Masterthesis

Moderation of Efficacy of Cognitive Behavioral Therapy for Adolescents with Insomnia

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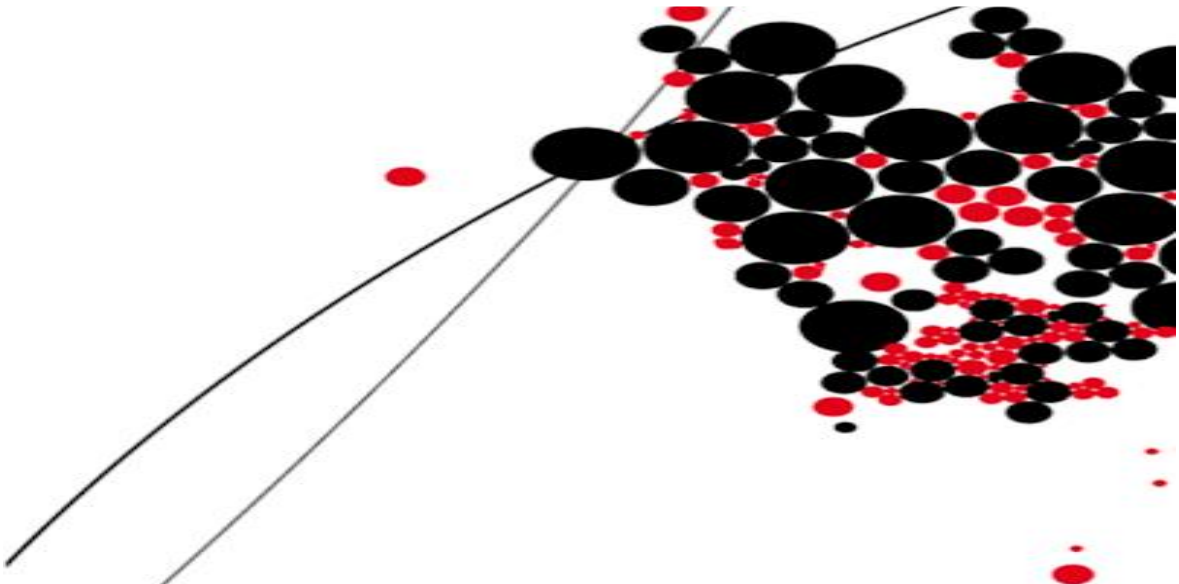

Abstract

Cognitive Behavioral Therapy for Insomnia (CBT-I) is effective for insomnia in adolescents. However, little is known about for whom this treatment is most effective. The present study aims to investigate the moderating effects of the following variables. It was tested whether 1) insomnia (baseline insomnia symptoms), and 2) mental health (baseline psychopathology symptoms) moderate effectiveness. In total, 116 adolescents with primary insomnia participated in the study (*M* = 15.6, *SD* = 1.6 years, 25 % males), receiving either internet-based treatment, group therapy or no treatment at all. The therapy consisted of six weekly sessions and a booster session after s months. Pre- and post-intervention as well as two months follow-up measurements assessed psychopathological and sleep parameters. Sleep was assessed by sleep efficiency (sleep logs) and insomnia symptoms (Holland Sleep Disorder Questionnaire). Moderating (baseline sleep efficiency and insomnia symptoms) and outcome variables were derived from these measurements. Baseline psychopathology symptoms were measured by the Youth Self-Report. From hierarchical regression analyses it appeared that CBT-I's effectiveness on reducing HSDQ levels was significantly moderated by baseline insomnia symptoms (β = -.27) and baseline psychopathology symptoms (β = .31). CBT-I's effectiveness on enhancing sleep efficiency was significantly moderated by baseline insomnia symptoms (β = .16), baseline sleep efficiency (β = -.38), and baseline psychopathology symptoms (β = -.18). Different effects for different sleep parameters can be explained by the different aspects of insomnia they are measuring. The HSDQ score represents insomnia-related distress while sleep efficiency represents the quantitative aspect of insomnia. The present study is one of the first to explore for whom CBT-I is most effective. Overall, it can be said, that the patients with high baseline levels of insomnia, less psychopathological symptoms and low sleep efficiency predict greater effectiveness of CBT-I.

Introduction

Insomnia in Adolescents

"Young and sleep deprived" (Weintraub, 2016) - The American Psychology Association pleads for later school start times due to chronic insufficient sleep among adolescents. Difficulties with sleep onset, duration, quality, and maintenance despite ample opportunities indicate a nocturnal disorder, called *insomnia* (World Health Organization, 1992). These difficulties are accompanied by energy loss and sleepiness during the day, decreased alertness and reduced performance (National Sleep Foundation, n.d.). Insomnia can be acute or chronic, while the latter is diagnosed after experiencing sleep disturbances for at least three months (American Psychiatric Association, 2013).

Exact prevalence rates cannot be determined due to different diagnostic criteria. However, it is believed that insomnia symptoms occur in at least 23.8 % of adolescents (Hysing, Pallesen, Stormark, Lundervold, & Sivertsen, 2013). This means that more than one out of five adolescents experience insomnia to some degree, which makes insomnia the most common sleep disorder in this age group (Donskoy, & Loghmanee, 2018). Also, it can be assumed that real prevalence rates are even significantly higher since adolescents show reluctance and lack of enthusiasm when it comes to seeking help (Cheng, 2009). Additionally, 88 % of adolescents experiencing symptoms report having a history with insomnia (de Zambotti, Goldstone, Colrain, & Baker, 2018) which indicates high prevalence rates of chronic insomnia. Interestingly, insomnia occurs more often in females than in male adolescents and more often in later stages of adolescence (Hysing et al., 2013; Johnson, Roth, Schultz, & Breslau, 2006). Thus, there are many adolescents suffering from insomnia. In order to paint a broader picture of the dimension of suffering – and therewith emphasizing the need for research in this area –, it is worthy to have a look at possible consequences and impairments associated with this disorder.

Symptoms of insomnia are associated with an array of physical and mental health issues, e.g.; 1) obesity and hypertension (Fatima, Doi, & Mamun, 2015; Kuciene, & Dulskiene, 2014; Park, 2011), 2) increased substance use (Pasch, Latimer, Cance, Moe, & Lytle, 2012); 3) weakened emotional-behavioral regulation (Schmidt, & Van der Linden, 2015) and 4) behavioral and emotional disorders (Dahl, & Harvey, 2007), among which depression and anxiety (Siomos et al., 2010; de Zambotti et al., 2018). Additional possible consequences can be found in Merdad, Akil, and Wali (2017). Insomnia is a risk and maintaining factor for several mental health problems, e.g depression (Riemann, & Voderholzer, 2003). These associated

physical- and mental health conditions illustrate that insomnia is not merely about sleep problems but has wide-ranging interactions with overall health and well-being.

This knowledge is important for an understanding of the need to research this topic in more depth since adolescents are exposed to a high chance of having insomnia during formative years. In this phase, adolescents are confronted with the challenge to deal with cognitive, environmental, physical - i.e. hormonal -, and emotional changes (Banyard, 2019) which could interact with sleep difficulties and reinforce the above-mentioned consequences (e.g. O'Brien, 2011). Also, the circadian rhythm in adolescents differs from the natural sleep-wake cycle in adults. This has to do with melatonin peaks which are much later in adolescents than in adults (Merdad et al., 2017). Therefore, it is important to note that findings from adult studies cannot be fully generalized to adolescent populations. These insights support the necessity for adolescent-focused research.

CBT-I as Effective Treatment for Insomnia in Adolescents

Effective treatments used to reduce symptoms of insomnia range from medication to psychotherapy (Donskoy, & Loghmanee, 2018). However, as the first choice of treatment of insomnia Cognitive Behavioral Therapy for Insomnia (CBT-I) has been recommended by numerous studies (e.g. Morgenthaler et al., 2006; Siebern, & Manber, 2011). Mainly, CBT-I consists of behavioral, educational and cognitive elements, namely sleep education, sleep hygiene, stimulus control, sleep restriction and compression, relaxation techniques, and cognitive therapy (Morgenthaler et al., 2006; Siebern, & Manber, 2011).

Among care providers and health professionals, there is a high preference for CBT-I since the effectiveness of this treatment for adults as well as for adolescents has been demonstrated in a large body of literature (e.g. Dewald-Kaufmann, de Bruin, & Gradisar, 2019; Donskoy, & Loghmanee, 2018; Okajima, Komada, & Inoue, 2011). Furthermore, de Bruin, Bögels, Oort, and Meijer (2015) assessed different modes of delivery for adolescents, namely group therapy and internet-based treatment. Their research has shown that both approaches are successful in reducing symptoms of insomnia.

So far, however, there has been little discussion about nuances and gradation of effectiveness. This finding is confirmed by the recent literature review by Buenaver, Townsend, and Ong (2019) who demonstrate shortcomings in prior studies by not including specific participant characteristics and suggest to take these into account in future studies. For example, it is not clear whether patients with high anxiety experience adverse effects after CBT-I treatment due to relaxation-induced anxiety (Heide, & Borkovec, 1983). In the study of Ong, Kuo and Mamber (2008) 40 % of participants did not complete the CBT-I treatment and

dropped out. This is predicted by short sleep duration and elevated symptoms of depression prior to the intervention. These variables predict drop-out but it remains speculative whether this means less effectiveness of the intervention as well. However, these studies were conducted with adults and results cannot be fully generalized to adolescents.

This leads to the aim of the current study, namely exploring factors that affect effectiveness in order to make the adoption of CBT-I for adolescents even more successful. Also, this would provide possibilities for further research in order to tailor CBT-I, so that it does not develop into a one-size-fits-all treatment.

The Current Study

The present paper is a follow-up paper to the work of de Bruin et al. (2015). In their study, a randomized controlled trial (RCT) was used to compare the effectiveness of CBT-I on treating insomnia disorder in adolescents. During this study, sleep parameters and psychopathological symptoms were assessed via a pre-test, post-test and two months follow up measurements. In total, 116 adolescents participated in the current study. Participants were allocated to one of three conditions, i.e. group therapy, internet treatment or the waiting list. The data and findings of this investigation are used to further disentangle the relationship between CBT-I and insomnia in adolescents. A thorough literature review shows two possible moderating variables: 1) baseline insomnia and 2) baseline psychopathology symptoms, which are likely to affect the CBT-I and insomnia relationship. Therewith, the present study intends to extend and further develop the insights by de Bruin et al., (2015). In order to do that, the following research question is posed: How do insomnia and psychopathology symptoms at baseline affect the effectiveness of CBT-I on insomnia symptoms?

The first moderating variable is baseline insomnia. Morin (2004) suggested that the level of baseline insomnia is likely to influence the effectiveness of CBT-I. So far, however, this assumption is not empirically tested. In contrast to studies on adults, the mechanisms and effects in adolescent populations are poorly understood. Therefore, the following argumentation is based on studies on adult samples and must be interpreted carefully. The idea to test baseline levels of a disorder or symptoms – i.e. insomnia symptoms, as a predictor of change, is not uncommon. For example, a recent study measured whether baseline pain severity moderates the effect of CBT-I on pain in fibromyalgia patients (McCrae, Curtis, Staud, Berry, & Robinson, 2019). It was found that higher levels of baseline pain predict greater change – i.e. decreased levels of pain – compared to lower baseline levels. This effect can also be conveyed to sleep problems and behavioral interventions. Although, using another type of intervention and sample, another RCT, showed that different levels of baseline sleep problems moderates the

effectiveness of Brief Behavioral Therapy (Chan et al., 2017). Hence, participants with more symptoms of sleep problems were more responsive to the intervention. Based on these findings, it is likely that baseline insomnia relates to the effectiveness of CBT-I, i.e. the higher baseline insomnia of adolescents the stronger the effect on the reduction of insomnia symptoms. The current study is the first to test the following hypothesis: Adolescents with higher baseline insomnia show greater reduction in insomnia symptoms than adolescents with lower baseline insomnia (H_1).

The second possible moderator is baseline psychopathology symptoms. A large body of literature suggests a bidirectional relationship between insomnia and psychopathology (e.g. Alcaro, Roberts, Harris, & Bruni, 2017). This is demonstrated by the mediating effect symptoms of insomnia have between CBT-I and psychopathology symptoms in adolescents (de Bruin, Bögels, Oort, & Meijer, 2018). To date, however, there has been little agreement on how levels of psychopathology influence the effectiveness of CBT-I on insomnia. On the one hand, studies on adults reveal that baseline psychopathology symptoms has no effect on the intervention-directed problem, i.e. insomnia symptoms (e.g. Hamoen, Redlich, & de Weerd, 2014; Lancee, van den Bout, van Straten, & Spoormaker, 2013; Manber et al., 2014). On the other hand, a recent RCT on adolescents (Blake et al., 2018) shows that higher levels of baseline anxiety and depressive symptoms are associated with more effective CBT-I. The explanation they provided was that participants with better mental health are less motivated, showed a lower drive to change and were less able to engage with the materials. Interestingly, the results of this latter study contradict the findings of the above-mention study conducted with adults. This could be explained by looking at conducted interventions; the before-mentioned studies on adults conducted CBT-I whereas the latter study makes use of the Sleep SENSE intervention. This intervention resembles CBT-I since it includes sleep education, sleep hygiene, stimulus control, and cognitive restructuring. However, anxiety-specific modules such as worry management and mindfulness are added which could explain why adolescents with higher anxiety and depression levels were more responsive to the intervention (Blake et al., 2018). Therefore, it cannot be said whether the effectiveness of a sleep intervention is moderated by baseline psychopathology symptoms in adolescents. Also, in the aforementioned studies, psychopathology is measured by anxiety and depression levels only. The present study, however, extends and explores this concept by adding symptom levels of affective problems, somatic problems, ADHD problems, oppositional defiant problems, and conduct problems in order to be able to draw broader conclusions about the moderating effect of psychopathology. Building on the work of Blake et al. (2018), it is suggested that CBT-I interventions are more

effective in adolescents with higher baseline psychopathological symptoms. Therefore, the present paper tests the following hypothesis: Adolescents with higher baseline psychopathology symptoms show a greater reduction in insomnia symptoms than adolescents with lower baseline psychopathology symptoms (H_2).

Method

Study Design

The current study is conducted with data gathered in a RCT (de Bruin et al., 2015). Participants were equally allocated to one of three conditions (group-therapy, internet-based intervention or waiting list) by concealed simple randomization with an equal allocation ratio by referring to a table of random numbers. The waiting list served as control condition to the other conditions containing CBT-I treatments.

Participants

In total, 478 people registered themselves online to take part in the study. They were approached by media, online newsletters, lectures, and in leaflets that were mailed to healthcare professionals, schools, and institutions. In total, approximately 76 % (n = 362) were excluded before (n = 342) or after (n = 20) the face-to-face assessment interview, mainly due to no response or incongruence with inclusion criteria. Inclusion criteria were: 1) age between 13 and 19 years, 2) absence of other psychiatric disorders, 3) difficulties with sleep onset and maintenance or feeling unrested after night sleep, 4) sleep problems occur at least three days per week for at least one month, 5) sleep disturbances lead to daytime impairments (e.g. academic performance or social functioning), 6) sleep problems are not the consequence of other sleep disorders, drug or medication intake or other physical disorders, and 7) sufficient motivation to participate in group therapy and appropriate traveling distance to treatment centers. After this screening procedure, 116 adolescents remained as participants (M = 15.6, SD = 1.6 years, 25 % males).

Procedure

The current study builds further upon a recently conducted RCT (de Bruin et al., 2015, 2018). The RCT was approved by the Medical Ethics Committee of the Academic Medical Center in Amsterdam (ref: NL3182701810) and registered at the International Standard Randomized Controlled Trials Number registry (ISRCTN33922163). After the above described screening procedure, participants were asked to fill in the Holland Sleep Disorder Questionnaire – insomnia scale (HSDQ) and the Youth Self-Report (YSR). Then participants were invited to a face-to-face interview that took approximately one hour during which congruence with DSM-criteria for insomnia was checked. Also, parents were involved in the face-to-face intake

interview and were provided with a booklet containing general information about the study. The remaining 116 participants were randomly allocated to one of the three conditions; internet treatment (n = 39), group therapy (n = 39) and waiting list (n = 38).

The participants in the treatment condition (online or group therapy) received weekly sessions over a period of 6 weeks and a booster session at two months after completion of the treatment. Therapists were trained in behavioral sleep medicine and were supervised by experienced sleep-psychotherapist. In every session, participants received advices about bed time based on their baseline sleep efficiency. Adolescents that received group therapy were asked to attend to weekly 90-min-sessions in a local youth mental health care center. The group sizes ranged from six to eight participants. Adolescents that received internet treatment could log in online to the treatment website once a week in order to have access to personalized bedtime recommendations, automated and personalized feedback from a sleep therapist. Also, explanations of the exercises, movies and interactive questionnaires were made accessible online. The estimated time participants would spent on the website was 90 min. Participants were not able to skip information and a session was only marked as completed when all of the information was accessed. After this, participants were able to review every session. Additionally, after session two participants were able to chat with a therapist for 15 min. Adolescents in the control condition were asked to abstain from sleep medication and received no further information or replacement for treatment.

In total, there were three measurement points; directly prior to, after and two months after the intervention. The questionnaires were filled in online at fixed times. If a participant did not complete the questionnaire, a reminder text-message was sent. Within those measurements, sleep parameters and psychopathological questionnaires were assessed. A more extensive description of the procedure, intervention, measurements and demographics of participants can be found in de Bruin et al. (2015, 2018).

Measurements

Insomnia. It was chosen to select self-reported sleep efficiency and insomnia symptoms as representative parameters of insomnia. The reason for this can be found in de Bruin et al. (2015): 1) sleep efficiency estimated from sleep logs improved with an effect size Cohen's *d* = 0.69 (internet-based treatment) and d = 0.52 (group therapy) between baseline and post-test. Moreover, they continued to improve after treatment, showing significant improvements, again, for internet treatment (β = .66) as well as for group therapy (β = .80), and; 2) insomnia symptoms measured by the HSDQ were affected by the CBT-I intervention with an effect size Cohen's *d* = -0.92 (internet-based treatment) and d = -1.08 (group therapy) between baseline

and post-test. Again, the internet treatment group (β = -1.34) as well as the group therapy group (β = -1.61) continued to improve after completing the intervention.

Sleep Efficiency. Sleep efficiency was measured by sleep logs, participants filled in directly prior to and after the treatment. Although sleep efficiency was also measured by actigraphy, it was chosen to use the sleep log measurements. According to Chambers (1994) or Iwasaki et al. (2010), actigraphy was not necessarily more accurate in assessing sleep times than sleep logs. De Souza et al. (2003) demonstrated that actigraphy can even overestimate awakenings during sleep. Moreover, results by Kushida et al. (2001) indicated that actigraphy is an accurate measurement for healthy individuals but measurements became more inaccurate with increasing sleep problems.

Sleep logs were filled in online for seven days right after participants woke up the next morning. Participants answered the following questions: "At what time did you go to bed?" [Dutch: *Op welk tijdstip ben je naar bed gegaan?*], "At what time did you turn off the light?" [Dutch: *Op welk tijdstip heb je het licht uit gedaan?*], and "How many minutes did it take to fall asleep after turning off the lights?" [Dutch: *Hoeveel minuten duurde het voordat je in slaap viel nadat je het licht had uitgedaan?*].

Insomnia symptoms. The HSDQ - insomnia scale was used in order to assess insomnia symptoms. This scale consists of eight items which were answered on a five-point Likert scale ranging from zero to five. The Items are listed in the appendix. The higher the score, the more the participants agreed on the item. The reported internal reliability coefficient in a Dutch sample of 1269 is high (α = .90) (Kerkhof et al., 2013).

Psychopathology. Psychopathological symptoms were assessed with the YSR questionnaire for adolescents consisting of 119 items (Achenbach, 1991). Items were answered on a three-point Likert scale ranging from "0", - not true, to "2" – very or often true. The 112 items were subdivided in six different subscales in line with diagnostic criteria of the DSM-IV. Cronbach's alpha measures are reported for younger and older adults and can be found in in Ebesutani, Bernstein, Martinez, Chorpita, and Weisz (2011). The DSM-oriented scales are: 1) affective problems (α = .68 and α = .79); 2) anxiety problems (α = .61 and α = .70); 3) somatic problems (α = .78 and α = .76), 4) ADHD problems (α = .78 and α = .78); 5) oppositional defiant problems (α = .70 and α = .76) and; 6) conduct problems (α = .77 and α = .81).

Statistical Investigation

Analyses of the current study were conducted using STATA version 14. First of all, a psychopathological score for each participant was created. Using prior established cut- off points, for each subscale was decided whether the participant scored "2" clinical, "1"

borderline, or "0" normal for the specific problem. Then the baseline psychopathology symptoms variable was created by summing up the subscales. Hence, the baseline psychopathology symptoms score can range from "0" to "12", where a "0" indicates the participant was not diagnosed with psychopathological symptoms and, "12" indicated the participant was clinically diagnosed with all psychopathological symptoms.

The dataset comprised two observations per individual, – baseline and post- measure. Therefore the dataset consisted of panel-data comprising 232 observations for 116 individuals. In order to assess the effectiveness of CBT-I on treating insomnia, hierarchical linear regression models were run. Hierarchical fixed effects regression models can adequately capture the panel-data structure of the dataset. Four models were run. The first model included the CBT-I variable and control variables (age and gender). In the second model, the interaction term between CBT-I and baseline insomnia is added. The third model includes the CBT-I variable, control variables and the interaction term between CBT-I and baseline psychopathology symptoms. Finally, in the fourth model all variables and interaction terms are added simultaneously to assess robustness of the predictions. To avoid multicollineairity issues and out of interpretation considerations, all variables were standardized before entering in regression. The variables were first standardized before creating their interaction terms (Cohen et al., 2003).

Also, the following two control variables were included in order to rule out possible interactions with the effectiveness of the insomnia treatment or tested moderation effects: 1) gender; According to Bruin et al. (2018), there are gender differences in responsiveness to CBT-I treatment. It was reported that scores of female adolescents were significantly higher for affective, anxiety and somatic problems and significantly lower for conduct problems. This indicated interaction effects of gender which is why it is controlled for gender in each analysis, and 2) age; De Bruin et al. (2015; 2018) reported no differential effects of age on the effectiveness of CBT-I. However, Feinberg and Campbell (2010) revealed that sleep in adolescents is affected by puberty status. In order to rule out any effect of age in the moderation analysis, it was decided to control for age in all conducted analyses.

Secondary analyses were conducted interchanging the moderating variables; insomnia symptoms predicted by baseline sleep efficiency and sleep efficiency predicted by baseline insomnia symptoms in order to assess robustness of the tested moderators.

Results

Table 1 shows the descriptive statistics of the dataset. The results of regression analysis are presented in Table 2. In order to test Hypothesis 1, predicting a moderating effect of baseline insomnia on the reduction of insomnia, Model 2 was run. The results indicate that CBT-I has a

significant effect on the reduction of participants' insomnia symptoms (β = -.75, $p < .001$). Moreover, CBT-I also has a significant effect on enhancing sleep efficiency (β = .44, $p < .01$). The effect of CBT-I on insomnia symptoms becomes stronger when participants' insomnia symptoms at baseline are higher (β = -.27, $p < .001$). The predictive effect of baseline insomnia symptoms on the relation between CBT-I and insomnia symptoms is plotted in Figure 1. The red line represents the treatment group (internet treatment and group therapy). It can be seen that the higher baseline insomnia symptoms, the more negative the prediction line becomes which equals more effectiveness of CBT-I. However, the opposite effect was found for the positive relation between CBT-I and sleep efficiency. The effectiveness of CBT-I on sleep efficiency becomes weaker when participants' sleep efficiency at baseline is higher (β = -.38, $p < .001$). The predictive effect of baseline sleep efficiency on the relation between CBT-I and sleep efficiency is plotted in Figure 2. There is evidence to support acceptance of Hypothesis 1 when treatment of insomnia is measured through HSDQ. However, in contrast, when insomnia is measured through sleep efficiency, Hypothesis 1 cannot be accepted.

Hypothesis 2 predicted a moderating role of baseline psychopathology symptoms on treating insomnia. In other words, the higher the baseline psychopathology symptoms the stronger the effect of CBT-I in treating insomnia. In order to test the hypothesis, Model 3 was run. The model shows a significant effect of CBT-I in reducing insomnia symptoms, (β = -.74, $p < .001$). However, the effectiveness of CBT-I on reducing insomnia symptoms becomes weaker when participants' baseline psychopathology symptoms are higher (β = .31, $p < .001$). The predictive effect of baseline psychopathology symptoms on the relation between CBT-I and insomnia symptoms is plotted in Figure 3. Second, Model 3 shows that CBT-I has a positive effect on enhancing sleep efficiency (β = .45, $p < .01$). However, in contrast to predictions, the effect of CBT-I on sleep efficiency gets weaker when participants' baseline psychopathology symptoms are higher (β = -.18, $p < .05$). In other words, the effectiveness of CBT-I on sleep efficiency is reduced when participants have higher levels of baseline psychopathology symptoms. The predictive effect of baseline psychopathology symptoms on the relation between CBT-I and sleep efficiency is plotted in Figure 4. There is no evidence to support Hypothesis 2. Moreover, the opposite is indicated by the results. Model 4 was run to test the robustness of the findings. The results indicated that interaction terms remained robust when entered simultaneously in regression analyses.

In all of the models listed in Table 2, no significant interacting effects of the control variable gender was found. However, it was shown that age does play a role when it comes to

enhancing sleep efficiency (β = -.19, p < .01). In other words, CBT-I's effectiveness on enhancing sleep efficiency is higher for younger participants.

Table 1

Descriptive Statistics: Independent Variables and Control Variables

	Non- Treatment (n= 39)		Treatment (n = 77)	
	M	*SD*	*M*	*SD*
Age	15.46	1.70	14.25	3.21
BIS (HSDQ)	3,58	.63	3.53	.55
BIS (SE)	80.30	13.13	82.23	7.61
BPS	1.5	1.59	.97	1.35
HSDQ				
T_1	3.58	.63	3.53	.55
T_2	3.74	.62	2.93	.66
SE				
T_1	80.30	13.13	82.23	7.61
T_2	81.56	12.66	88.25	6.98

Table 2

Results of Hierarchical Regression Models Predicting lowering of Insomnia Symptoms (HSDQ) and enhancement of Sleep Efficiency (SE)

	Model 1		Model 2		Model 3		Model 4	
	HSDQ	SE	HSDQ	SE	HSDQ	SE	HSDQ	SE
CBT- I	-.75***	.44**	-.74***	.50***	-.74***	.45**	-.72***	.50***
Gender	-.04	-.25	.02	-.152	-.04	-.26	.02	-.14
Age	-.01	-.10*	.05	-.12**	-.02	-.10*	.04	-.19**
CBT –I x BIS			-.17	-.21*			-.13	-.20*
treatment			-.27***	-.38***			-.40***	-.43***
CBTI- I x BPS					-.11	.12	-.09	.09
treatment					.31***	-.18*	.42***	-.24**
Constant	.67	1.42*	-.25	1.63*	.87	1.37*	-.15	1.46*

Notes. 232 observations of 116 individuals.

* $p < 0.05$, ** $p < 0.01$ *** $p < 0.001$, two-tailed tests.

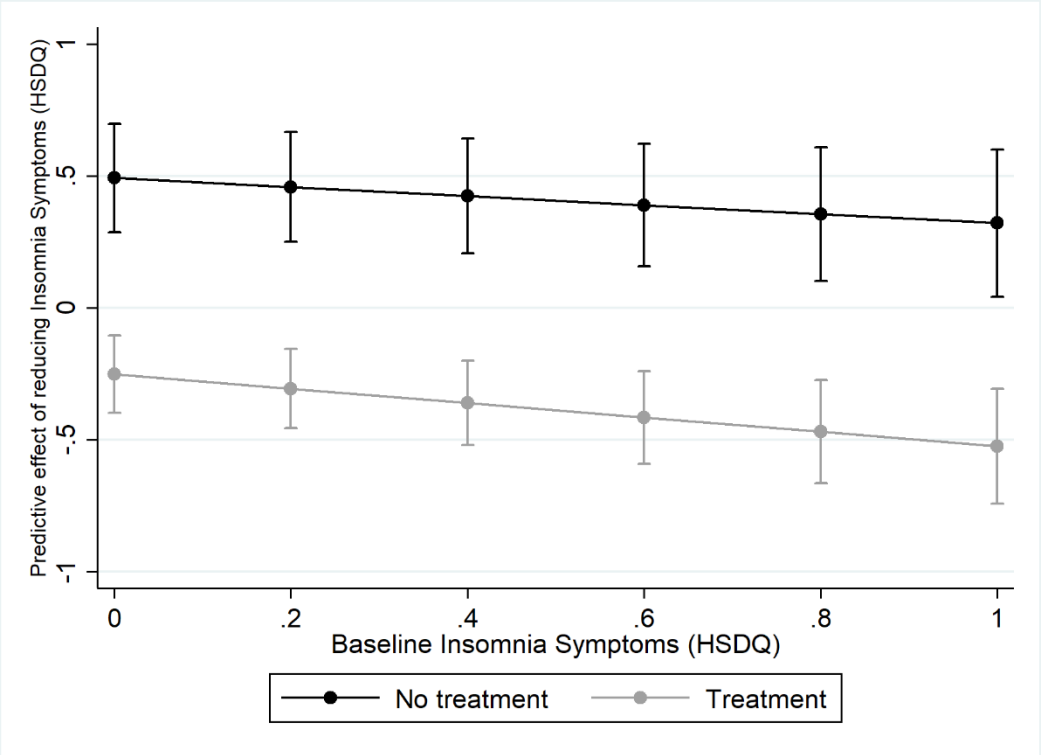

Figure 1. Interaction effect of baseline insomnia symptoms and CBT- I on lowering HSDQ

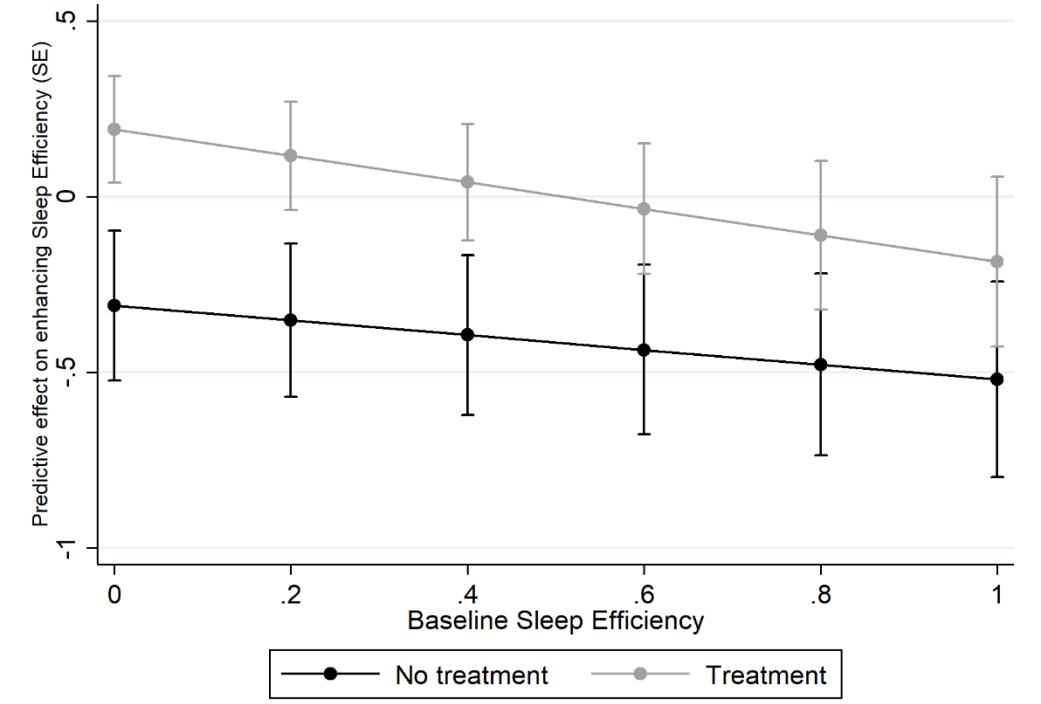

Figure 2. Interaction effect of baseline sleep efficiency and CBT- I on enhancing SE

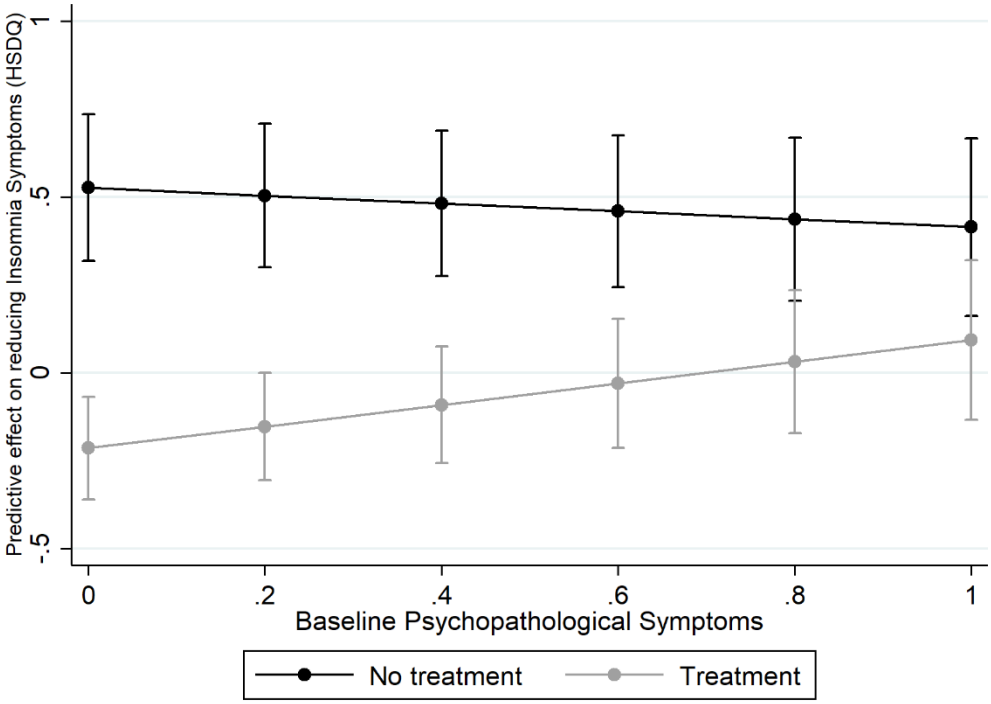

Figure 3. Interaction effect of baseline psychopathology symptoms and CBT- I on lowering HSDQ

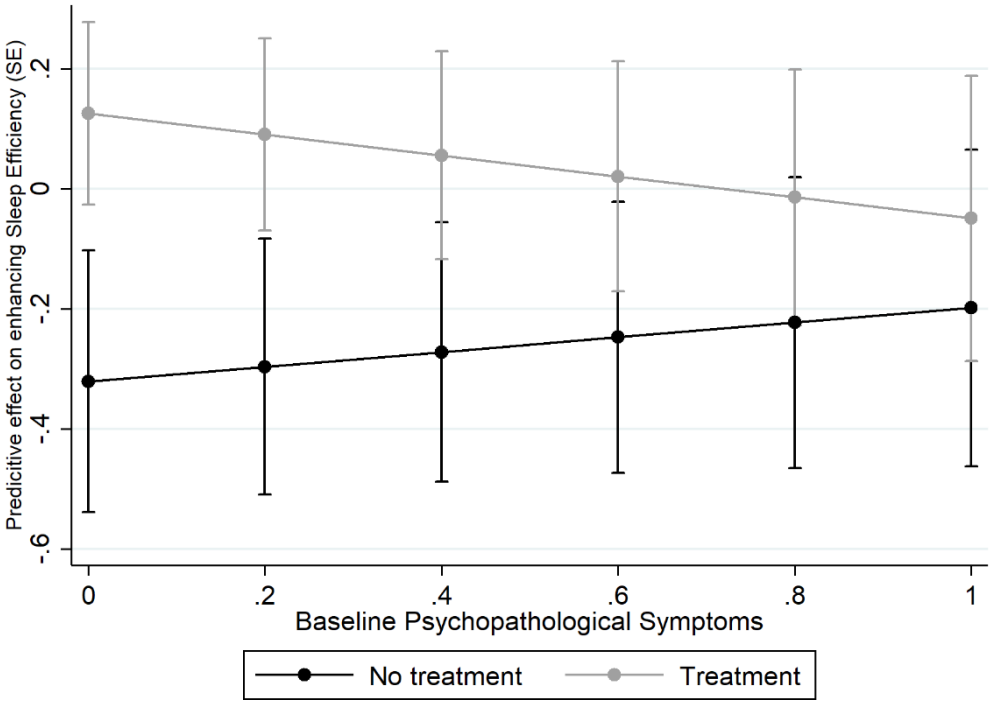

Figure 4. Interaction effect of baseline psychopathology symptoms and CBT- I on enhancing SE

Secondary Analysis

In order to explore the robustness of the above-mentioned moderation effects – and therefore testing H_1 –, it was chosen to conduct the same hierarchical regression analysis by adding baseline insomnia level of the other sleep variable. In other words, it was tested whether baseline insomnia symptoms moderate CBT-I's effectiveness on sleep efficiency and whether baseline sleep efficiency moderates effectiveness on insomnia symptoms. Results show that baseline insomnia symptoms significantly moderate the effectiveness on sleep efficiency (β = .16, p < .10). Therefore, higher levels of baseline insomnia symptoms predict greater effectiveness on sleep efficiency compared to lower baseline scores. This finding supports the robustness of baseline insomnia symptoms as a moderator in the treatments' effectiveness. However, a moderating effect of baseline sleep efficiency on effectiveness on insomnia symptoms cannot be found which differs from the above-mentioned moderating effect. To conclude, these secondary analysis support the hypothesis 1 but only for baseline insomnia symptoms; effectiveness is higher when participants show a higher level of insomnia symptoms at baseline.

Discussion

The current study aimed to investigate moderation of efficacy of CBT-I for adolescents with insomnia by baseline levels of insomnia symptoms, sleep efficiency, and psychopathology. The results of the current study indicate that CBT-I is more effective on lowering insomnia symptoms for participants showing higher baseline insomnia symptoms and lower baseline psychopathology symptoms. The efficacy of the intervention on enhancing sleep efficiency is higher for participants with higher baseline insomnia symptoms, lower baseline sleep efficiency and lower baseline psychopathology symptoms.

While the moderating effects of baseline psychopathology symptoms and baseline insomnia symptoms are consistent for both outcome variables, this is not the case for baseline sleep efficiency. Moderating properties vary per outcome variable. Effectiveness on increasing sleep efficiency was more effective for participants with lower baseline sleep efficiency which is in line with the results by Chan et al. (2019), McCrae et al. (2019), and Morin (2004). This result can be explained by the set-up of the intervention. Participants with sleep efficiency below 85 % at baseline were asked to reduce time in bed to their total sleep time where a minimum of 6h was set. Participating adolescents with a sleep efficiency ranging from 85 to 90 % were advised to keep the time they spent in bed. Therefore, the intervention itself took baseline differences into account. In other words, participants with lower baseline sleep efficiency took an extra step in building a sleeping schedule. This may explain why those

participants showed greater improvement in enhancing sleep efficiency. However, for the outcome variable insomnia symptoms no interaction effects were found. This unexpected finding can be explained by having a closer look at the construct of insomnia and how it is measured. Sleep efficiency indicates the time a participant sleeps while spending time in bed. Insomnia symptoms measured by the HSDQ, however, represent subjective insomnia symptoms resulting from insufficient sleep, such as sleepiness, mood, concentration and memory problems, or loss of energy. This can also be seen in the items listed in the appendix. Therefore, these two measurements represent two aspects of insomnia; sleep efficiency stands for the quantity and fragmentation of sleep a participant gets while spending time in bed, and the insomnia symptoms score represents the level of subjective feelings of sleep-related distress due to insomnia. This idea is supported by Pilcher, Ginter, and Sadowsky, B. (1997). In their study, college students were asked to keep a sleep log for seven days combined with questionnaires about mental well-being. The results showed that sleep quantity and quality are two distinct constructs and are not necessarily correlated. In addition to that, the results indicated that sleep quality is associated with well-being while sleep quantity is not. This could explain why baseline sleep efficiency had no effect on insomnia symptoms (i.e. insomnia-related well-being) while insomnia symptoms at baseline did have an effect.

The moderating effect of pre-intervention insomnia symptoms on insomnia symptoms and sleep efficiency is robust for both outcome variables; participants with higher baseline insomnia symptoms showed greater improvement. This is comparable to the results by Chan et al. (2019) and McCrae et al. (2019) and supports the suggestion that baseline insomnia plays a role in CBT-I's effectiveness by Morin (2004). The following explanation can be offered. High levels of insomnia-related distress trigger motivation to change – called hedonic motivation (Higgins, 1997). In other words, participants with more insomnia symptoms at baseline are more motivated to change by engaging and identifying with the content of the treatment. Possibly, participants were fully consciously involved during the sessions and practiced consistently outside of therapy. Additionally, it is possible that participants experiencing higher subjective suffering at baseline took sleeping schedules seriously, for example they did not take naps during the day, so that sleep efficiency improved significantly more than in participants showing less insomnia-related distress at baseline.

The moderating effect of baseline psychopathology symptoms is consistent across outcome variables; efficacy of CBT-I is higher for people with lower levels of psychopathology – i.e. better mental health. This contradicts the findings of Blake et al. (2018). They found that participating adolescents with higher anxiety and depression levels showed greater recovery.

Moreover, the opposite is found in the current study. Comorbid mental disorders such as anxiety, ADHD or depression interfere with CBT-I's effectiveness. For example, adolescents with ADHD find it challenging to stick to routines and everyday requests (American Psychological Association, n.d.). This could influence building and maintaining a night time schedule. Also, adolescents suffering from comorbid depression or anxiety might experience arousal and cognitive activities such as rumination or worrying (e.g. Bélanger, Morin, Gendron, & Blais, 2005; Dahl, 2002; Dahl, & Harvey, 2007) which could delay sleep onset or interrupt sleep duration. Since the relationship between insomnia and psychopathology is bidirectional (e.g. Alcaro et al., 2017), it is possible that psychopathology has an influence on insomnia so that treating mere insomnia is not enough to alleviate sleep problems if symptoms of other mental health problems are present.

An unexpected effect was found in the control variable age. Results indicated that older participants showed less effectiveness of CBT-I in enhancing sleep efficiency. Possibly, older adolescents find it more difficult to follow a sleeping schedule. Carskadon (2011) demonstrated that the difference between hours of sleep adolescents get during school nights and weekend nights becomes greater the older adolescents are. In other words, older adolescents sleep much longer in the weekend than during the week, which might give an explanation for the found effects. Also, at a certain point adolescents start going out for parties, for example in clubs. This happens usually during night time and occurs more often in older Dutch adolescents than in younger ones (Centraal Bureau voor de Statistiek, 2003). This, again, might interfere with building consistent sleep patterns and schedules and can provide a possible explanation for the moderating effect of age on enhancing sleep efficiency. Moreover, the intensity of parental control and monitoring decreases as adolescents become older (Keijsers and Poulin, 2013). According to (Pieters et al., 2014), less parental control is, for example, associated with increased pre-sleep media use which in turn could reduce sleep quality and quantity. Therefore, older adolescents may experience more autonomy when it comes to determining sleep times compared to younger adolescents. Also, parents were aware of the CBT-I intervention and therewith could, using their parental control, encourage younger adolescents to stick to sleep schedules.

Practical Implications

Next to the above mentioned theoretical suggestions, this study offers practical implications as well. Adolescents that experience more insomnia-related discomfort show greater effectiveness. Therefore, CBT-I is definitely applicable to clients with high levels of insomnia-related distress.

Also, adolescents who suffer from comorbid disorders may need further targeted support when applying this intervention. One possibility would be to integrate additional content. An example intervention including anxiety-specific modules can be found in Blake et al. (2018). Other modules could contain trainings in distraction, systematic desensitization, self-instruction, or cognitive restructuring (Greco, Blackledge, Coyne, & Ehrenreich, 2005) in order to reduce psychopathological suffering.

Limitations

Apart from the fact that this was the first study to investigate nuances in effectiveness of CBT-I for adolescents, this study came with limitations. First, the current paper put all participants receiving a treatment (internet-based or group therapy) into one condition. This, however, might lead to a loss of possibly valuable information. Although de Bruin et al. (2015; 2018) reported no differences on a 0.05-level between the internet- and group-therapy conditions, there were small differences between those two conditions. For example, sleep efficiency from sleep logs showed a slightly larger increase from post-intervention to follow-up measurement ($\beta = 0.19$) for the group therapy condition. Although follow-up is not a part of the current study, it still shows possible differences due to mode of delivery. Therefore, one limitation of the current study is that treatment conditions are not taken into account, and it is recommended to do so in future research.

The second limitation is based on the descriptives of the samples. Age in the treatment group showed more variation than the control group ($M = 14.25$, $SD = 3.21$ and $M = 15.46$, $SD = 1.70$). This is not necessarily interfering with the hierarchical regression analysis so that remaining results remain robust. However, valuable information about age differences are possibly lost due to less variation in the control group. This is especially important when looking at the effect the control variable age has.

Future Research

The current study explored the moderating effect of two essential aspects of insomnia. Future research should keep using these two parameters of insomnia as an evaluation tool of sleep interventions. The current study shows that mechanisms within those aspects can differ and cannot necessarily be generalized to the other variable. This suggestion is similar to the request by Pilcher et al. (1997). They emphasized the need to complement quantitative measurements such as sleep efficiency with measurements of depth of sleep, feeling rested, and general satisfaction with sleep. Accurate evaluations of sleep interventions can lead to more precise recommendation and appliance. Also, it can spot patients that possibly need more targeted support.

Conclusion

Insomnia is the most common sleep disorder among adolescents (Donskoy, & Loghmanee, 2018) and has severe mental and physiological consequences (e.g. Merdad et al., 2017). Thorough literature review reveals that CBT-I is an effective treatment in treating insomnia (e.g. de Bruin et al., 2015). Yet, only one study is found that explores participant characteristics in adolescents that moderate effectiveness. According to Blake et al. (2018), adolescents with insomnia benefit more from cognitive behavioral sleep interventions when psychopathological distress is high. The present study extends this finding by incorporating more measurements of psychopathology. Also, baseline insomnia is tested as a possible moderator. It was hypothesized that higher levels of baseline psychopathology symptoms and higher levels of baseline insomnia predict greater effectiveness. There is evidence to support acceptance of H_1 when baseline insomnia is measured through HSDQ. However, in contrast, when insomnia is measured through sleep efficiency, H_1 cannot be accepted. Furthermore, H_2 cannot be accepted either. Moreover, results of the current study indicate the opposite. However, when embedding current findings into scientific research, this difference can be explained. HSDQ measures subjective levels of insomnia-related distress while sleep efficiency represents a quantitative measurement. Interestingly, interpreting results based on this distinction leads to cohesive results. It appears that adolescents experiencing higher levels of insomnia-related distress are more responsive to CBT-I. Furthermore, participants showing higher levels of psychopathology at baseline were less responsive to CBT-I. It is advised to complement CBT-I with psychopathology-specific modules as in Blake et al. (2018) in order to enhance responsiveness to the treatment for adolescents with high BPS. Future research is needed to explore this topic in more detail. For example, sleep quality such as sleep depth should be included in future studies in order to assess the influence of these factors as well. Also, it would be interesting to pair sleep logs with actigraphy measurements in order to rule out any bias by self-report and to provide even more robust findings.

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Appendix

Items of the Insomnia Scale (HSDQ)

[Dutch]

Ik heb overdag last van vermoeidheid.

De kwaliteit van mijn slaap is slecht en ik voel me 's morgens dan ook niet uitgerust.

Overdag verricht ik handelingen 'op de automatische piloot', zonder me die later te herinneren.

Ik maak me zorgen over de gevolgen van mijn slechte slaap (bijvoorbeeld voor mijn gezondheid).

Vooral na een slecht nacht heb ik overdag last van 1 of meer van deze gevolgen: vermoeidheid, slaperigheid, slecht humeur, zwakke concentratie, geheugenproblemen, gebrek aan energie.

Ik krijg onvoldoende slaap, ondanks dat ik volop gelegenheid heb om lang te slapen.

Omdat ik weinig slaap krijg, functioneer ik overdag minder goed.

Ik heb last van tijdelijk geheugenverlies ('black-outs').

[Translated in English]

During the day, I suffer from sleepiness.

My sleep quality is bad and I don't feel refreshed in the morning.

During the day, I am on "autopilot", so that I cannot remember my behaviour afterwards.

I worry about consequences of insufficient sleep (for example for my health).

Especially after having bad sleep, I experience one of these consequences the following day: fatigue, sleepiness, bad mood, reduced concentration, memory problems, loss of energy.

I don't get sufficient sleep despite having the chance to sleep for a long time.

Because of insufficient sleep, I experience reduced funtioning during the day.

I suffer from temporary memory loss ('black-outs').