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Evaluating the Effectiveness of Internet-Based Treatment for Insomnia

Literature thesis

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SUMMARY

One of the most prevalent psychological disorders is insomnia, which encompasses all conditions related to difficulties falling or staying asleep. A relative new intervention for insomnia is Internet-based treatment, an online psychological treatment based on the principles of *cognitive behavioral therapy for insomnia* (CBT-I). Currently, a variety of CBT-I online treatments for insomnia are available, however it is uncertain for healthcare providers which treatment reaches most optimal outcomes. Therefore, by conducting a systematic literature review, this study aimed to explore: 1) what the influence is of different online treatment characteristics (e.g. duration, degree of personal guidance, coverage of CBT-I content) is in reducing insomnia symptoms, and 2) whether online treatment is effective in reducing sleep medication usage. After abstract and full text screening, 17 randomized controlled trials published between 2004-2018 were included in the review. Data extraction, analysis and quality assessment was completed. Results show that internet-based treatment for insomnia reported is overall effective in improving sleep efficiency and decreasing insomnia severity. Including all CBT-I components in online treatment results in better outcomes. Additionally, a treatment duration of 6-8 weeks and offering personal support besides online treatment (e.g. sending motivational messages and reminders and reviewing homework) are associated with reduced insomnia symptoms. Interestingly, treatment without personal guidance seems to create clinically good effects as well. Finally, there was no ambiguous answer whether online treatment is effective in reducing sleep medication usage, nevertheless overall small improvements have been reported. These results suggest that duration, personal guidance, and degree of coverage of CBT-I modules are of influence on treatment outcomes and should be considered when prescribing online treatment. The theoretical, practical and methodological implications are discussed.

One of the most overlooked and undertreated psychological disorders in current society is insomnia, encompassing all condition relating to having difficulties with falling or staying asleep (NHG-werkgroep Slaapproblemen en slaapmiddelen, 2014). In the Netherlands, insomnia prevalence rates are estimated from 20-30% among adults and are often caused due to stress, tension and bad sleeping habits (Roth et al., 2011). Despite the high prevalence rate, only a small group of them seeks help, due to high treatment costs and perceived barriers to visit a doctor (Matthews, Arnedt, McCarthy, Cuddihy, & Aloia, 2013; NHG-werkgroep Slaapproblemen en slaapmiddelen, 2014). The low treatment rate is alarming as numerous studies have substantiated the negative consequences of having insomnia has on health and society. Insomnia reduces cognitive performance in the short term and is thereby considered as one of the main causes of serious traffic accidents (Garbarino et al., 2017). On long term, insomnia is associated with a substantiated risk on developing depression, obesity, diabetes mellitus 2, heart failures and ultimately a significant shortened life expectancy (Baglioni et al., 2011; Javaheri & Redline, 2017; Kaleth, Edwards, & Butner, 2013). Additionally, it rises societal costs due to decreased productivity or absence at work (Roizen, 2010). Proper accessible treatment of insomnia is therefore a public health issue which need to be addressed.

Treatment for insomnia can be broadly categorized in two classifications, namely a pharmaceutical and a psychological approach. Up to recently, insomnia has been mainly treated by prescribing pharmaceuticals such as benzodiazepines (NHG-werkgroep Slaapproblemen en slaapmiddelen, 2014). Studies substantiated the short term effectiveness of treating insomnia with pharmaceuticals (Buscemi et al., 2007). However, these pharmaceuticals comes along with a variety of side effects, such as concentration and coordination problems (Buscemi et al., 2007). Furthermore, sleep medication such as benzodiazepines are known for their addictive effects, as a consequence a substantial number of patients becomes dependent on this type of medication (Buscemi et al., 2007). Therefore, in updated guidelines developed for Dutch general practitioners, it is advised to prefer psychological interventions over pharmaceuticals (NHG-werkgroep Slaapproblemen en slaapmiddelen, 2014).

Psychological therapy for treating insomnia is based on components of cognitive behavior therapy for insomnia (CBT-I). CBT-I is a psychological method which aims to improve behavior and habits regarding to sleep by changing thoughts, attitudes and habits (Trauer, Qian, Doyle, Rajaratnam, & Cunnington, 2015). It is indicated that CBT-I is also effective for sleep-medication adherent patients to constructively reduce insomnia related symptoms, thereby also reducing their need to use sleep medication (Kaldo et al., 2015). Generally, CBT-I exist of five different elements, namely: 1) stimulus control, 2) sleep hygiene education, 3) sleep restriction, 4) relaxation training and 5) cognitive therapy (Trauer et al., 2015). Stimulus control aims to create a positive mental association between the bedroom and sleeping (Trauer et al., 2015). Sleep hygiene education focusses on improving the sleeping environment and educate persons which habits influences sleep patterns (Trauer et al., 2015). Sleep restriction aims to fall asleep more quickly which is established by minor sleep deprivation and as a consequence reducing the time spend in bed awake (Trauer et al., 2015). Relaxation training teaches how to reduce stress and mental alertness which forms a potential barrier for falling asleep (Trauer et al., 2015). Finally, the goal of cognitive therapy is to restructure unhelpful thoughts and beliefs about their condition (Trauer et al., 2015). These interventions have been proven to be effective in treating insomnia (Riemann & Perlis, 2009). However, psychological therapy in person has some drawbacks: it often requires person-to-person meetings which are perceived as time-consuming and costly. As a consequence the adherence rate of is considered low (Matthews et al., 2013).

A way to overcome these barriers is by using internet-based platforms to deliver psychological treatment. Internet-based therapy for treating insomnia is easier to access and has lower costs compared to therapy in person (De Bruin, van Steensel, & Meijer, 2016). Online treatment for insomnia includes one or more elements of CBT-I applied in real-life psychological treatment and mainly lasts between one to two months (Zachariae, Lyby, Ritterband, & O'Toole, 2016). These internet-based treatments are usually structured in such a way that each week a new CBT-I component is introduced. Additionally, some treatments are offered in combination with professional guidance (e.g. Lancee, van den Bout, Sorbi, & van Straten, 2013). A growing body of literature indicate that internet-delivered therapy based on CBT-I principles are effective in treating insomnia (Cheng & Dizon, 2012; Zachariae et al., 2016). Due to the benefits such as accessibility and low-costs, online treatment for insomnia has become more popular and is currently in a wide range available on the market.

Consequently, the great variety on treatments available on the market let healthcare professionals questioned which one is most effective. The current online insomnia treatment offers on the market mainly vary in content; some online interventions only include a smaller sample of the five CBT-I components whiles others offer a broader range of CBT-I modules. Besides, previous studies also differ in the duration of the online treatment or in the presence of clinical personal guidance (e.g. sending motivational messages, reviewing homework) they include. Finally, it is indefinite whether online treatment may form a good solution to all patients group; specifically, it particularly questioned whether internet-based treatment for insomnia may form a potential solution to help reducing sleep medication usage of patients. To date no studies are present in current have been found investigating specifically the influence of treatment characteristics on the efficacy of online interventions for insomnia. These different treatment characteristics (including presence/absence of CBT-I elements, degree of personal guidance, duration of intervention) varies per study and are likely to influence the effectiveness of online treatment. Additionally, it is questioned if online treatment is also beneficial for the specific patient group of sleep-medication adherent patients to help reducing their medication usage. Understanding which factors influence the efficacy of online treatment for insomnia will help healthcare professional to be better able to advice patients with insomnia which type of online treatment for insomnia suits the patient the best. Therefore, the specific objective of this study was to 1) evaluate how the different treatment characteristics (coverage of CBT-I components, duration, presence of personal guidance) influence the effectiveness 2) investigate whether online treatment for insomnia is effective in reducing sleep medication usage among patients.

The following questions were developed to guide this review:
- What is the influence of online treatment characteristics (coverage of CBT-I modules, duration, presence of personal guidance) in reducing insomnia symptoms in adults?
- To which extent is online treatment effective in reducing sleep medication usage among insomnia patients?

2 METHODOLOGY

2.1 STUDY DESIGN

A systematic literature review was conducted to review recent literature about internet-based treatment for insomnia. Conducting a systematic review has the benefit to offer a comprehensive overview of current literature on this topic. In this study, the systematic review offers the opportunity to gain insight into the effectiveness of different types of internet-based treatment for insomnia for adults. The review was written conform the Prisma guidelines to ensure internal validity. Prisma guidelines are worldwide accepted guidelines developed for performing systematic reviews of meta-analysis, it ensures clarity and transparency of the performed search (Liberati et al., 2009). Since a systematic review was written, PRISMA guidelines applicable to meta-analysis were not used in this literature review.

2.3 STUDY SELECTION

Before the search was performed, in- and exclusion criteria were developed for the selection of eligible articles. In order to select relevant literature for the systematic review, a PICOS approach (Patient, Intervention, Comparison, Outcome Study design) was applied to guide the search. A PICOS approach is a commonly used method used in evidence-based medicine, known for its effective way to search for relevant articles (Methley, Campbell, Chew-Graham, McNally, & Cheraghi-Sohi, 2014). This method is also recommended according to the PRISMA guidelines for writing a systematic review or meta-analysis. The following PICOS methodology was developed:

- **P:** Adults (18 years and older) with insomnia or difficulties falling or staying asleep. Studies including children below 18 years were excluded since treatment guidelines in this group varies from adults. As well as specific target groups (patients diagnosed with disorders such as cancer or tinnitus) were excluded since the cause of insomnia and specific treatment may vary in these target groups.
- **I:** An online intervention delivered over the internet, containing one or more elements of cognitive behavioral therapy (i.e., sleep education, stimulus control, sleep restriction, relaxation, sleep hygiene, cognitive exercises)
- **C:** Adults included in the study which were assigned to a non-online CBT-I based condition
- **O:** Both pre- and post-measures regarding to sleep, including at least one of the primary outcome measures of Insomnia severity or Sleep Efficiency. Insomnia severity index is worldwide the most used and validated tool to measure changes in insomnia severity. Sleep efficiency represents the effective sleeping time and is considered as an important measure to gain insight in changes in sleeping patterns and is widely used in studies and accepted in research area of sleeping studies. Earlier systematic reviews conducted on this topic included same primary outcome measures (Cheng & Dizon, 2012; Zachariae et al., 2016). Reporting the measures Sleep Efficiency and Insomnia Severity Index allows to compare results both internally with comparing the different results of included studies as well as externally with earlier published articles. Secondary outcome measures which were reported are the Total Sleep Time, Sleep onset Latency, Wake Time After Sleep Onset, Sleep Quality and Number of Nocturnal awakenings. An elaborated description and interpretation of the primary and secondary outcome measures is displayed in table 1.

- **S:** Peer-reviewed articles using a Randomized Controlled Trial study design. RCT were selected. This type study design is known for its high level of evidence (Burns, Rohrich, & Chong, 2011).

Table 1 Description of primary and secondary outcome measures

Measure	Abbreviation	Minimum and maximum value	Interpretation
Primary outcome measures			
Insomnia severity index	ISI	0-28 score	ISI is calculated by the sum of seven sleep related questions, using a 5 point-Likert scale. A score of 0-7 indicates no clinically significant insomnia, 8-14 subthreshold insomnia, 15-21 moderate insomnia and 22-28 severe insomnia.
Sleep Efficiency	SE	0 - 100%	The percentage of time in bed that is spent sleeping. A value above 85% indicated clinically normal sleep. Values below 85% suggest clinical insomnia.
Secondary outcome measures			
Total sleep time	TST	0 – 24 hours	The number of hours slept in a 24-hour period
Sleep onset Latency	SOL	0 minutes	The time, expressed in minutes it takes to fall asleep
Sleep Quality	SQ	0 – 4 Score	Measured on a 5-point scale from very poor to very good.
Nocturnal Awakenings	NWAK	0 times	Number of times a person awoke during the night

2.2 DATA COLLECTION

The systematic search was conducted in the following two databases: PubMed and Scopus. The usage of more than one database decreases the chance of missing relevant articles, which increases the quality of the review (Bramer, Rethlefsen, Kleijnen, & Franco, 2017). PubMed is the most common used search base for medical and psychological disorders (Bramer et al., 2017). Scopus is known to be the largest abstract and citation database of peer-reviewed literature, offering articles on a broad range of topics (Bramer et al., 2017). Additional relevant articles which were not found in MEDLINE could therefore be identified by SCOPUS.

The first step of the systematic search was performing an orienting search in google scholar to become more familiar with the topic. Next, based on the key concepts of the research question, a search strategy was developed which was inspired by earlier systematic reviews on this topic to ensure a good qualitative search (Cheng & Dizon, 2012; Zachariae et al., 2016). The search was performed at 16 November 2019. This search strategy covers three main concepts and their respective synonyms or Mesh terms: (insomnia OR Sleep Initiation and Maintenance Disorders) AND (internet OR internet-delivered OR web OR web-based OR online OR computer OR digital) AND (Treatment OR Intervention OR Therapy OR Self-Help). Besides, to further define the search, exclusion criteria were developed. Studies were excluded when not published in the Dutch or English language. Furthermore, since the first reported online intervention for insomnia was published in 2004 the searching criteria was narrowed to the period of 2004 to 2018 (Ström, Pettersson, & Andersson, 2004). Besides, backward snowball sampling was used by scanning literature lists of the articles included in the review for any additionally articles which were missed in the search to ensure maximum coverage of articles in the literature review. The specific searching syntax per database is displayed in table 2.

Table 2 Searching syntax for the databases PubMed and Scopus

PubMed (N=191)	((("sleep initiation and maintenance disorders" OR insomnia)) AND (internet OR internet based OR internet delivered OR web OR web-based OR online OR digital OR computer*)) AND (intervention OR treatment OR self-help OR therapy) Sort by: PublicationDate Filters: Randomized Controlled Trial
Scopus (N=320)	TITLE-ABS-KEY (INSOMNIA OR "SLEEP INITIATION AND MAINTENANCE DISORDERS ") AND TITLE-ABS-KEY (INTERNET OR INTERNET-BASED OR INTERNET-DELIVERED OR WEB OR WEB-BASED OR ONLINE OR DIGITAL OR COMPUTER) AND TITLE-ABS-KEY (INTERVENTION OR TREATMENT OR SELF-HELP OR THERAPY) AND TITLE-ABS-KEY ("RANDOMIZED CONTROL*" OR "RANDOMISED CONTROL*" OR RCT)) AND (LIMIT-TO (DOCTYPE , "AR")) AND (LIMIT-TO (LANGUAGE , "ENGLISH"))

2.3 DATA EXTRACTION AND ANALYSIS

A two-phased screening method was used to extract relevant articles. Before the search was performed, duplicate articles which were found in both Scopus and Medline were removed from the search. The first-phase of the search consist of screening articles based on the developed inclusion and exclusion criteria on title and abstract. To select relevant studies, all titles and abstracts were screened to evaluate whether they were included based on the formulated inclusion criteria. In the secondary stage of the study selection, remaining articles were assessed by full-text screening. This data was re-examined to identify the final list of included articles. After the final list of articles was composed, data about study characteristics was extracted from the included articles regarding: study design, population and country; treatment arms, presence of different CBT components of applied intervention, the degree of personal guidance offered in the intervention group, the duration of the intervention, control condition. Besides, results of articles were derived by extracting significance levels, pre- and post-measures and average improvement on primary and secondary outcome variables. Finally, when available, information about the medication usage pre- and posttreatment was derived from included articles to assess the effect of online intervention usage on tempering sleep medication usage among participants.

2.4 QUALITY ASSESSMENT

The methodological quality of included studies was assessed based on journal impact factors of each included article. Journal impact factors were derived from ResearchGate. An impact factor above 1,0 indicates a sufficient level of quality. Results of the journal impact factors were reported in the result section.

3.1 STUDY SELECTION

The study selection method is described in figure 1. In total, the search identified in 441 articles in the databases PubMed and Scopus. After removing duplicates, 345 articles were screened according to the developed inclusion and exclusion criteria for title and abstract. After the first screening, 46 articles were fully screened for eligibility. During the secondary screening, one study was included by screening reference lists. Main reasons for non-eligibility during the secondary screening were not using a of a randomized controlled trial study design and using other primary outcomes which were not sleep-related. In total, 17 peer-reviewed randomized controlled trials evaluating the effectiveness of online interventions designed for treating insomnia published between 2004 and 2018 were included in the literature review, presented in table 1.
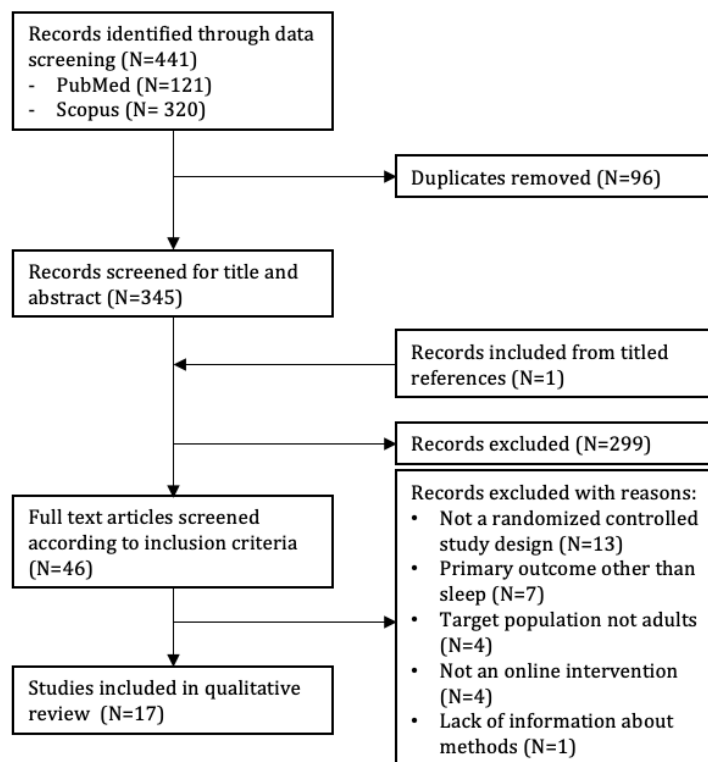

Figure 1. Prisma study inclusion flowchart

Table 1 represents an overview of the characteristics of the included studies. All included studies applied a RCT design as described in the inclusion criteria in the method section. A majority of the studies took place in the Netherlands(N=6), Sweden (N=4) or the United States (N=3). Other countries in which studies are conducted are Canada, Germany and the United Kingdom. The sample size of the included studies varied between 45 participants reported in Ritterband et al., (2009) and 623 participants in the study of Lancee et al., (2012).. In addition, different outcome measures for sleep were reported across the included studies. The most reported measures were the measures Sleep Efficiency, reported in 14 studies, and Insomnia severity index reported in 15 studies. Table 2 represents an overview of the reported outcome measures pre- and post-treatment per included study. Furthermore, regarding to quality assessment all included studies reported a journal impact factor above 1, indicating a sufficient level of quality of the reported articles

Almost all studies applied an intervention which was delivered by an online platform, with one exception of Horsch et al., (2017) which made use of a mobile application format. Generally, the online interventions were designed in such a way that each week a new component of CBT was introduced. Concerning the duration of the delivery of the intervention a majority of the interventions were offered over a period of 6 weeks. Exceptions were the studies of Ström et al., (2004) and Vincent & Lewycky, (2009) which applied a 5 week format. Furthermore, the studies of Blom et al., (2015, 2016) and Kaldo et al., (2015) offered an intervention with a 8 week duration.

Besides duration, the degree of personal guidance differs across included studies. Nine studies offered an active form of personal guidance, which includes getting (online) personal feedback, receiving motivational messages and having the opportunity to contact a professional clinician (Blom et al., 2015, 2016; Kaldo et al., 2015; Lancee et al., 2015, 2013, 2016; Ström et al., 2004; Thiart et al., 2015; Van Straten et al., 2014). Four studies offered a more passive way of personal guidance by sending motivational messages or reminders when it was noted that the participant did not complete a part of the treatment (Chow et al., 2018; Corine et al., 2017; Espie et al., 2012; Ritterband et al., 2009). Finally, four studies offered an online treatment without any personal involvement (Holmqvist et al., 2014; Lancee et al., 2012; Ritterband et al., 2017; Vincent & Lewycky, 2009).

Regarding to the content of the employed online interventions in the included studies, all interventions existed of multiple components based on cognitive behavioral therapy, including: stimulus control, sleep restriction, sleep hygiene and education, relaxation training and cognitive therapy. In the majority of the included studies, all components were covered in the online treatment (Blom et al., 2015, 2016; Espie et al., 2012; Holmqvist et al., 2014; Lancee et al., 2015, 2013; Ström et al., 2004; Thiart et al., 2015; Van Straten et al., 2014; Vincent & Lewycky, 2009). Moreover, five studies did not incorporate relaxation exercises in the employed online treatment (Chow et al., 2018; Kaldo et al., 2015; Lancee et al., 2012; Ritterband et al., 2009, 2017). Additionally, the studies of Horsch et al., (2017) and; Lancee et al., (2016) did not include the component stimulus control in the online intervention. Finally, the study of Horsch et al., (2017) did not incorporate any cognitive exercises.

To conclude, a large variety of control conditions were reported. Eight studies describes the application of a waiting-list control condition in which no intervention was employed (Horsch et al., 2017; Lancee et al., 2015, 2016; Ritterband et al., 2009; Ström et al., 2004; Thiart et al., 2015; Van Straten et al., 2014; Vincent & Lewycky, 2009). Besides, five studies applied an attenuated version of the CBT intervention, proposing a treatment in which educational material about insomnia was given and some common tips and trick about how to improve their sleeping behavior (Blom et al., 2015; Chow et al., 2018; Espie et al., 2012; Ritterband et al., 2017) .

Furthermore, a minority of the studies included a more active control intervention, offering CBT in a not-online platform such as face-to-face, by telemedicine or on paper (Blom et al., 2015; Holmqvist et al., 2014; Lancee et al., 2012, 2016). Lastly, Lancee et al., (2013) examined the influence of offering personal guidance besides online CBT-I; this study applied an online CBT treatment for insomnia without guidance as a control condition.

3.3 GENERAL EFFECTIVENESS OF ONLINE TREATMENT FOR INSOMNIA

Table 3 presents an overview of the results regarding to the main reported outcome measures Insomnia severity Index (ISI) and Sleep Efficiency (SE) per included study. To assess whether online treatment was effective in reducing insomnia symptoms, ISI scores were compared within the intervention group pre- and post-treatment. All studies which included ISI measures, reported a significant decline in insomnia symptoms pre-post treatment within the online intervention condition (Blom et al., 2015; Chow et al., 2018; Holmqvist et al., 2014; Horsch et al., 2017; Lancee et al., 2015, 2016, Ritterband et al., 2009, 2017; Thiart et al., 2015; Van Straten et al., 2014; Vincent & Lewycky, 2009). A closer look at the results shows that in all included studies pre-treatment ISI scores could be categorized as 'moderate insomnia'. Pre-Treatment ISI Scores variated between the lowest score of 15,7 reported by Ritterband et al., (2009) and a maximum score of 18,7 reported in the study of Holmqvist et al., (2014). Interestingly, post treatment all reported ISI scores were declined to the level of 'subthreshold insomnia' varying between a score of 6,6 by Ritterband et al., (2009) to an ISI score of 13,5 reported by Holmqvist et al., (2014). These results indicate that, nevertheless the differences in treatment characteristics, all online interventions are, in some extent, effective in reducing insomnia symptoms.

Second, sleep efficiency scores were compared to gain insight in the effectiveness of online interventions in improving sleep. Pre-treatment sleep efficiency scores were in all studies below the 85% clinically insomnia level, variated within a range of lowest 63,2% sleep efficiency, reported in Espie et al., (2012) and highest 77,3% sleep efficiency in the study of Ritterband et al., (2009). Post-treatment, all studies significantly improved sleep efficiency score in the intervention group. Five studies reported a mean score above 85% sleep efficiency, indicating a clinically cure of the diagnosis of insomnia (Blom et al., 2015; Lancee et al., 2013; Ritterband et al., 2009, 2017; Thiart et al., 2015). Generally, reported post-treatment sleep efficiency score variated between lowest score of 78.1% in the study of Lancee et al., (2016) and highest reported score of 89.3 % in the study of Ritterband et al., (2009). Taken together, these results indicate that online interventions also are effective in improving the quality of sleep.

Finally, to gain further insight in the effectiveness of online interventions, the significance level of ISI and SE scores of the online intervention were compared with the reported control groups. There was a significant difference in treatment outcomes between online intervention and waiting list-conditions, with an advantage for the online intervention (Horsch et al. 2017, Lancee et a. 2015, Lancee et al. 2016, Thiart et al. 2015, Vincent et al 2009, Ström et al. 2004, Lancee et al 2012, Straten et al. 2014). Similarly, a comparison between SE and ISI scores pre- and post-treatment between online intervention and control condition patient education showed that online interventions reported significantly better treatment outcomes on SE and ISI (Chow et al. 2018, Ritterband 2017, Espie 2012, Kaldo 2015, Blom 2016). Interestingly, taken a closer look at differences in treatment outcomes between online treatment and other platforms (e.g. treatment on paper, telemedicine), no significant differences were found in treatment outcomes, indicating that delivering insomnia treatment online is just as effective as through other non-direct personal mediums (Holmqvist 2014, Lancee 2012). Finally, comparing treatment outcomes of online interventions with in person treatment, different results were reported across studies. Holmqvist et al. 2014 reported no significant difference in treatment outcomes between the online intervention group and the control group which received treatment in person. On the contrary, Lancee et al. 2016, reported a slightly significant better score on sleep efficiency for the control

condition which received face to face treatment compared with the online intervention group. Overall. These results suggest that online treatment is effective in treating insomnia compared to other control conditions, with one exception of treatment in person which may be slightly more effective.

3.4 INFLUENCE OF TREATMENT CONTENT

The first aim of the research question was to compare the difference in treatment components in the effectiveness in improving sleep in patients with insomnia. A level of homogeneity of content was present within this literature review; as described in the study characteristics all included studies reported to have incorporated at least the elements of sleep restriction and sleep hygiene education in their online interventions. In order to identify which components are important for reducing insomnia, the presence and absence of different treatment modules and their association with primary sleep parameters were compared with each other. Furthermore, since sleep hygiene education was present in all studies, effectiveness of this component was assessed by comparing intervention treatments with only sleep hygiene education which was used in the studies of as control group. Table 1 provides an overview of the presence of different modules per study.

Efficacy of including relaxation training
A majority of the studies reported to include relaxation exercises in the online intervention. Regarding to the outcome measures of ISI and SE, no major differences were reported between studies which did include a relaxation component compared to studies which did not include relaxation exercises. Deriving from these results, a clear benefit of incorporating relaxation exercises to reduce insomnia could not be identified in this analysis. Nevertheless, employing relaxation exercises in the online intervention also did not has any negative effect on the sleep related outcomes.

Efficacy of stimulus control
Only two studies of Horsch et al., (2017) and Lancee et al., (2016) did not incorporate stimulus control exercises in the online interventions. Comparing the studies of Horsch et al., (2017) and Lancee et al., (2016) with the remaining 15 studies which did include stimulus control exercises, differences in post-treatment measures were observed. The studies who did include stimulus control exercises reported slightly better results in improving sleep efficiency and reducing insomnia symptoms compared the two studies which did not include stimulus control exercises. These results indicate that incorporating stimulus control exercises in an online intervention are of added value to effectively reduce insomnia symptoms.

Efficacy of cognitive exercises
Only Horsch et al., (2017) did not include any cognitive exercises. All other 16 included studies did incorporate cognitive exercises in the online treatment. The studies which include cognitive exercises in their online intervention reported better scores on the insomnia severity index and sleep efficiency compared to the results of Horsch et al., (2017). Consequently, the presence of cognitive exercises in almost all online interventions indicate the importance of including these exercises in an online intervention for insomnia to be more effective in reducing complaints.

Efficacy of sleep restriction
All included sleep restriction exercises in their online treatment, therefore the added value sleep restriction exercises could not be derived from current analysis. Nevertheless, as well as reported under cognitive exercises, the presence of sleep restriction in all studies may imply the importance of including this component in online treatment for insomnia. All included studies substantiated the inclusion of sleep restriction (e.g. Morin, Culbert, & Schwartz, 1994; Murtagh & Greenwood, 1995). Subsequently, these results indicate that

sleep restriction has already to be widely proven and accepted to be effective in reducing insomnia. Yet, it is interesting that the effectiveness of online sleep restriction exercises has not been separately investigated yet in current literature.

Efficacy of sleep hygiene education

All studies included information about sleep hygiene education in their applied online interventions. To gain insight in the added value of sleep education in online treatment for insomnia, a comparison was made between control treatments which compared sleep hygiene education alone with the online intervention (Blom et al., 2015; Chow et al., 2018; Espie et al., 2012; Ritterband et al., 2017). Results indicate sleep hygiene education alone has a small effect in reducing insomnia symptoms and improving sleep efficiency. However, when comparing to the online intervention groups, analysis reveals that interventions are about twice as effective. As a result, it can be concluded that patient education has an effect on reducing insomnia symptoms, however in more severe cases it is advised to include multiple components of CBT-I, rather than sleep hygiene education alone.

3.5 THE EFFECT OF PERSONAL GUIDANCE

The second aim of the research question was to identify the effect of offering personal guidance besides online treatment. The average scores on the primary outcomes insomnia severity and sleep efficiency were compared across the three different types of guidance: 1) No guidance, 2) automated email guidance which mainly includes receiving reminders and 3) personal guidance including motivating messages and feedback on homework. Analysis showed that both guided as unguided interventions were effective in improving sleep and reducing insomnia. However, studies which included online interventions which were personally guided or automated guided by email reminders were more effective in reducing insomnia symptoms and improving sleep efficiency compared to unguided online interventions.

Interestingly one recent study of Lancee et al (2013) specifically aimed to evaluate the additional effects of personal guidance delivered via email in an online intervention for insomnia. Guidance in this study existed of receiving additional 40 minutes on average personal support during the 6-week online intervention. Results of this study show that adding personal support significantly enhances the effectivity of the online treatment regarding to reducing insomnia symptoms and improving sleep compared to the same treatment without guidance. Overall, these results indicate the importance of offering some automated or personal guidance besides an online treatment.

3.6 INFLUENCE OF DURATION OF INTERVENTION ON TREATMENT EFFICACY

The third aim of the research question was to gain insight whether duration of intervention was of influence on the effectiveness of the online treatment. Most studies (N=13) had a duration of six weeks. The studies of Ström et al., (2004) and Vincent & Lewycky (2009)reported an intervention which lasted five weeks. A treatment duration of eight weeks was reported in three studies (Blom et al., 2015, 2016; Kaldo et al., 2015). Interventions with a treatment duration of six or eight weeks reported a higher decrease in perceived insomnia severity and a higher increase in sleep efficiency compared to the two studies who included a 5-week online treatment. These results suggest that a longer treatment duration of 6 to 8 weeks is most effective in improving sleep and reducing insomnia.

3.7 EFFECTIVENESS OF ONLINE INTERVENTIONS IN REDUCING MEDICATION USAGE

Finally, the fourth aim of this review was to identify the effectiveness of online intervention in reducing sleep medication usage among participants. In total, nine included studies reported information about the usage of medication pre- and post-treatment among participants. Interestingly, results varied between the nine included studies referring to efficacy of tempering medication usage. In total, five studies reported a significant reduction in sleep medication usage post-treatment among participants who received an online treatment (Blom et al., 2015, 2016; Holmqvist et al., 2014; Lancee et al., 2012; Ritterband et al., 2009). One study reported a non-significant decline in medication usage (Van Straten et al., 2014). Finally, three studies reported no difference in medication usage post-treatment (Blom et al., 2016; Lancee et al., 2015; Vincent & Lewycky, 2009). Overall, medication usage was in none of the nine reported studies increased post-intervention. Taken together, these results indicate that online treatment may reduce sleep medication usage, though the results are not strikingly convincing. Nevertheless, since there were no increases in medication usage found in the analysis, it can be concluded that applying online intervention can safely be applied in patients with insomnia which are using sleep medication without exacerbating insomnia symptoms.

Table 1 study characteristics

Author, (publication year)	Published in	Country	Number randomized	Number of study arms (types)	ICBT-I duration (weeks)	Presence of CBTI elements*					Guided (yes/no)	Type treatment delivery	Journal impact score
						Stimulus control	Sleep restriction	Sleep hygiene education	Relaxation training	Cognitive therapy			
Ström et al. (2004)	Journal of consulting and clinical psychology	Sweden	109	2 (WLC)	5	x	x	x	x	x	Yes, active online support and feedback therapist	Internet-delivered	3,56
Ritterband et al. (2009)	Archives of General Psychiatry	United States	45	2 (WLC)	6	x	x	x		x	Yes, automated reminders	Internet-delivered	6,78
Vincent et al. (2009)	SLEEP	Canada	118	2 (WLC)	5	x	x	x	x	x	no	Internet-delivered	3,22
Espie et al. (2012)	SLEEP	United Kingdom	164	3 (Patient education, TAS)	6	x	x	x	x	x	Yes, automated reminders	Internet-delivered	3,22
Lancee et al. (2012)	Behavior Research and Therapy	The Netherlands	623	3 (Paper-based CBT, WLC)	6	x	x	x		x	No	Internet-delivered	4,45
4,45Lancee et al. (2013)	Behavior Research and Therapy	The Netherlands	262	2 (Internet-based CBTI, without personal support)	6	x	x	x	x	x	Yes, active online support and feedback therapist	Internet-delivered	4,45
Holmqvist et al. (2014)	Sleep medicine	Canada	73	3 (Telehealth-delivered, In-person CBT)	6	x	x	x	x	x	No	Internet-delivered	6,53
Straten et al. (2014)	Psychological Medicine	The Netherlands	118	2 (WLC)	6	x	x	x	x	x	Yes, active online support and feedback therapist	Internet-delivered	3,96
Blom et al. (2015)	Behavior Research and Therapy	Sweden	48	2 (Group CBTI)	8	x	x	x	x	x	Yes, active online support and feedback therapist	Internet-delivered	4,45

Author	Journal	Country	N	Arms	Weeks	C1	C2	C3	C4	C5	Support	Delivery	Score
Kaldo et al. (2015)	Behavior Research and Therapy	Sweden	148	2 (Patient education)	8	x	x	x		x	Yes, active online support and feedback therapist	Internet-delivered	4,45
Lancee et al. (2015)	Cognitive behavior therapy	The Netherlands	63	2 (WLC)	6	x	x	x	x	x	Yes, active online support and feedback therapist	Internet-delivered	3,12
Thiart et al. (2015)	Scandinavian Journal for work environment and health	Germany	128	2 (WLC)	6	x	x	x	x	x	Yes, active online support and feedback therapist	Internet-delivered	3,43
Blom et al. (2016)	SLEEP	Sweden	148	2 (Patient education)	8	x	x	x	x	x	Yes, active online support and feedback therapist	Internet-delivered	3,22
Lancee et al. (2016)	SLEEP	The Netherlands	90	2 (Face-to-Face, WLC)	6		x	x	x	x	Yes, active online support and feedback therapist	Internet-delivered	3,22
Horsch et al. (2017)	Journal of Medical internet research	The Netherlands	153	2 (WLC)	6		x	x	x		Yes, automated reminders	Mobile app	5,82
Ritterband et al. (2017)	JAMA Psychiatry	United States	303	2 (Patient education)	6	x	x	x		x	No	Internet-delivered	9,86
Chow et al. (2018)	Sleep medicine	United States	302	2 (Patient education)	6	x	x	x		x	Yes, automated reminders	Internet-delivered	6,53

*X indicate the presence of an CBT-I component

Table 3 Summary of results per included study, Pretreatment, posttreatment and the mean difference between Pre and post treatment.

First Author (year)	Intervention/control	N=	Insomnia Severity Index (ISI)			Sleep Efficiency		
			ISI pre-intervention	ISI Post intervention	ISI difference pre-post Intervention	SE Pre-treatment	SE post-treatment	SE Difference Pre-post treatment
Ström et al. (2004)	Intervention	54				69,4	79,9	10,5
	WLC	55				73,4	77,5	4,1
Ritterband et al (2009)	Intervention	22	15,7	6,6	-9,1	77,3	89,3	12,0
	WLC	23	16,3	15,5	-0,8	79,6	81,6	2,0
Vincent et al. (2009)	Intervention	59	18,1	12,4	-5,7	75,5	82,7	7,2
	WLC	59	18,1	17,0	-1,1	75,8	79,3	3,5
Espie et al. (2012)	intervention	55				63,2	82,7	19,5
	Patient education	55				65,1	70,8	5,7
	TAS	54				55,6	62,0	6,4
Lancee et al (2012)	intervention	214	23,7			70,1	81,0	10,9
	Paper and pencil	203	23,5			70,3	81,0	10,7
	WLC	200	23,8			70,5	74,3	3,8
Lancee et al. (2013)	Intervention	129				72,8	84,3	11,5
	same intervention, without motivational support	129				71,1	76,4	5,3
Holmqvist et al (2014)	Intervention	39	18,7	13,5	-5,2	65,8	78,2	12,4
	Telehealth control	33	18,5	12,5	-6,0	62,5	77,4	14,9
	In-person	34	18,6	12,7	-5,9	60,9	70,7	9,8
Straten et al. (2014)	Intervention	73	16,8	8,3	-8,5	70,6	84,7	14,1
	Patient education	75	16,5	11,8	-4,7	71,5	77,8	6,3
Blom et al. (2015)	intervention	24	18,7	9,3	-9,4	73,0	88,0	15,0
	Group treatment	24	17,9	8,4	-9,5	67,0	87,0	20,0
Kaldo et al. (2015)	Intervention	73	16,8	8,3	-8,5	70,6	84,7	14,1
	Patient education	73	16,5	11,8	-4,7	71,5	77,8	6,3
Lancee et al. (2015)	intervention	36	18,1	12,3	-5,8	67,3	79,7	12,4
	WLC	37	18,3	16,4	-1,9	67,0	65,1	-1,9
Thiart et al (2015)	Intervention	64	18,0	9,2	-8,8	76,0	86,0	10,0
	Control WLC	64	17,8	15,6	-2,2	79,0	84,0	5,0
Blom et al (2016)	Intervention	24	16,5	8,3	-8.2			0,0
	control CBT-I	24	16,8	11.8	-4.7			0,0
Lancee et al (2016)	Intervention	30	18,2	12,4	-5,8	64,1	78,1	14,0
	Face-to-face	30	17,3	7,1	-10,2	67,1	84,3	17,2
	Waiting list	30	17,5	16,5	-1,0	67,4	74,1	6,7
Horsch et al. (2017)	Intervention	77	16,4	9,8	-6,6	77,6	84,8	7,2
	Waitlist control	74	16,4	16,4	0,0	77,0	78,3	1,3
Ritterband et al. (2017)	intervention	151	17,0	9,3	-7,7	73,2	85,6	12,4
	patient education	152	17,0	14,7	-2,3	70,5	77,2	6,7
Chow et al. (2018)	Intervention	151	17,0	9,3	-7,7			
	patient education	152	17,8	14,7	-3,1			

*WLC=Waiting List condition, TAU=Treatment as usual

Principal findings and comparison to earlier results

This study aimed to research the influence of different online treatment characteristics on reducing insomnia. Gaining insights in this topic was important to develop recommendations for healthcare providers which treatment can be considered as best practice. Additionally, it was explored whether online treatment was effective for sleep medication adherent patients to reduce their usage. The implications of these finding are discussed below.

Taking a closer look at how the presence of different CBT-I elements influence the effectiveness of the treatment, it was interesting to note that most studies included multiple or all CBT-I elements. For instance, the module sleep restriction was included in all studies, thereby indirectly indicating the importance of this element in online treatment as extensively described in earlier literature (Spielman, Saskin, & Thorpy, 1987). Focusing on the results of relaxation exercises, it seems that that component have no influence on the effectiveness of the treatment which is contractionary with previous findings (Irwin, Cole, & Nicassio, 2006). A theoretical explanation might be that the composition of relaxation exercises with other CBT-I components revoke the individual effects of relaxation exercises. However, it might also be attributed to methodological factors; taking a closer look at study drop-out levels, it seems that these studies reported higher drop-out rates when compared to other studies. Another clarification may be that four out of five studies without relaxation exercises did not include personal guidance which possibly has biased this result as personal guidance was associated with better treatment outcomes.

In addition, another finding which emerged from the analysis of how CBT-I elements influences the effectiveness of the treatment was that including the modules stimulus control and cognitive exercises in the online intervention seems to create larger treatment effects, comparable with results of previous studies (Miller et al., 2014; Trauer et al., 2015). Besides, results of this study indicated that sleep hygiene education alone had small effects on treatment outcomes, nevertheless these are not comparable with larger effects of multicomponent CBT-I online treatment. Earlier studies confirmed the small effects of providing sleep hygiene education alone on reducing insomnia, which may therefore be a good solution for patient with mild insomnia caused by bad sleeping habits which can be treated by education. (Stepanski & Wyatt, 2003).

Taken together, the added value of each CBT-I component alone could not be obtained from the results of this study. Nevertheless, since a majority of this study included multiple CBT-I components in the online treatment, it can be concluded that including a wider variety of CBT-I modules is most effective for treating insomnia. Treating insomnia by combining multiple elements of CBT-I seems to be most effective; thereby targeting with each component the complex psychological causes which underlie in the development of insomnia. This theory is supported in earlier studies studying the efficacy of CBT-I in a non-online environment (e.g. Mitchell, Gehrman, Perlis, & Umscheid, 2012). Lastly, these online treatments should at least include the component sleep restriction exercises; in this inquiry it appeared to be the core module included in all online interventions.

The second aim of this study was to explore which duration of the treatment reaches most optimal outcomes. The duration of treatment differed moderately between the included studies. Longer treatment durations (6-8 weeks) were related to larger effects compared to shorter treatment durations (5 weeks). This finding is consistent with previous study investigating the effects of online CBT for anxiety (Hoffmann, Wu, & Boettcher, 2014). A plausible theoretical explanation for this finding may be that a longer treatment duration is more intensive, thereby creating greater sustainable sleeping habits and thereby improving treatment results

(Koffel, Koffel, & Gehrman, 2015). These results indicate that a more extensive online treatment with a duration of 6 to 8 weeks reaches most optimal effects.

Thirdly, a higher level of personal guidance was related to improved treatment outcomes which is consistent with current literature on similar internet-based interventions (Spek et al., 2007). The provided guidance functioned as an information source to explain modules in the treatment, review homework and to encourage patients to finish modules. This effect could be plausibly explained that personal guidance increases the adherence rate of the therapy and thereby improves treatment outcomes (Lancee et al., 2013). Placing this result in a wider context in society with raising healthcare costs and increasing work pressure on clinician, it is questionable whether adding personal guidance to online treatment is cost-effective; results of this review indicate that fully automated online treatment also reaches good effects. Therefore, it may be important to determine on forehand which persons may benefit most of the added value of personal guidance and which persons can benefit from automated online interventions alone. To the authors' knowledge, no studies are present researching this topic in current literature. However, it may be hypnotized based on the above elaborated theory that for instance, patients with difficulties to adhere to treatments or are not educated enough to understand treatment instructions may be more likely to benefit more from personal guidance. As a result, personal guidance can be deployed at the specific persons who needs it, thereby increasing efficient allocation of healthcare resources.

Additionally, it was investigated 'how' personal guidance was employed in the included online interventions. Outcomes of this study indicates that exclusively professional support in person may not be necessary; a majority of the included studies employed clinical psychology students which received a short training about how to guide patients with the online treatment. Accordingly, these findings implicate that personal support may also be employed by psychological for this matter after following a decent training how to inform and encourage patients to complete this treatment. This result can be explained as the 'effective components' are already included in the online program; consequently, personal support may rather function as a tool to increase treatment adherence then as the main treatment core (Lancee et al., 2013). This recommendation can form a compromise to employ personal guidance without having the adverse effects of increasing workload of healthcare professionals.

Another important result regarding to personal guidance was that adding automated personal messages and reminders were associated to better outcomes than online treatment which did not include these. As described in previous studies, this result can be explained by the mechanism that including persuasive design techniques such as automated reminders in online treatment increases the motivation and adherence of the treatment which in turn leads to better treatment outcomes (Beun, 2013; van Gemert-Pijnen et al., 2011). This finding is of great importance since this feature offers minimal effort; it should only be implemented during the design phase but offers great effects for patients. Accordingly, this outcome implicates the importance of keeping in mind the persuasive design by including automated reminders in online insomnia treatment, in order to achieve most optimal treatment effects.

Finally, findings of this study indicate that sleep medication usage was in some studies reduced while other studies reported no change after online insomnia treatment. Importantly, none of the included studies reported an increase in sleep medication usage. The complex interplay of the development of insomnia in combination with sleep medication dependence makes it probably more difficult to treat sleep medication adherence through CBT-I(Morin et al., 2011). This finding implicates that online interventions for insomnia can be without harm prescribed through patients which are already using sleep medication; though it should be noted that good effects in reducing sleep medication usage cannot be assured.

Strengths and limitations

A major strength of this study was the inclusion of high-quality studies which applied a randomized controlled trial design, which allowed to gain directly insights in the effects of online interventions on treatment outcomes. All studies were conducted in Western countries; therefore, it is expected that results are external generalizable to the Dutch population. Besides, it was chosen to select two databases in order to comprehensively search for relevant articles within the limited timeframe available, however the relative limited number of searching engines may have resulted in the chance of missing of relevant articles. This chance has been minimized by applying snowball sampling and selecting two databases (PubMed and Scopus) which offer the highest chance of finding relevant articles on this topic. Finally, another strength of this study is the application of PRISMA guidelines for finding and selecting relevant articles which increases the internal validity of this study.

Results of this study has demonstrated that personal guidance offered besides online treatment leads improved outcomes; nevertheless, online treatment without personal guidance seems to reach good effects as well Personal guidance provides explanations and instructions how certain exercises work and motivate patients to complete the treatment, thereby improving treatment outcomes (Lancee et al., 2013). Accordingly, it can be hypothesized that population groups which are at risk of non-adherence or not sufficiently able to understand descriptions and instructions in the online treatment may benefit the most of personal guidance, however nor this study neither current literature has not demonstrated this assumptions yet. Therefore, future research should focus of identifying target groups the addition of personal guidance along online treatment would benefit the most, in order to optimally allocate the current limited healthcare resources available.

Finally, the application of a systematic review with randomized controlled trials was chosen as it allows to gain meaningful insights in the influence of online treatment on improving insomnia to assess effectiveness. As a consequence, this review does include any qualitative insights in the perspectives of patients about, for instance, how they experienced the online treatment and their perception how online treatment can be best designed and disseminated. To date, limited attention has been paid to this matter in current literature. These insights are of create importance to identify the underlying factors of the acceptability of online treatment for insomnia, which is likely to form an important indicator to increase the adherence of a treatment. Earlier studies in the area of eHealth substantiates the importance of adapting online technology to the needs and values of patients (van Gemert-Pijnen et al., 2011). This topic is especially of relevant in the current paradigm shift in healthcare, laying a greater focus on the values and perceptions of patients. Further qualitative research should gain more insight this topic, thereby allowing eHealth designers and medical specialists to adapt their treatment to the perceived needs and values of patients.

Conclusion

In conclusion, this review provides novel insights in the influencing factors of treatment characteristics on the efficacy of online treatment for insomnia. A greater coverage of CBT-I components with a treatment duration of 6-8 weeks seems to create most optimal treatment effects. Other aspect such as adding personal guidance positively influenced treatment outcomes, though non-guided online treatment reaches good effects as well. Future studies are advised to investigate which population groups may benefit the most of personal guidance in order to apply it in a cost-effective way. Finally, a persuasive design (e.g. addition of automated reminders of motivational messages) plays an important role in improving treatment effectiveness. More research is needed to qualitatively focus on how the treatment can be most optimal designed according to the perception of insomnia patients.

Practical recommendations

This review was commissioned by General Practitioner organization, location Oude Turfmarkt Amsterdam. Based on the results of this review the following practical recommendations were developed.

- Regarding to the content and duration of online interventions for insomnia, it is advised to propose an online treatment with a duration of 6-8 weeks which includes all components of CBT-I (sleep restriction, sleep hygiene education, stimulus control, cognitive therapy and relaxation exercises) for patients with insomnia.
- Sleep hygiene education alone has small effects and can be considered by patients with milder form of insomnia, caused by bad sleeping habits.
- Personal guidance which exists of sending motivational messages, being available to explain information and contact patients in cases of non-adherence leads to more optimal treatment outcomes. Nevertheless, online treatment without personal guidance seems to reach good effects as well. It is the clinician opinion whether adding personal guidance is worth the extra costs and effort for a patient.
- Online treatment may decrease sleep medication usage, however strong evidence is not present. Nevertheless, in no study it was reported to increase medication usage post-treatment. Thereby it can be concluded that prescribing online intervention through sleep medication users can be done without inducing harmful effects.

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