior. Data from two time points (T1 and T3) of the TRacking Adolescents' Individual Lives Survey (TRAILS; n = 2,229) were analyzed using (hierarchical) multiple regressions. The results support a reciprocal relationship between sleep problems and externalizing problem behavior. Contrary to expectations, a lower SES did not amplify this relationship, and while effortful control was significantly associated with externalizing problem behavior, it did not explain the relationship between sleep problems at T1 and externalizing problem behavior at T3. The results highlight the intricacy of the link between sleep issues and externalizing problem behavior and call for further investigation into other potential moderators and mediators. Understanding these relationships can contribute to the development of targeted interventions for adolescents experiencing sleep problems and externalizing problem behaviors.

*Key words:* sleep problems, externalizing problems, socio-economic status, effortful control

### ***Dutch***

Ondanks het erkende effect van slaapproblemen op externaliserend probleemgedrag bij adolescenten, blijft het onduidelijk of deze relatie bidirectioneel is. Bovendien zijn de mechanismen die deze relatie sturen niet volledig ontrafeld. Deze studie had daarom als doel de bidirectionele relatie tussen slaapproblemen en externaliserend probleemgedrag in de adolescentie te verduidelijken. Daarnaast werd de mogelijke modererende rol van de sociaaleconomische status (SES) en de mediërende rol van effortful control in het traject van slaapproblemen naar externaliserend probleemgedrag onderzocht. Gegevens van twee meetmomenten (T1 en T3) van de TRacking Adolescents' Individual Lives Survey (TRAILS; n = 2.229) werden geanalyseerd met behulp van (hiërarchische) meervoudige regressies. De resultaten ondersteunen een wederkerige relatie tussen slaapproblemen en externaliserend

probleemgedrag. Tegen de verwachting bleek een lagere SES de relatie niet te versterken. Hoewel effortful control significant geassocieerd was met externaliserend probleemgedrag, bleek het geen verklarende rol te spelen in de relatie tussen slaapproblemen bij T1 en externaliserend probleemgedrag bij T3. De resultaten benadrukken de complexiteit van de relatie tussen slaapproblemen en externaliserend probleemgedrag en pleiten voor verder onderzoek naar andere mogelijke moderatoren en mediators. Begrip van deze relaties kan bijdragen aan de ontwikkeling van gerichte interventies voor adolescenten die kampen met slaapproblemen en externaliserend probleemgedrag.

*Sleutelwoorden:* slaapproblemen, externaliserende gedragsproblemen, sociaaleconomische status, effortful control

## **Introduction**

In 2021, 18.7% of girls and 18.4% of boys in Dutch secondary schools displayed delinquent, impulsive, or aggressive behaviors, known as externalizing problem behavior (Boer et al., 2022; Walton et al., 2011). This is concerning because research has shown that externalizing problem behavior in adolescence can negatively impact adult education, employment, and mental health outcomes (Laub & Sampson; 2018; Siennick, 2007). Furthermore, externalizing behaviors can negatively impact societal structures, as they lead to increased crime rates and strains on social and health services (Brame et al., 2001; Scott et al., 2001).

There is a well-established association between sleep problems and externalizing problem behavior in adolescence, but further prospective research is needed to clarify the bidirectional nature of this relationship (Liu et al., 2022). Understanding the bidirectional link is crucial as sleep problems can also have negative consequences on adolescent life, including academic performance, emotional wellbeing, and overall health (Dewald et al., 2010), which can lead to declining educational standards and an overburdened health care system (Hafner et al., 2017). Therefore, this study aims to investigate the potential bidirectional relationship between sleep problems and externalizing problem behavior in adolescence, specifically among early adolescents.

In addition, despite recent research demonstrating the unidirectional effect of sleep problems on externalizing problem behavior (Becker et al., 2015; Shimizu et al., 2020), the mechanisms driving this relationship are not fully understood (Van Veen et al., 2021). Hence, this study additionally aims to uncover the potential mediating role of effortful control and moderating role of socio-economic status (SES) in this relation. The results of this study can inform early intervention, needed to prevent subsequent problems during this crucial period of development (Liu et al., 2022).

### ***Theoretical substantiation***

There are two main approaches to explain the link between sleep problems and externalizing problem behavior. On the one hand, sleep issues can cause neurocognitive deficits and emotional dysregulation, which can result in externalizing problem behavior (Fortier-Brochu et al., 2012; Pilcher et al., 2015; Walker et al., 2009). On the other hand, it is also possible that negative thoughts or actions throughout the day may have an adverse impact on the quality of sleep through heightened physiological arousal and stress (Krizan & Herlache, 2016). This suggests that the relationship between sleep problems and externalizing behavior is reciprocal.

According to the self-regulation theory (Atherton, 2020), individuals with higher levels of effortful control are better able to regulate their emotions and behaviors, which can lead to better outcomes in various domains, such as externalizing problem behavior. A lack of qualitative sleep can lead to neurocognitive impairments and emotional instability, which in turn is linked with decreased effortful control in adolescence (Medda et al., 2019; Moore et al., 2011; Pilcher et al., 2015). Furthermore, research has found that better sleep quality is associated with relatively more effortful control and reduced behavioral problems in children (Goodnight et al., 2007). This indicates that effortful control could be a mediating factor in the causal relationship from sleep problems to externalizing problem behaviors.

In addition, the Family Stress Model (FSM) suggests that a lower SES increases family stress, leading to chaos and reduced support at home (Conger & Conger, 2002). This chaos, marked by inconsistent routines and high noise levels, may disrupt adolescents' sleep routines and quality (Bagley et al., 2015). Similarly, reduced familial support could heighten adolescents' psychological stress, which is known to negatively affect sleep (Conger & Conger, 2002). The combination of these factors could intensify the impact of sleep problems on externalizing behavior. Adolescents with sleep problems, who are also growing up in more adverse environments, may have fewer resources to cope with their lack of qualitative sleep and consequently may be more prone to behavioral issues. Therefore, the negative effects of sleep issues on externalizing behaviors could be amplified in low-SES families.

### ***Review of empirical studies***

While cross-sectional studies have established an association between sleep quality and externalizing problem behavior (Bayes & Bullock, 2019; Van Veen et al., 2021), the causal relationship remains unclear. Longitudinal studies have found that sleep problems in adolescence can predict the development of externalizing problem behavior (Becker et al., 2015; Shimizu et al., 2020). In addition, longitudinal studies also suggest that externalizing problem behavior may also lead to the development of sleep problems in adolescence (Rubens et al., 2019; Shimizu et al., 2021).

Recent longitudinal research has investigated the potential bidirectional relationship between sleep problems and externalizing problem behavior in adolescence. While some studies have found evidence of reciprocal effects (Quach et al., 2018; Shen et al., 2022), others have found that the relationship is primarily unidirectional, with sleep problems influencing externalizing behavior (Pieters et al., 2015) or effects being limited to childhood (Meldrum &

Truco, 2022). To explore this inconsistency in the literature, the bidirectional relationship between sleep problems and externalizing problems is investigated in this study.

The mechanisms underlying the association between sleep problems and externalizing problem behavior are understudied, particularly in early adolescents, aged 10-16 years (Van Veen et al., 2021). Effortful control - a characteristic representing the level of self-regulation abilities - is proposed as a potential mediator, given its linkage to both sleep problems and externalizing behavior (Dimakos et al., 2021; Robson et al., 2020). However, these studies have focused on children or adolescents with ADHD, leaving a gap in knowledge about the general population of early adolescents. It is crucial to investigate this age group as it is a formative period of rapid physiological and psychological changes that can uniquely influence sleep patterns and behavior (Basch et al., 2019). Moreover, the onset of sleep problems often occur during this stage (Dregan et al., 2010). Therefore, more longitudinal studies are necessary to unravel the role of effortful control in the interplay between sleep problems and externalizing behavior in this critical age group.

Studies investigating the moderating role of SES in the relationship between sleep quality and externalizing problem behavior in adolescence are scarce (El-Sheikh et al., 2020) and show mixed results. Some studies have found that the relationship between sleep problems and externalizing problem behavior is stronger for individuals from low-SES backgrounds (El-Sheikh et al., 2019; El-Sheikh et al., 2020), while others have found no evidence of SES moderating this relationship (Vazsonyi et al., 2018). One potential limitation of the studies is that they are cross-sectional in nature, meaning that they assess the relationship between variables at a single point in time. These mixed findings therefore illustrate the need for in-depth analyses, using a large sample of adolescents followed over time.

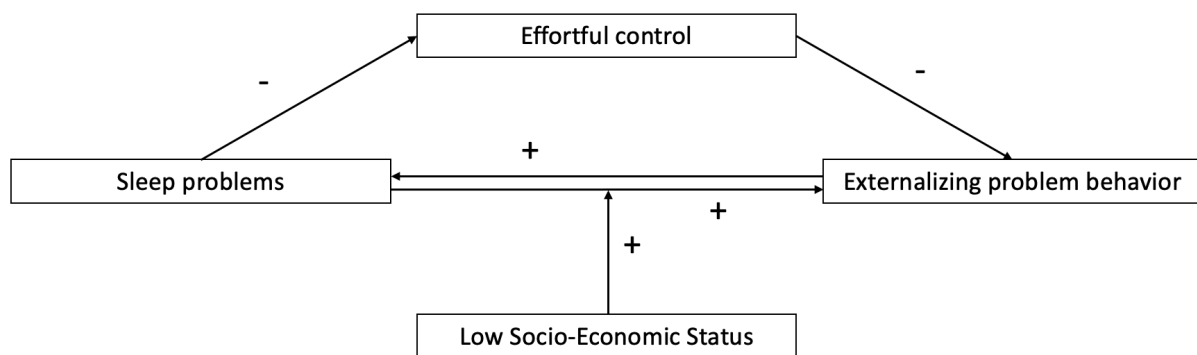
### ***The current study***

In this study, the bidirectional nature of sleep problems and externalizing problem behavior in adolescents is investigated as prior research has mostly concentrated on their unidirectional relationship (Quach et al., 2018). Furthermore, although the effect of sleep problems on externalizing behavior is well-founded (Bayes & Bullock, 2019; Pieters et al., 2015; Van Veen et al., 2021), there is a lack of research on potential mediating and moderating factors, such as effortful control and SES. Additionally, previous research has often overlooked potential differences in the relationship between these constructs for specific subgroups, such as those from different socio-economic backgrounds (El-Sheikh et al., 2019), or early adolescents (Basch et al., 2019). Further research is therefore needed to improve our understanding of the

relationship between sleep problems and externalizing problem behavior. The aim of the current study is to investigate the potential bidirectional nature of and the role of effortful control and SES in this relationship. First, we will investigate whether there is a bidirectional relationship between sleep problems and externalizing problem behavior in adolescence. Based on the literature, it is expected that the relationship between sleep problems and externalizing problem behavior in early adolescence is reciprocal (Quach et al., 2018; Shen et al., 2022).

Second, we will test how effortful control may mediate the causal relationship from sleep problems to externalizing problem behavior, and how SES may moderate this relationship. It is expected that effortful control will (partially) mediate, and thus (partially) explain, the effect of sleep problems on externalizing problem behavior in adolescence and that SES will moderate this effect, such that the relationship will be stronger for individuals from lower-SES backgrounds (Atherthon, 2020; Conger & Conger, 2002).

By examining these research questions and hypotheses, the goal of this study is to provide a more comprehensive understanding of the mechanisms driving the relationship between sleep problems and externalizing problem behavior and thereby yield new insights that can inform interventions to prevent sleep problems and externalizing behavior problems during adolescence. A conceptual model of the current study is presented in Figure 1.



**Figure 1:** Conceptual model of the current study

## Methods

### *Sample and procedure*

The data utilized in this study is derived from the Tracking Adolescents' Individual Lives Survey (TRAILS) Study. TRAILS is a longitudinal cohort study which is used to investigate the social and psychological development patterns of Dutch adolescents. The study sample comprised adolescents from 135 schools spread across five municipalities in the northern Netherlands, encompassing both urban and rural areas. All primary schools in this area and

parents of children attending these school were informed of the goals, design, and practical procedures of TRAILS through information brochures and telephone calls. Detailed information about the sampling procedure can be found elsewhere (Huisman et al., 2008). The initial cohort consisted of 2,229 participants out of 3,145 approached individuals, marking the first wave of the study. The demographic characteristics of the sample were as follows: 49% were female, and 11% were from ethnic minority backgrounds. This 11% included a variety of ethnicities, encompassing individuals of Turkish, Moroccan, Surinamese, Antillean, and Indonesian/Moluccan heritage. The age range at the start of the study was between 11 and 12 years. This cohort has been tracked for over 15 years, and the study is still in progress.

Data from the baseline (T1) and second follow-up (T3), with an average interval of 5 years between these two waves, are included in the current study. Out of the initial cohort of 2,229 participants (average age = 11.10, SD= 0.56), 1,818 individuals participated at T3 (average age = 16.27, SD = 0.71), indicating a participation rate of 81,6%. A comparative analysis of the participants who continued in both waves and those who dropped out revealed some differences. Dropouts were more likely to be male (56% versus 48%,  $p=0.002$ ), had a lower family SES score (-0.36 versus 0.02,  $p <0.001$ ) and reported slightly higher baseline externalizing problem behavior scores (0.29 versus 0.27,  $p = 0.047$ ) and sleep problems (0.40 versus 0.47,  $p=0.024$ ). Informed consent for the TRAILS study was given by both parents and adolescents. Furthermore, The Dutch Central Committee on Research Involving Human Subjects (CCMO) gave its approval for each study wave, which was carried out in accordance with the Declaration of Helsinki's guidelines.

### ***Measurement variables***

#### **Sleep problems**

Sleep problems were measured at both waves, using two items from the Youth Self Report (YSR), a well-established instrument for assessing behavioral and emotional problems over the preceding 6 months (Achenbach, 2013). These items were: "I sleep less than most kids my age" and "I have trouble sleeping". Responses were rated on a three-point Likert scale, ranging from "not true", to somewhat/sometimes true," and "very/often true." The items were transformed into a sleep problems scale by calculating mean scores for each participant, with a maximum score of 2. This scale was unidimensional, and Cronbach's alpha was found to be 0.64 for both measurement waves, indicating acceptable internal consistency. The normality of this variable was assessed by examining histograms and Quantile-Quantile (QQ) plots (see



Appendix A, Figures A1-A4). From those figures, it is observed that the dispersion of this variable is relatively large, suggesting a significant deviation from a normal distribution. However, given our interest in the bidirectional relationship between sleep problems and externalizing problem behavior, we opt to measure sleep problems on a continuous scale. Using the same scale type for both variables provides consistency in measurement and interpretation. To ensure that the results are not influenced by this deviation from normality, a sensitivity analysis is conducted. The sleep problems scale was dichotomized to create a binary scale, indicating whether respondents either did or did not have sleep problems, with 0 indicating no sleep problems and 1 indicating sleep problems.

### **Externalizing problem behavior**

Information on externalizing problem behavior was also derived from the YSR. The aggressive behavior and delinquent behavior subscales were utilized, encompassing items such as “I break the rules at home, at school, or elsewhere”, “I steal things outside”, and “I vandalize other people's belongings”. These two subscales consist of 32 items, with a Cronbach’s alpha of 0.85 for T1 and 0.87 for T3, indicating a high internal consistency. Each item is scored on a three-point scale (0 = not true; 1 = somewhat or sometimes true; 2 = very or often true). The items were transformed into a scale for externalizing problem behavior by computing mean scores for each participant, with a maximum score of 2 (Peeters et al., 2019). Figures A5-A8 indicate that, despite slight deviations from the normal distribution in the tails of the externalizing problem behavior scores at both timepoints, the variable was deemed sufficiently normal.

### **Effortful control**

Effortful control was assessed using the Early Adolescent Temperament Questionnaire (EATQ-R), which includes the activation control, attention, and inhibitory control subscales (Ellis, 2002). This 11-item scale, answered by the parents, has a Cronbach's alpha of 0.86, indicating high internal consistency. Items on this scale include statements such as “It is very difficult for my child to finish things on time” and “My child first does something fun for a while before starting chores or schoolwork, even if that is not the intention.” The data for this variable appear to follow a normal distribution, as illustrated in Figures A9 and A10.

### **Socio-Economic Status**

At both time points, SES was measured using a scale consisting of parental (mother’s and father’s) education and occupation, along with household income. The scale was calculated by

averaging these variables, providing a widely accepted measure with high internal consistency, as evidenced by a Cronbach's alpha of 0.84 (Schmengler et al., 2022). The QQ-plots in Figure A12 suggest that this variable sufficiently conforms to a normal distribution.

### **Confounders**

In this study, sex and ethnicity have been considered as confounders due to their established influence on both sleep patterns and externalizing problem behaviors. Sex differences in sleep patterns have been observed across different stages of development. For example, females tend to have longer sleep duration and better sleep quality than males during adolescence (Hagenauer et al., 2009). Additionally, males tend to show higher rates of externalizing problem behaviors compared to females (Moffitt & Caspi, 2001).

Disparities in sleep patterns among different ethnic groups have been observed, with non-Hispanic white children generally sleeping longer than their African American and Hispanic peers (Hale & Do, 2007). Ethnic disparities also exist in the prevalence of externalizing problem behaviors, potentially due to the complex interplay of SES, family stress, and cultural context (Bradley & Corwyn, 2002). In the data, ethnicity was represented as a binary variable. A value of 0 was assigned when both parents were born in a developed country, and a value of 1 was assigned when at least one parent was born in a non-developed country. By controlling for these confounders, a more accurate understanding of the relationship between sleep problems and externalizing problem behaviors in early adolescents is provided.

### ***Statistical Analysis***

The Statistical Package of Social Sciences (SPSS) version 28.0 is used for statistical analysis. First, a summary of the descriptive statistics and correlation between the variables is presented. Subsequently, to test the main research question, the relationship between sleep problems and externalizing problems is assessed in both directions, while controlling for confounders and previous behavior. To test the moderating effect of SES on the link between sleep problems at T1 and externalizing problem behavior at T3, an interaction term between SES and sleep problems at T1 is created. Using hierarchical regression, this analysis first determines the main impacts of the confounders, sleep issues and SES, before adding the interaction term between SES and sleep issues at T1.

Regression analyses are used to evaluate the mediation effect of effortful, following the methodology outlined by Baron and Kenny (1986). This involves three steps: first, externalizing problem behavior is regressed on sleep problems; second, we perform a

regression to test whether sleep problems influence effortful control; and finally, a regression with both sleep problems and effortful control as regressors and externalizing problem behavior as the dependent variable is performed. In all analyses, a p-value below 0.05 will be used to test for statistical significance.

## Results

### *Descriptive statistics and Correlations*

Table 1 displays the descriptive statistics of all study variables, including the mean, standard deviation, minimum and maximum values. Both the mean scores of externalizing problem behavior and sleep problems remained relatively stable from baseline to follow-up. Furthermore, the mean score of effortful control (3.20) was slightly higher than the expected average value of 3.

**Table 1:** Descriptive statistics

	N	Mean	Standard Deviation	Minimum	Maximum
Sex <sup>a</sup> (T1)	2229	0.49	0.50	0	1
Ethnicity <sup>b</sup> (T1)	2229	0.11	0.31	0	1
SES (T1)	2187	-0.05	0.80	-1.94	1.73
Effortful Control (T3)	1509	3.20	0.66	1.27	5.00
Externalizing problem behavior (T1)	2188	0.27	0.20	0	1.27
Externalizing problem behavior (T3)	1660	0.21	0.31	0	1.16
Sleep problems (T1)	2157	0.46	0.57	0	2
Sleep problems (T3)	1647	0.45	0.56	0	2

*Note:* Reference category<sup>a</sup>=male, reference category<sup>b</sup>=both parents not born in a non-developed country.

The correlations in Table 2 show that sleep problems at baseline were positively correlated with externalizing problem behavior at baseline (correlation coefficient ( $r$ ) = 0.31,  $p < 0.01$ ) and follow-up ( $r = 0.19$ ,  $p < 0.01$ ). Conversely, effortful control at T3 demonstrated negative correlations with both sleep problems at T1 ( $r = -0.09$ ,  $p < 0.01$ ) and externalizing problem behavior at T3 ( $r = -0.31$ ,  $p < 0.01$ ). Higher SES status at baseline was associated with more effortful control ( $r = 0.08$ ,  $p < 0.01$ ) and lower externalizing problem behavior at follow-up ( $r = -0.09$ ,  $p < 0.01$ ), respectively. Moreover, the significant positive correlation between externalizing problem behavior at baseline and follow-up ( $r = 0.34$ ,  $p < 0.01$ ) confirms stability over time. However, the correlation between sleep problems at baseline and follow-up ( $r = 0.28$ ,  $p < 0.01$ ) indicates only moderate stability over this period.

**Table 2:** Correlations between sex, ethnicity, SES, effortful control, externalizing problem behavior, and sleep problems

Variable	1	2	3	4	5	6	7	8
1.Sex <sup>a</sup> (T1)	-							
2.Ethnicity <sup>b</sup> (T1)	-.01	-						
3.SES status (T1)	-.30	-.17**	-					
4.Effortful control (T3)	-.23**	.04	.08**	-				
5.EPB (T1)	.18**	-.01	-.05*	-.20**	-			
6.EPB (T3)	.07**	.02	-.09**	-.31**	.34**	-		
7.Sleep problems (T1)	.00	-.01	.03	-.09**	.31**	.19**	-	
8.Sleep problems (T3)	-.05	.05*	-.01	-.08**	.16**	.34**	.28**	-

Note: Reference category<sup>a</sup>=male, reference category<sup>b</sup>=both parents not born in a non-developed country. EPB = externalizing problem behavior.

\* $p < 0.05$ , \*\* $p < 0.01$ .

### ***Bidirectional relationship between sleep problems and externalizing problem behavior***

The regression analyses presented in Tables 3 and 4 examine the bidirectional relationship between sleep problems and externalizing problem behavior, while controlling for sex and ethnicity. As shown in Model 2 from Table 3, sleep problems at T1 significantly predicted externalizing problem behavior at T3 ( $B = 0.040$ ,  $p < 0.001$ ), even after controlling for externalizing problem behavior at T1. Similarly, as can be seen from Model 2 in Table 4, externalizing problem behavior at T1 significantly predicted sleep problems at T3 ( $B = 0.270$ ,  $p < 0.001$ ), even after controlling for sleep problems at T1. This result remained consistent even when sleep problems were dichotomized, indicating that an increase externalizing problem behavior elevates the chance of developing sleep problems. The results of this sensitivity analysis are given in the Table 5.

**Table 3:** Regression analyses with externalizing problem behavior at T3 as outcome predicted by sleep problems at T1, controlled for by sex, ethnicity, and externalizing problem behavior at T1.

	Model 1			Model 2			Model 3		
	B	SE	Beta	B	SE	Beta	B	SE	Beta
Sex <sup>a</sup> (T1)	0.003	0.010	0.006	0.005	0.010	0.012	0.005	0.010	0.013
Ethnicity <sup>b</sup> (T1)	0.012	0.019	0.015	0.001	0.019	0.001	0.001	0.019	0.001
Externalizing problem behavior (T1)	0.380***	0.027	0.339	0.338***	0.028	0.302	0.334***	0.028	0.299
Sleep problems (T1)				0.040***	0.009	0.108	0.042***	0.009	0.113
SES (T1)				-0.022***	0.006	-0.082	-0.022***	0.006	-0.080
Sleep problems x SES							-0.015	0.011	-0.033
$R^2$	0.116			0.132			0.133		

Note: Reference category<sup>a</sup>=male, reference category<sup>b</sup>=both parents not born in a non-developed country.

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

Model 1: including control variables sex, ethnicity, and externalizing problem behavior at T1

Model 2: including the main effect of sleep problems and SES

Model 3: including the moderating effect of SES

**Table 4:** Regression analyses with sleep problems at T3 as outcome predicted by externalizing problem behavior at T1, controlled for by sex, ethnicity, and sleep problems at T1

	Model 1			Model 2		
	B	SE	Beta	B	SE	Beta
Sex <sup>a</sup> (T1)	-0.051	0.027	-0.045	-0.070*	0.027	-0.063
Ethnicity <sup>b</sup> (T1)	0.102*	0.049	0.050	0.102*	0.049	0.050
Sleep problems (T1)	0.275***	0.023	0.287	0.248***	0.024	0.260
Externalizing problem behavior (T1)				0.270***	0.074	0.093
R <sup>2</sup>	0.087			0.095		

Note: Reference category<sup>a</sup>=male, reference category<sup>b</sup>=both parents not born in a non-developed country. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

Model 1: including control variables sex, ethnicity, and sleep problems at T1

Model 2: including the main effect of externalizing problem behavior

**Table 5:** Logistic regression analyses with sleep problems (dichotomized) at T3 as outcome predicted by externalizing problem behavior at T1, controlled for by sex, ethnicity, and sleep problems (dichotomized) at T1

	Model 1			Model 2		
	B	SE	Exp(B)	B	SE	Exp(B)
Sex <sup>a</sup> (T1)	0.151	0.090	1.163	0.083	0.092	0.368
Ethnicity <sup>b</sup> (T1)	0.798***	0.165	2.221	0.804***	0.166	2.235
Sleep problems (T1)	0.497***	0.090	1.645	0.384***	0.094	1.468
Externalizing problem behavior (T1)				1.020***	0.259	2.772
-2 Log-Likelihood	2813.834			2797.869		

Note: Reference category<sup>a</sup>=male, reference category<sup>b</sup>=both parents not born in a non-developed country. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

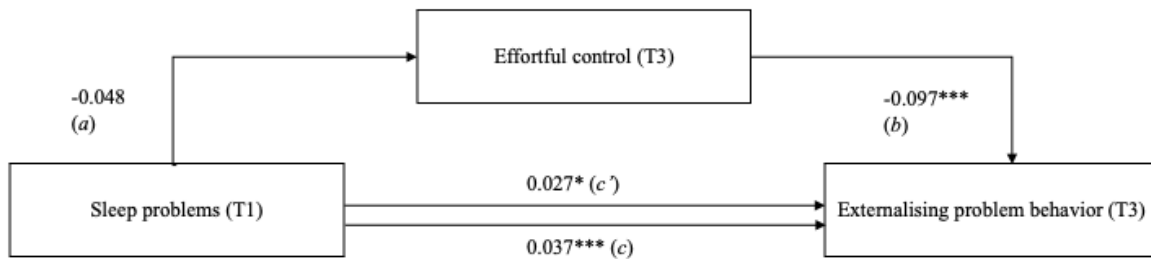
Model 1: including control variables sex, ethnicity, and sleep problems at T1

Model 2: including the main effect of externalizing problem behavior

### ***Effortful control: A non-significant mediator***

The results of the mediation analysis, which are presented in Figure 2 and control for sex and ethnicity, show some interesting trends. The unstandardized coefficient for the relationship between sleep problems at T1 and effortful control at T3 (path a) was -0.048, with a p-value of 0.071. This means that there is no direct association between sleep problems at baseline and effortful control at follow-up. Therefore, effortful control does not mediate the relationship between sleep problems and externalizing problem behavior.

The effect of effortful control on externalizing problem behavior at T3 (path b) was significant when controlling for sleep problems ( $B = -0.097$ ,  $p < 0.001$ ), suggesting that lower levels of effortful control are associated with an increase in externalizing problem behavior between T1 and T3. Lastly, the direct effect of sleep problems at T1 on externalizing problem behavior at T3, while controlling for effortful control (path c'), revealed a small but significant positive association ( $B = 0.027$ ,  $p < 0.05$ ). This association was smaller than the unstandardized coefficient of the total effect (path c,  $B = 0.037$ ,  $p < 0.001$ ), indicating that controlling for effortful control partly reduces the impact of sleep problems at T1 on externalizing problem behavior at T3.



**Figure 2:** Graphical presentation of the unstandardized effects of sleep problems on effortful control (path a), effortful control on externalizing problem behavior (path b), and the direct effect (path c') of sleep problems at T1 on externalizing problem behavior at T3. The total effect of sleep problems at T1 on externalizing problem behavior at T3 is given by path c.

Note: \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

### ***SES: A non-significant moderator***

The goal of the moderation analysis was to determine the moderating role of SES on the relationship between sleep problems at T1 and externalizing problem behavior at T3. We hypothesized that the relationship between sleep problems and externalizing problem behavior would be stronger for individuals from lower-SES backgrounds. The results presented in Table 3, however, illustrate that SES did not moderate this relationship, as the interaction term between SES and sleep problems at baseline was not significant ( $B = -0.015$ ,  $p > 0.05$ ). In addition, the inclusion of the interaction term between SES and sleep problems in Model 3 did not lead to a significant improvement in the overall model fit. Namely, the value of  $R^2$  was 0.132 in Model 2 and 0.133 in Model 3. This suggests that the moderation effect of SES was not large enough to provide additional explanatory power to the model. Interestingly, there was a main effect of SES on externalizing behavior problems with adolescents with a relatively lower socio-economic background experiencing more externalizing behavior problems.

## **Discussion**

In this study, the bidirectional relationship between sleep problems and externalizing problem behavior in early adolescents was investigated. Recent literature underscores the significant association between sleep problems and externalizing problem behaviors in adolescence (Bayes & Bullock, 2019; Van Veen et al., 2021). In addition, several literature reviews have uncovered a longitudinal effect of sleep problems on externalizing problem behavior (Quach et al., 2018; Shen et al., 2022). However, it remains unclear whether this relation is reciprocal, and what the mechanisms underlying this relationship are.

The results found in this study suggest a reciprocal relationship between sleep problems and externalizing problem behavior. One line of reasoning posits that lack of qualitative sleep

leads to neurocognitive deficits and emotional dysregulation, which in turn manifest as externalizing problem behavior (Fortier-Brochu et al., 2012; Pilcher et al., 2015; Walker et al., 2009). The observed bidirectionality in our study supports this theory, reflecting the detrimental effect of sleep problems on behavior. Another line of reasoning, the arousal-stress theory, suggests that externalizing behaviors can adversely impact sleep through increased physiological arousal and stress (Krizan & Herlache, 2016). This theory is also substantiated by the findings of the current study, as the reciprocal relationship observed indicates that behaviors during the day can negatively affect sleep quality at night. The reciprocal nature of this relationship suggests a complex interplay between sleep and behavior during early adolescence, with each influencing and exacerbating the other.

The findings of this study, presenting a significant bidirectional relationship, are consistent with some previous findings (Quach et al., 2018; Shen et al., 2022), but contrast other studies (Meldrum & Truco, 2022; Pieters et al., 2015). This variation may be due to different measurement scales used for sleep problems (Pieters et al., 2015) or differences in sample origin (Meldrum & Truco, 2022). As such, we recommend future research to incorporate harmonized measurement scales and diverse samples to gain a comprehensive understanding of the complex relationship between sleep problems and externalizing problem behavior in adolescence.

Contrary to expectations, our results rejected the hypothesis of effortful control as a mediator in the effect of sleep problems on externalizing problem behavior. Namely, the path between sleep problems and effortful control was non-significant. However, effortful control did show a significant negative relationship with externalizing problem behavior, indicating that early adolescents who score lower on effortful control display more externalizing problem behavior later in adolescence. This is consistent with the self-regulation theory (Atherton, 2020). Hence, it is concluded that effortful control might be a confounder in the relationship between sleep problems and externalizing problem behavior.

The non-significant relation between sleep problems and effortful control might be explained by the longitudinal design of this study. The data used measured sleep problems at baseline and effortful control at follow-up, on average 5 years apart. Previous research demonstrating a significant association between sleep problems and effortful control studied the association between sleep problems and externalizing behaviors using cross-sectional data (Medda et al., 2019; Moore et al., 2011). While there is a correlation between sleep problems at baseline and effortful control at follow-up, the regressions reveal that sleep problems do not significantly affect effortful control later in adolescence. We recommend further research to

explore a research approach with closer assessment periods, which could give better insight in the relationship between sleep problems and effortful control.

Lastly, while we hypothesized that socio-economic status (SES) would moderate the effect of sleep problems on externalizing problem behavior, the results did not support this. As the results demonstrate a non-significant effect of the interaction between SES and sleep problems, we cannot conclude that the effect of sleep problems on externalizing behavior is significantly strengthened for adolescents from a lower-SES background. It is interesting to note that SES did predict differences in externalizing behavior. Namely, a lower SES at baseline led to more externalizing behavior problems at follow-up. The current study, conducted in the Dutch context, may exhibit different findings from those of the family stress model (Conger & Conger, 2002), which was primarily developed based on research in the United States. The differences between the Netherlands and the United States, such as the Netherlands' high standard of living, lower income inequality, and comprehensive social welfare system (De Nardi et al., 2021), could diminish the moderating effect of SES on the relationship between sleep problems and externalizing behavior compared to studies from countries with greater income inequality like the United States (Hofstede, 2001). Moreover, Dutch study designs do not adequately represent individuals from lower SES brackets (Fakkel et al., 2020). This implies a potential shortfall in capturing the full range of familial stress dynamics within the Dutch context. Further research is needed to investigate the influence of cultural differences on the associations among sleep problems, SES, and externalizing behavior across diverse populations and SES groups.

### ***Strengths and limitations***

The current study possesses several strengths. The study is based on longitudinal data, which allows to investigate the bidirectional relationship over time. Furthermore, the use of a large sample enhances the generalizability of the findings and the consideration of potential confounding and moderating factors strengthens the internal validity of the results. Still, several limitations must be noted when drawing the conclusions. Firstly, the predominantly Dutch sample of this study may limit the generalizability of the findings to other cultural groups, given the influence of cultural factors on sleep patterns, stress, and externalizing behavior (Hofstede, 2001). Future research should strive to include more diverse populations. Secondly, the reliance on self-report measures for sleep problems and externalizing behavior, while validated, may be subject to biases. Incorporating objective measures like actigraphy or parent/teacher reports could yield more accurate data. Thirdly, the design of our study, with



only two time-points, limits the understanding of the longitudinal dynamics between sleep problems and externalizing behavior. A more comprehensive, longitudinal design could elucidate whether the bidirectional relationships observed remain stable or change over time. Lastly, while SES and effortful control were considered as potential influences, there might be other moderating and mediating factors like genetic influences, family dynamics, peer influence, or school environment. Future studies should explore these aspects for a more complete understanding of the relationship between sleep problems and externalizing behavior in adolescence.

### ***Conclusion and Practical Implications***

In conclusion, the findings of this study demonstrate a reciprocal relationship between sleep problems and externalizing problem behavior in early adolescents, affirming the significance of both sleep quality and behavioral factors in adolescent development. However, no mediation by effortful control and no moderation by SES in this relationship was found. These findings have important practical implications. First, the results underscore the need for early identification and intervention for sleep problems in adolescents. These interventions may not only improve sleep but could also potentially reduce externalizing problem behavior (Willgerodt et al., 2014; Wing et al., 2015). Screening for sleep problems and behavioral issues should be part of routine health assessments for adolescents, a responsibility that typically falls to youth health care services in the Netherlands, including preventive child healthcare doctors and school health coordinators. Furthermore, policies that support mental health services in schools and communities could target the externalizing problem behaviors (Atkins et al., 2010).

Also parenting practices could be addressed. As the findings suggests a potential link between sleep problems and externalizing problem behaviors, parents may need to prioritize consistent sleep schedules and healthy sleep environments for their children. By informing parents about the importance and impact of such practices, their awareness can be heightened, potentially contributing to mitigating sleep-related issues and associated behavioral problems in their children (Wing et al., 2015). Lastly, this research supports the need for policy decisions that prioritize adolescent health, including sleep health. This could include later school start times, which has been suggested by sleep researchers to align better with the natural circadian rhythms of adolescents (Owens et al., 2010). In short, this research emphasizes the complex and multifaceted nature of sleep problems and externalizing behavior in early adolescence, advocating for interventions that are as comprehensive and nuanced as the problems they seek to address.

## References

- Achenbach, T. M. (1991). *Manual for the Child Behavior Checklist/4-18 and 1991 profile*. Burlington, VT: University of Vermont, Department of Psychiatry.
- Atherton, O. E. (2020). Typical and atypical self-regulation in adolescence: The importance of studying change over time. *Social and personality psychology compass*, 14(1), e12514. <https://doi.org/10.1111/spc3.12514>
- Atkins, M. S., Hoagwood, K. E., Kutash, K., & Seidman, E. (2010). Toward the integration of education and mental health in schools. *Administration and policy in mental health and mental health services research*, 37, 40-47. <https://doi.org/10.1007/s10488-010-0299-7>
- Bagley, E.J., Kelly, R.J., Buckhalt, J.A., & El-Sheikh, M. (2015). What keeps low-SES children from sleeping well: The role of presleep worries and sleep environment. *Sleep Medicine*, 16(4), 496-502. <https://doi.org/10.1016/j.sleep.2014.10.008>
- Basch, M. C., Stromberg, S. E., Krietsch, K., Chardon, M. L., Reynolds, C. M., Acharya, R., & Janicke, D. M. (2019). Adolescent-reported sleep/wake patterns in the relationships between inhibitory control and internalizing and externalizing problems. *Journal of Developmental & Behavioral Pediatrics*, 40(9), 679-685. <https://doi.org/10.1097/DBP.0000000000000707>
- Bayes, D. M., & Bullock, B. (2019). Sleep problems in school aged children: A common process across internalising and externalising behaviours?. *Clocks & Sleep*, 2(1), 7-18. <https://doi.org/10.3390/clockssleep2010002>
- Becker, S. P., Langberg, J. M., & Evans, S. W. (2015). Sleep problems predict comorbid externalizing behaviors and depression in young adolescents with attention-deficit/hyperactivity disorder. *European child & adolescent psychiatry*, 24(8), 897-907. <https://doi.org/10.1007/s00787-014-0636-6>
- Boer, M., van Dorsselaer, S. A. F. M., de Looze, M., de Roos, S. A., Brons, H., van den Eijnden, R., ... & Stevens, G. (2022). HBSC 2021. Gezondheid en welzijn van jongeren in Nederland.
- Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual review of psychology*, 53(1), 371-399. <https://doi.org/10.1146/annurev.psych.53.100901.135233>

Brame, B., Nagin, D. S., & Tremblay, R. E. (2001). Developmental trajectories of physical aggression from school entry to late adolescence. *Journal of child psychology and psychiatry*, 42(4), 503-512. <https://doi.org/10.1111/1469-7610.00744>

Conger RD, Conger KJ. Resilience in Midwestern families: Selected findings from the first decade of a prospective, longitudinal study. *Journal of Marriage and Family*. 2002;64:361–373. <https://doi.org/10.1111/j.1741-3737.2002.00361.x>

De Nardi, M., Fella, G., Knoef, M., Paz-Pardo, G., & Van Ooijen, R. (2021). Family and government insurance: Wage, earnings, and income risks in the Netherlands and the US. *Journal of Public Economics*, 193, 104327. <https://doi.org/10.1016/j.jpubeco.2020.104327>

Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A., & Bögels, S. M. (2010). The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep medicine reviews*, 14(3), 179-189. <https://doi.org/10.1016/j.smr.2009.10.004>

Dimakos, J., Gauthier-Gagné, G., Lin, L., Scholes, S., & Gruber, R. (2021). The associations between sleep and externalizing and internalizing problems in children and adolescents with attention-deficit/hyperactivity disorder: Empirical findings, clinical implications, and future research directions. *Child and Adolescent Psychiatric Clinics*, 30(1), 175-193. <https://doi.org/10.1016/j.chc.2020.08.001>

Dregan, A., & Armstrong, D. (2010). Adolescence sleep disturbances as predictors of adulthood sleep disturbances—a cohort study. *Journal of Adolescent Health*, 46(5), 482-487. <https://doi.org/10.1016/j.jadohealth.2009.11.197>

Ellis, L. K. (2002). Individual differences and adolescent psychosocial development. University of Oregon: Unpublished doctoral dissertation.

El-Sheikh, M., Saini, E. K., Gillis, B. T., & Kelly, R. J. (2019). Interactions between sleep duration and quality as predictors of adolescents' adjustment. *Sleep health*, 5(2), 180-186. <https://doi.org/10.1111/j.1467-8624.2005.00897.x>

El-Sheikh, M., Shimizu, M., Philbrook, L. E., Erath, S. A., & Buckhalt, J. A. (2020). Sleep and development in adolescence in the context of socioeconomic disadvantage. *Journal of adolescence*, 83, 1-11. <https://doi.org/10.1016/j.adolescence.2020.06.006>

Fakkal, M., Peeters, M., Lugtig, P., Zondervan-Zwijnenburg, M. A. J., Blok, E., White, T., ... & Vollebergh, W. A. M. (2020). Testing sampling bias in estimates of adolescent social competence and behavioral control. *Developmental Cognitive Neuroscience*, 46, 100872. <https://doi.org/10.1016/j.dcn.2020.100872>

Fortier-Brochu, É., Beaulieu-Bonneau, S., Ivers, H., & Morin, C. M. (2012). Insomnia and daytime cognitive performance: A meta-analysis. *Sleep medicine reviews, 16*(1), 83-94. <https://doi.org/10.1016/j.smr.2011.03.008>

Goodnight, J. A., Bates, J. E., Staples, A. D., Pettit, G. S., & Dodge, K. A. (2007). Temperamental resistance to control increases the association between sleep problems and externalizing behavior development. *Journal of Family Psychology, 21*(1), 39. <https://doi.org/10.1037/0893-3200.21.1.39>

Hafner, M., Stepanek, M., Taylor, J., Troxel, W. M., & Van Stolk, C. (2017). Why sleep matters—the economic costs of insufficient sleep: A cross-country comparative analysis. *Rand health quarterly, 6*(4).

Hagenauer, M. H., Perryman, J. I., Lee, T. M., & Carskadon, M. A. (2009). Adolescent changes in the homeostatic and circadian regulation of sleep. *Developmental neuroscience, 31*(4), 276-284. <https://doi.org/10.1159/000216538>

Hale, L., & Do, D. P. (2007). Racial differences in self-reports of sleep duration in a population-based study. *Sleep, 30*(9), 1096-1103. <https://doi.org/10.1093/sleep/30.9.1096>

Hofstede, G. (2001), *Culture's Consequences: Comparing Values, Behaviors, Institutions, and Organizations Across Nations*, 2nd ed. Sage, Thousand Oaks, CA.

Huisman, M., Oldehinkel, A. J., de Winter, A., Minderaa, R. B., de Bildt, A., Huizink, A. C., ... & Ormel, J. (2008). Cohort profile: The Dutch 'TRacking adolescents' individual lives' survey'; TRAILS. *International Journal of Epidemiology, 37*, 1227- 1235. <https://doi.org/10.1093/ije/dym273>

Krizan, Z., & Herlache, A. D. (2016). Sleep disruption and aggression: Implications for violence and its prevention. *Psychology of Violence, 6*(4), 542. <https://doi.org/10.1037/vio0000018>

Laub, J. H., & Sampson, R. J. (2018). Unemployment, marital discord, and deviant behavior: The long-term correlates of childhood misbehavior. In *The generality of deviance* (pp. 235-252). Routledge.

Liu, J., Magielski, J., Glenn, A., & Raine, A. (2022). The bidirectional relationship between sleep and externalizing behavior: A systematic review. *Sleep Epidemiology, 100039*. <https://doi.org/10.1016/j.sleepe.2022.100039>

Medda, E., Alessandri, G., Delfino, D., Fagnani, C., Ferri, M., Violani, C., & Stazi, M. A. (2019). Adolescents self-reported sleep quality and emotional regulation: A discordant twin study. *Annali dell'Istituto Superiore di Sanità, 55*(2), 118-123.

Meldrum, R. C., & Trucco, E. M. (2022). Sleep problems and self-control: An examination of reciprocal effects across childhood and adolescence. *Journal of Criminal Justice*, 101975. <https://doi.org/10.1016/j.jcrimjus.2022.101975>

Moffitt, T. E., & Caspi, A. (2001). Childhood predictors differentiate life-course persistent and adolescence-limited antisocial pathways among males and females. *Development and psychopathology*, 13(2), 355-375. <https://doi.org/10.1017/S0954579401002097>

Moore, M., Slane, J., Mindell, J. A., Burt, S. A., & Klump, K. L. (2011). Sleep problems and temperament in adolescents. *Child: care, health and development*, 37(4), 559-562. <https://doi.org/10.1111/j.1365-2214.2010.01157.x>

Owens, J. A., Belon, K., & Moss, P. (2010). Impact of delaying school start time on adolescent sleep, mood, and behavior. *Archives of pediatrics & adolescent medicine*, 164(7), 608-614. <https://doi.org/10.1001/archpediatrics.2010.96>

Peeters, M., Oldehinkel, A., Veenstra, R., & Vollebergh, W. (2019). Unique developmental trajectories of risk behaviors in adolescence and associated outcomes in young adulthood. *PloS one*, 14(11), e0225088. <https://doi.org/10.1371/journal.pone.0225088>

Pieters, S., Burk, W. J., Van der Vorst, H., Dahl, R. E., Wiers, R. W., & Engels, R. C. (2015). Prospective relationships between sleep problems and substance use, internalizing and externalizing problems. *Journal of youth and adolescence*, 44(2), 379-388 <https://doi.org/10.1007/s10964-014-0213-9>

Pilcher, J. J., Morris, D. M., Donnelly, J., & Feigl, H. B. (2015). Interactions between sleep habits and self-control. *Frontiers in human neuroscience*, 9, 284. <https://doi.org/10.3389/fnhum.2015.00284>

Quach, J. L., Nguyen, C. D., Williams, K. E., & Sciberras, E. (2018). Bidirectional associations between child sleep problems and internalizing and externalizing difficulties from preschool to early adolescence. *JAMA pediatrics*, 172(2), e174363-e174363. <https://doi.org/10.1001/jamapediatrics.2017.4363>

Robson, D. A., Allen, M. S., & Howard, S. J. (2020). Self-regulation in childhood as a predictor of future outcomes: A meta-analytic review. *Psychological bulletin*, 146(4), 324. <https://doi.org/10.1037/bul0000227>

Rubens, S. L., Miller, M. A., & Zeringue, M. M. (2019). The sleep environment and its association with externalizing behaviors in a sample of low-income adolescents. *Journal of community psychology*, 47(3), 628-640. <https://doi.org/10.1002/jcop.22142>

Schmengler, H., Peeters, M., Kunst, A. E., Oldehinkel, A. J., & Vollebergh, W. A. (2022). Educational level and alcohol use in adolescence and early adulthood—The role of social causation and health-related selection—The TRAILS Study. *PloS one*, *17*(1), e0261606. <https://doi.org/10.1371/journal.pone.0261606>

Scott, S., Knapp, M., Henderson, J., & Maughan, B. (2001). Financial cost of social exclusion: follow up study of antisocial children into adulthood. *Bmj*, *323*(7306), 191. <https://doi.org/10.1136/bmj.323.7306.191>

Shen, C., Mireku, M. O., Di Simplicio, M., Dumontheil, I., Thomas, M. S., Röösl, M., ... & Toledano, M. B. (2022). Bidirectional associations between sleep problems and behavioural difficulties and health-related quality of life in adolescents: Evidence from the SCAMP longitudinal cohort study. *JCPP Advances*, *2*(3), e12098. <https://doi.org/10.1002/jcv2.12098>

Shimizu, M., Gillis, B. T., Buckhalt, J. A., & El-Sheikh, M. (2020). Linear and nonlinear associations between sleep and adjustment in adolescence. *Behavioral sleep medicine*, *18*(5), 690-704. <https://doi.org/10.1080/15402002.2019.1665049>

Shimizu, M., Zeringue, M. M., Erath, S. A., Hinnant, J. B., & El-Sheikh, M. (2021). Trajectories of sleep problems in childhood: Associations with mental health in adolescence. *Sleep*, *44*(3), zsaa190. <https://doi.org/10.1093/sleep/zsaa190>

Siennick, S. E. (2007). The timing and mechanisms of the offending-depression link. *Criminology: An Interdisciplinary Journal*, *45*, 583–615. <https://doi.org/10.1111/j.1745-9125.2007.00091.x>

Van Veen, M. M., Lancel, M., Beijer, E., Remmelzwaal, S., & Rutters, F. (2021). The association of sleep quality and aggression: A systematic review and meta-analysis of observational studies. *Sleep medicine reviews*, *59*, 101500. <https://doi.org/10.1016/j.smrv.2021.101500>

Vazsonyi, A. T., Jiskrova, G. K., & Ksinan, A. J. (2018). Sleep, low self-control, and deviance: Direct and indirect links across immigrant groups and socioeconomic strata. *Journal of Adolescence*, *68*, 40-49. <https://doi.org/10.1016/j.adolescence.2018.06.002>

Walton, K. E., Ormel, J., & Krueger, R. F. (2011). The dimensional nature of externalizing behaviors in adolescence: Evidence from a direct comparison of categorical, dimensional, and hybrid models. *Journal of abnormal child psychology*, *39*, 553-561. <https://doi.org/10.1007/s10802-010-9478-y>

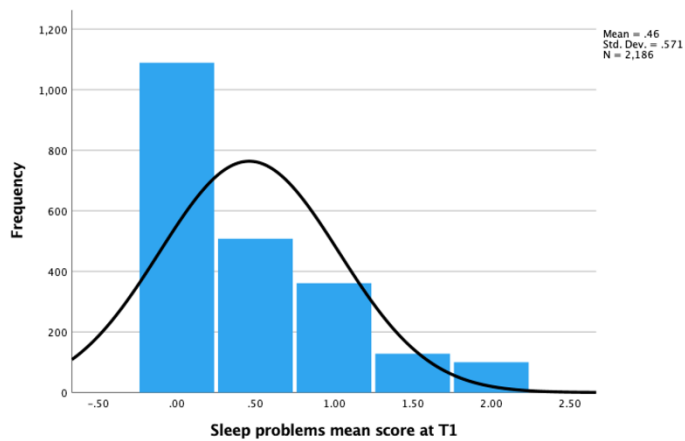
Walker, M. P. (2009). The role of sleep in cognition and emotion. *Annals of the New York Academy of Sciences*, 1156(1), 168-197. <https://doi.org/10.1111/j.1749-6632.2009.04416.x>

Willgerodt, M. A., Kieckhefer, G. M., Ward, T. M., & Lentz, M. J. (2014). Feasibility of using actigraphy and motivational-based interviewing to improve sleep among school-age children and their parents. *The Journal of School Nursing*, 30(2), 136-148. <https://doi.org/10.1177/1059840513489711>

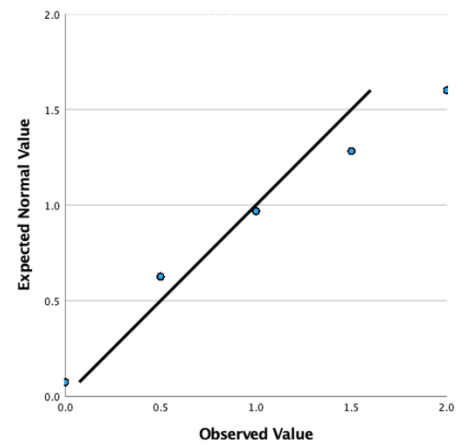
Wing, Y. K., Chan, N. Y., Man Yu, M. W., Lam, S. P., Zhang, J., Li, S. X., ... & Li, A. M. (2015). A school-based sleep education program for adolescents: A cluster randomized trial. *Pediatrics*, 135(3), e635-e643. <https://doi.org/10.1542/peds.2014-2419>

Zhou, Q., Chen, S. H., & Main, A. (2012). Commonalities and differences in the research on children's effortful control and executive function: A call for an integrated model of self-regulation. *Child development perspectives*, 6(2), 112-121. <https://doi.org/10.1111/j.1750-8606.2011.00176.x>

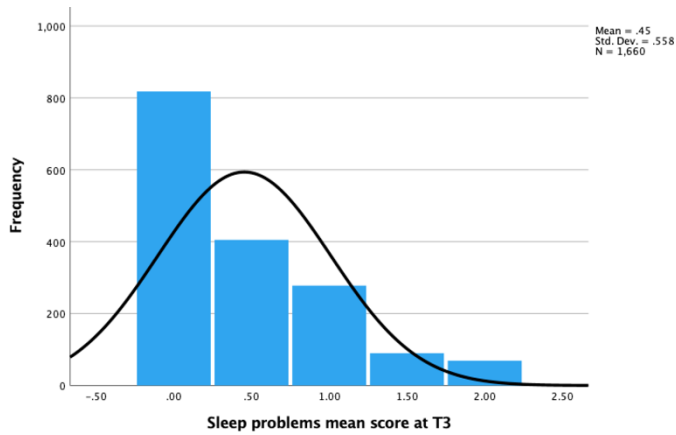
## Appendix A: Visual Checks for Normality Assumption



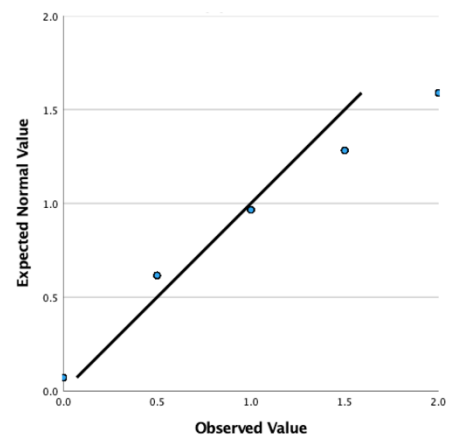
**Figure A1:** Distribution of sleep problems at T1



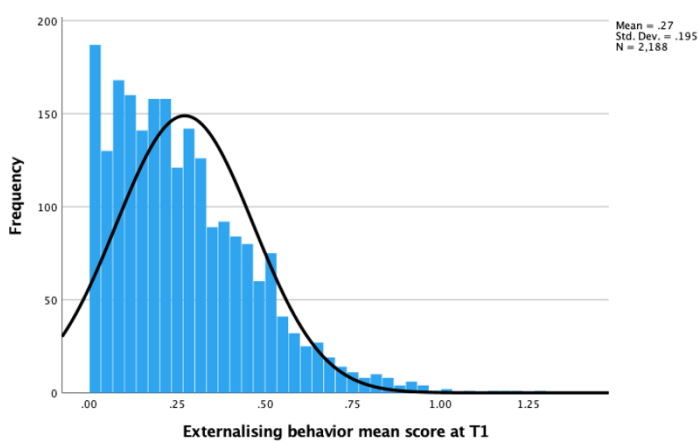
**Figure A2:** QQ-plot for comparing the distribution of sleep problems at T1



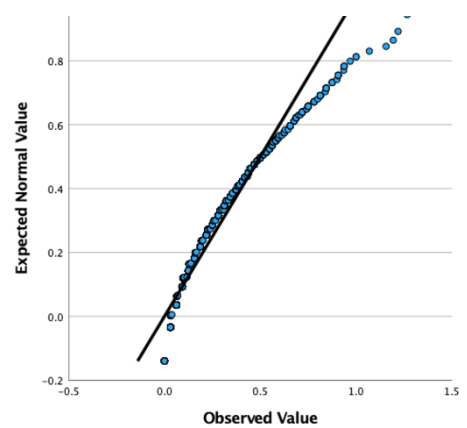
**Figure A3:** Distribution of sleep problems at T3



**Figure A4:** QQ-plot for comparing the distribution of sleep problems at T3

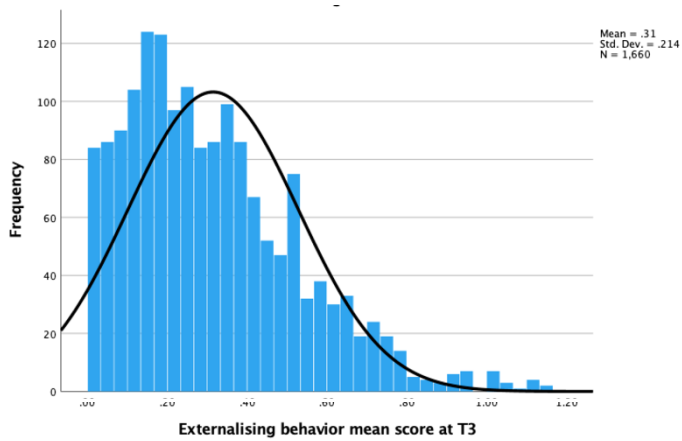


**Figure A5:** Distribution of externalizing problem behavior at T1

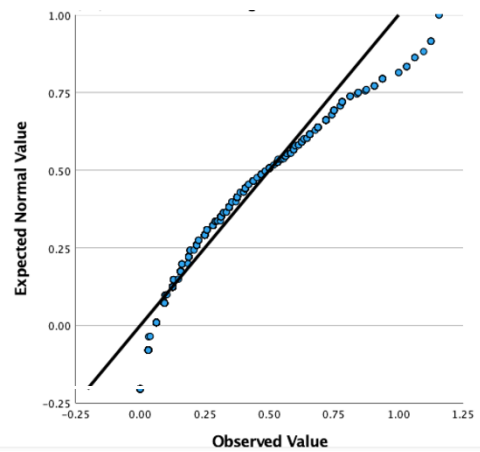


**Figure A6:** QQ-plot for comparing the distribution of externalizing problem behavior at T1

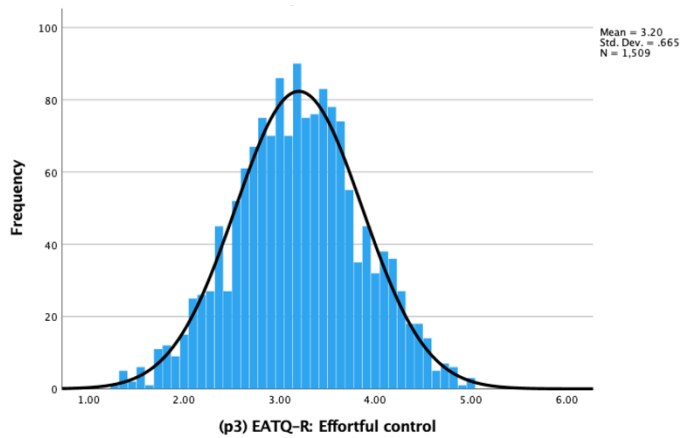




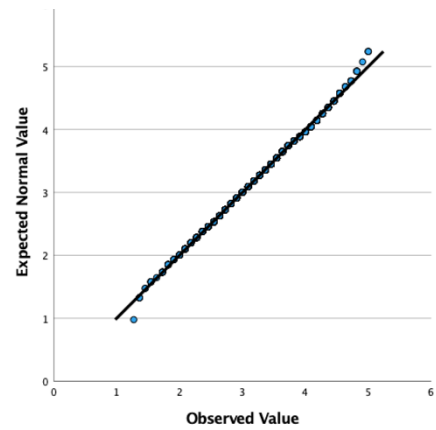
**Figure A7:** Distribution of externalizing problem behavior at T3



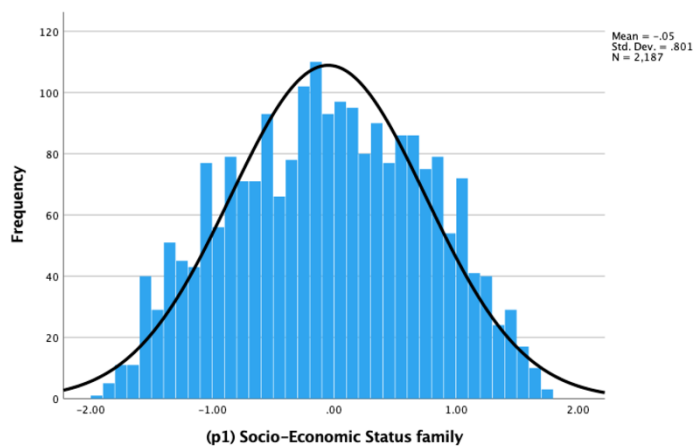
**Figure A8:** QQ-plot for comparing the distribution of externalizing problem behavior at T3



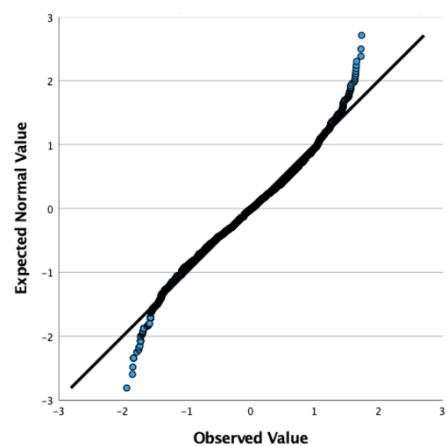
**Figure A9:** Distribution of effortful control



**Figure A10:** QQ-plot for comparing the distribution of effortful control



**Figure A11:** Distribution of Socio-Economic Status



**Figure A12:** QQ-plot for comparing the distribution of Socio-Economic Status