Telemedicine and insomnia: a comprehensive systematic review and meta-analysis

Abstract

Background: Telemedicine has been introduced as a new and effective method in dealing with public health challenges and reducing healthcare costs in today's world. Insomnia, as the most common sleep disorder, causes several challenges for patients, and according to previous studies, telemedicine has been found to be an effective approach in improving various diseases. Therefore, the aim of this study was to assess whether telemedicine can be a substitute for face-to-face measures for the diagnosis, follow-up, and treatment of insomnia.

Materials and Methods: In this systematic review and meta-analysis, studies related to telemedicine and insomnia were identified and selected, using the keywords of telemedicine, insomnia, sleep disorder, treatment, non-pharmacological treatment. The international databases of Embase, ProQuest, ScienceDirect, Scopus, PubMed and Web of Science (WoS), and Google Scholar were searched without a lower time limit, and until July 12, 2021. Data were analyzed within the Comprehensive Meta-Analysis (version 2) software, and the significance level of the test was considered $P<0.05$.

Results: A systematic review of 16 selected studies showed that the results of these studies showed that telemedicine interventions have a positive effect on improving insomnia in different groups. The meta-analysis was performed on 2 studies. Based on the results, it was found that CBTI interventions based on telemedicine have a greater effect on improving chronic insomnia than CBTI face to face with an average difference of 2.55 ± 0.66 based on the random effects model. Moreover, the difference between the mean in the telemedicine intervention group and the non-intervention group was 0.65 ± 0.19, which shows the positive effect of the telemedicine intervention.

Conclusion: The use of telemedicine methods in the treatment of insomnia not only accelerates access to sleep services, but can also improve the efficiency of health services in terms of time and cost, as well as therapeutic effects.

Keywords: Insomnia, Sleep disorder, Telemedicine, Systematic review, Meta-analysis

Introduction

Telemedicine is defined as "the use of medical information exchanged from one location to another via electronic communication means to improve a patient's clinical health" [1]. Telemedicine provides care for patients who are at home, living in rural or low-income areas, or who face other barriers that limit their access to care [2]. Similarly, telemedicine specialists can use new technologies to care for patients with medical disorders [3, 4]. Apart from patients who do not have access to facilities, patients who have access to in person care may also welcome telemedicine [5].

Numerous studies have shown that telemedicine has a positive effect on therapeutic effects, efficiencies in the health services, and technical usability [6]. Telemedicine programs in developing countries can be considered as an opportunity for providing basic health services to the general population and closing the service level gap between rural areas and specialized hospitals (that are usually located in large cities) [7]. In addition to the above, telemedicine has many potential benefits. These benefits include: better access to information, provision of care that was not previously available, better access to services and increased care, and reduced healthcare costs [8].

At present, COVID-19 has led to the cancellation and postponement of outpatient medical visits to medical centers [9]. Due to necessity, the use of telemedicine and virtual care has been suggested as a way to maintain the continuity of healthcare for patients. As a result, the prevalence of telemedicine adoption and virtual care has increased during the COVID-19 pandemic [10]. Telemedicine and

virtual care can be integrated into the healthcare system as an approach to maximize the efficiency of healthcare delivery [10]. Telemedicine is a pertinent 21st century phenomenon, and can be offered in many different ways and for a variety of healthcare related specialties [11].

Insomnia is defined as the inability to initiate and/or maintain sleep, resulting in impaired day function [12]. Insomnia is one of the most common diseases, and is associated with decreased quality of life, decreases in perceived health, increased risk for new mood and increased substance use disorders, and exacerbation of co-occurring health conditions [13]. The expansion of knowledge on sleep disorders has created a widespread need and effort by sleep healthcare services to support patients in all countries around the world [14]. Diagnosis and management of sleep disorders can be a good basis for using telemedicine. Telemedicine is more considered in sleep disorders than in many other medical fields [15]. Using telehealth technologies, various sleep disorder centers perform testing, implementation, and provision of primary care and follow-up for patients with sleep disorders [15].

As the most common sleep disorder, insomnia affects the lives of 10-30% of people globally [16]. Further, the prevalence of insomnia symptoms is significantly high i.e. 30-40% [17]. Gender differences in this disorder are more pronounced than other sleep disorders; The prevalence of insomnia in women is 1.2 to 2 times higher than in men [18]. Insomnia is also very common in patients with underlying problems. In fact, insomnia is more common with problems such as cancers (especially breast cancer), stroke, and schizophrenia [17, 19, 20].

The results of previous meta-analyses have shown a positive effect of telemedicine on a variety of diseases, such as myocardial infarction, chronic obstructive pulmonary disease, diabetes, pain management, and mental health [21]. To date, no systematic review and meta-analysis of the efficacy and effect of telemedicine on insomnia has been performed. Therefore, the purpose of this study is to answer the following research question: "Can telemedicine be an alternative to face-to-face measures for the diagnosis, follow-up, and treatment of insomnia?".

Materials and Method

Protocol and registration

The research protocol has been registered in the PROSPERO international prospective register of systematic reviews, (CRD42021268125).

Study approach and research question

The approach to the systematic review and meta-analysis is in accordance with the Cochran review which includes: selecting a research question, determining inclusion and exclusion criteria, identifying articles, selecting studies, evaluating the quality of studies, extracting data, analyzing and interpreting findings; the approach used also incorporates the additions to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA2020) [22, 23].

As also outlined earlier in this paper, the identified research question is: "Can telemedicine be a substitute for face-to-face measures to diagnose, follow up and treat insomnia?" The study population includes: patients with insomnia, Outcome entails: methods of diagnosis, pharmacological and non-pharmacological treatments, management and follow-up of insomnia through telemedicine, Search time or duration includes: No lower time-limit and up to 12 July 2021, and the type of study (study design) includes: clinical trial and intervention.

Inclusion and exclusion criteria considering the research question

Clinical trial and intervention studies examining telemedicine in the diagnosis, treatment, follow-up, and management of insomnia that have been published in English and their full text were available

were eligible for inclusion in the study. Case reports, case studies, cohort studies, reviews including systematic review and meta-analysis were excluded from the work.

Article search and identification strategy

Systematic search of documents in international databases was performed with selected English keywords. The searched scholarly repositories were ScienceDirect, Web of Science (WoS), ProQuest, Embase, Medline (PubMed), and Scopus. The Google Scholar engine was also searched to access Grey Literature - a text which its results have not been published. The selected keywords were extracted from the Medical Subject Headings (MeSH) thesaurus. Keywords related to the studied population (P) were:

Sleep disorder, sleep disturbance, Insomnia, Insomnia Disorders of Initiating Maintaining Sleep, DIMS, Sleep Initiation Maintenance Disorders, Chronic Insomnia, Primary Insomnia, and leeplessness.

And outcome-related keywords were (O):

Pharmacological Treatment, Non-pharmacological Treatments, Insomnia Management, Follow-up of Insomnia, Telemedicine, Telediagnostic, Teleconsultation, Teletherapy, Telemonitoring, Telematics, Telecare, Telerehabilitation, Telecoaching, Telemetric, Teleexpertise, Telehealth, Teletreatment, OR Teleinsomnia, Virtual Care Health, and Remote Care.

The search strategy in each database followed the Advanced Search option, and the keyword combinations were made using the AND, and OR operators. For instance, the search strategy in the PubMed database was as follows (also please see Table 1):

PubMed search strategy: ("sleep disorder" [Title / Abstract] OR "sleep disturbance" [Title / Abstract] OR Insomnia [Title / Abstract] OR Insomnia Disorders of Initiating Maintaining Sleep [Title / Abstract] OR DIMS [Title / Abstract] OR Sleep Initiation Maintenance Disorders [Title / Abstract] OR chronic Insomnia [Title / Abstract] OR primary insomnia [Title / Abstract] OR Sleeplessness [Title / Abstract]) AND (pharmacological treatment [Title / Abstract] AND non-pharmacological treatments [Title / Abstract] OR insomnia management [Title / Abstract] OR follow-up of insomnia [Title / Abstract] OR telemedicine [Title / Abstract] OR telediagnostic [Title / Abstract] OR teleconsultation [Title / Abstract] OR teletherapy [Title / Abstract] OR telemonitoring [Title / Abstract] OR telematics [Title / Abstract] OR telecare [Title / Abstract] OR telerehabilitation [Title / Abstract] OR telecoaching [Title / Abstract] OR telemetric [Title / Abstract] OR teleexpertise [Title / Abstract] OR telehealth [Title / Abstract] OR teletreatment [Title / Abstract] OR teleinsomnia [Ti tle / Abstract] OR virtual care [Title / Abstract] OR virtual health [Title / Abstract] OR remote care [Title / Abstract])

Table 1: Search Strategy for Selected Databases

Database	Search strategy	Date	Number
PubMed	("sleep disorder"[Title/Abstract] OR "sleep disturbance"[Title/Abstract] OR Insomnia[Title/Abstract] OR Insomnia Disorders of Initiating Maintaining Sleep[Title/Abstract] OR DIMS[Title/Abstract] OR Sleep Initiation Maintenance Disorders[Title/Abstract] OR chronic Insomnia[Title/Abstract] OR primary insomnia[Title/Abstract] OR Sleeplessness[Title/Abstract]) AND (pharmacological treatment[Title/Abstract] AND non-pharmacological treatments[Title/Abstract] OR insomnia management[Title/Abstract] OR follow-up of insomnia[Title/Abstract] OR telemedicine[Title/Abstract] OR telediagnostic[Title/Abstract] OR teleconsultation[Title/Abstract] OR teletherapy[Title/Abstract] OR telemonitoring[Title/Abstract] OR telematics[Title/Abstract] OR telecare[Title/Abstract] OR telerehabilitation[Title/Abstract] OR	2021.7.12	156

	telecoaching[Title/Abstract] OR telemetric[Title/Abstract] OR teleexpertise[Title/Abstract] OR telehealth[Title/Abstract] OR teletreatment[Title/Abstract] OR teleinsomnia[Title/Abstract] OR virtual care[Title/Abstract] OR virtual health[Title/Abstract] OR remote care[Title/Abstract])		
Scopus	TITLE-ABS ("sleep disorder" OR "sleep disturbance" OR insomnia OR "Insomnia Disorders of Initiating Maintaining Sleep" OR dims OR "Sleep Initiation Maintenance Disorders" OR "chronic Insomnia" OR "primary insomnia" OR sleeplessness) AND TITLE-ABS ("pharmacological treatment" AND "non-pharmacological treatments" OR "insomnia management" OR "follow-up of insomnia" OR telemedicine OR telediagnostic OR teleconsultation OR teletherapy OR telemonitoring OR telematics OR telecare OR telerehabilitation OR telecoaching OR telemetric OR teleexpertise OR telehealth OR teletreatment OR teleinsomnia OR "virtual care" OR "virtual health" OR "remote care")	2021.7.12	169
WOS	TS=("sleep disorder" OR "sleep disturbance" OR Insomnia OR "Insomnia Disorders of Initiating Maintaining Sleep" OR DIMS OR "Sleep Initiation Maintenance Disorders" OR "chronic Insomnia" OR "primary insomnia" OR Sleeplessness) AND TS=("pharmacological treatment" AND "non-pharmacological treatments" OR "insomnia management" OR "follow-up of insomnia" OR telemedicine OR telediagnostic OR teleconsultation OR teletherapy OR telemonitoring OR telematics OR telecare OR telerehabilitation OR telecoaching OR telemetric OR teleexpertise OR telehealth OR teletreatment OR teleinsomnia OR "virtual care" OR "virtual health" OR "remote care")	2021.7.12	196
Pro quest	AB,TI("sleep disorder" OR "sleep disturbance" OR insomnia OR "Insomnia Disorders of Initiating Maintaining Sleep" OR dims OR "Sleep Initiation Maintenance Disorders" OR "chronic Insomnia" OR "primary insomnia" OR sleeplessness) AND AB,TI("pharmacological treatment" AND "non-pharmacological treatments" OR "insomnia management" OR "follow-up of insomnia" OR telemedicine OR telediagnostic OR teleconsultation OR teletherapy OR telemonitoring OR telematic OR telecare OR telerehabilitation OR telecoaching OR telemetric OR teleexpertise OR telehealth OR teletreatment OR teleinsomnia OR "virtual care" OR "virtual health" OR "remote care")	2021.7.12	20
Embase	('sleep disorder':ti,ab OR 'sleep disturbance':ti,ab OR insomnia:ab OR 'insomnia disorders of initiating maintaining sleep':ti,ab OR dims:ti,ab OR 'sleep initiation maintenance disorders':ti,ab OR 'chronic insomnia':ti,ab OR 'primary insomnia':ti,ab OR sleeplessness:ti,ab) AND ('pharmacological treatment':ti,ab AND 'non-pharmacological treatments':ti,ab OR 'insomnia management':ti,ab OR 'follow-up of insomnia':ti,ab OR telemedicine:ti,ab OR telediagnostic:ti,ab OR teleconsultation:ti,ab OR teletherapy:ti,ab OR telemonitoring:ti,ab OR telematics:ti,ab OR telecare:ti,ab OR telerehabilitation:ti,ab OR telecoaching:ti,ab OR telemetric:ti,ab OR teleexpertise:ti,ab OR telehealth:ti,ab OR teletreatment:ti,ab OR teleinsomnia:ti,ab OR 'virtual care':ti,ab OR 'virtual health':ti,ab OR 'remote care':ti,ab)	2021.7.12	102
Science direct	Find articles with these terms: telemedicine OR telediagnostic OR teleconsultation OR teletherapy OR telemonitoring OR telematics OR telecare OR telerehabilitation OR telecoaching Title, abstract, keywords: sleep disorder OR sleep disturbance OR Insomnia OR Insomnia Disorders of Initiating Maintaining Sleep OR DIMS OR Sleep Initiation Maintenance Disorders OR chronic Insomnia OR primary insomnia OR SleeplessnessTitle: teleexpertise OR telehealth OR virtual care OR virtual health OR remote care OR telemetric	2021.7.12	3
Scholar	("sleep disorder"[Title/Abstract] OR "sleep disturbance"[Title/Abstract] OR Insomnia[Title/Abstract] OR Insomnia Disorders of Initiating Maintaining Sleep[Title/Abstract] OR DIMS[Title/Abstract] OR Sleep Initiation Maintenance Disorders[Title/Abstract] OR chronic Insomnia[Title/Abstract] OR primary insomnia[Title/Abstract] OR Sleeplessness[Title/Abstract]) AND (pharmacological	2021.7.12	30

	treatment[Title/Abstract] AND non-pharmacological treatments[Title/Abstract] OR insomnia management[Title/Abstract] OR follow-up of insomnia[Title/Abstract] OR telemedicine[Title/Abstract] OR telediagnostic[Title/Abstract] OR teleconsultation[Title/Abstract] OR teletherapy[Title/Abstract] OR telemonitoring[Title/Abstract] OR telematics[Title/Abstract] OR telecare[Title/Abstract] OR telerehabilitation[Title/Abstract] OR telecoaching[Title/Abstract] OR telemetric[Title/Abstract] OR teleexpertise[Title/Abstract] OR telehealth[Title/Abstract] OR teletreatment[Title/Abstract] OR teleinsomnia[Title/Abstract] OR virtual care[Title/Abstract] OR virtual health[Title/Abstract] OR remote care[Title/Abstract])		

In order to access the latest published studies, an alert was created on a number of important databases, including PubMed and Scopus, to check if any new articles have been published during the study. Moreover, to access all related articles, the sources of articles that met the inclusion criteria were manually reviewed. To avoid errors and mistakes, all steps of article search, study selection, quality evaluation, and data extraction were performed by two reviewers independently. For this purpose, the information of all articles found in each database was transferred into the EndNote X8 reference management software. After completing the search in all the databases, duplicate articles were removed. Then, in order to avoid the risk of bias in study selection, the names of the authors and the titles of the journals were removed, and a checklist was prepared based on the titles and abstracts of the studies. If there was a difference of opinion between the reviewers in relation to the inclusion of an article, and to avoid the risk of bias for specific studies, a final agreement was reached first through discussion and in some cases with the participation and opinion of a third reviewer. The full text of all remaining articles was then evaluated.

Quality evaluation of clinical trial studies

The quality of articles was evaluated based on selected and related items of the CONSORT checklist (i.e. study plan, background and review of texts, place and time of study, outcome, inclusion criteria, sample size, and statistical analysis). Articles that fulfilled to 6 to 7 criteria were considered as high quality articles, articles that scored 2 or 3 items were considered as articles of medium, and low methodological quality respectively [24].

Data extraction

After selecting articles for the systematic review and meta-analysis process, their data were extracted, and the studies were summarized. An electronic checklist was prepared for this purpose. The items on the checklist included: surname of the first author, year of publication, and year of study, place of study, age, sample size, diagnostic methods, type of treatment, insomnia follow-up status, and management information. Different checklists were used to extract different parts: one checklist was designed to extract statistical data (for meta-analysis), one checklist was designed to extract general data of articles (for complete and partial review). Furthermore, to increase the accuracy of the work, articles which their target population had an underlying disease, and articles that the study population did not have a specific underlying disease, were separated with the used checklists.

Statistical Analysis

To analyze and combine the results of different studies, information about treatment methods and other reported statistics were considered as the probability of binomial distribution and its variance and were calculated through binomial distribution. Heterogeneity of studies was assessed using the I^2 index. In general, heterogeneity is classified into three categories, heterogeneity less than 25% (low heterogeneity), between 25 to 75% (moderate heterogeneity), and more than 75% (high heterogeneity), which due to high heterogeneity in the analysis of studies, the random effects model

was used to combine the results of the articles. Publication bias was examined the Egger's test, and corresponding funnel plots were drawn. Data were analyzed within the Comprehensive Meta-Analysis (version 2) software, and the significance level of the test was considered $P<0.05$.

Findings

Article search and extraction

In the first phase, 676 articles were found, and 217 duplicate studies were omitted. Moreover, 459 studies entered the screening stage and 276 articles were deleted based on the inclusion and exclusion criteria and after reviewing the title and abstract of each study. In the next stage (eligibility assessment), out of 183 studies remaining from the screening stage, 128 articles were removed by reviewing the full text of articles and due to them being irrelevant. In the remaining 55 studies, by omitting 39 studies for the reasons mentioned in Figure 1, 16 related studies entered the systematic review and meta-analysis process (Figure 1).

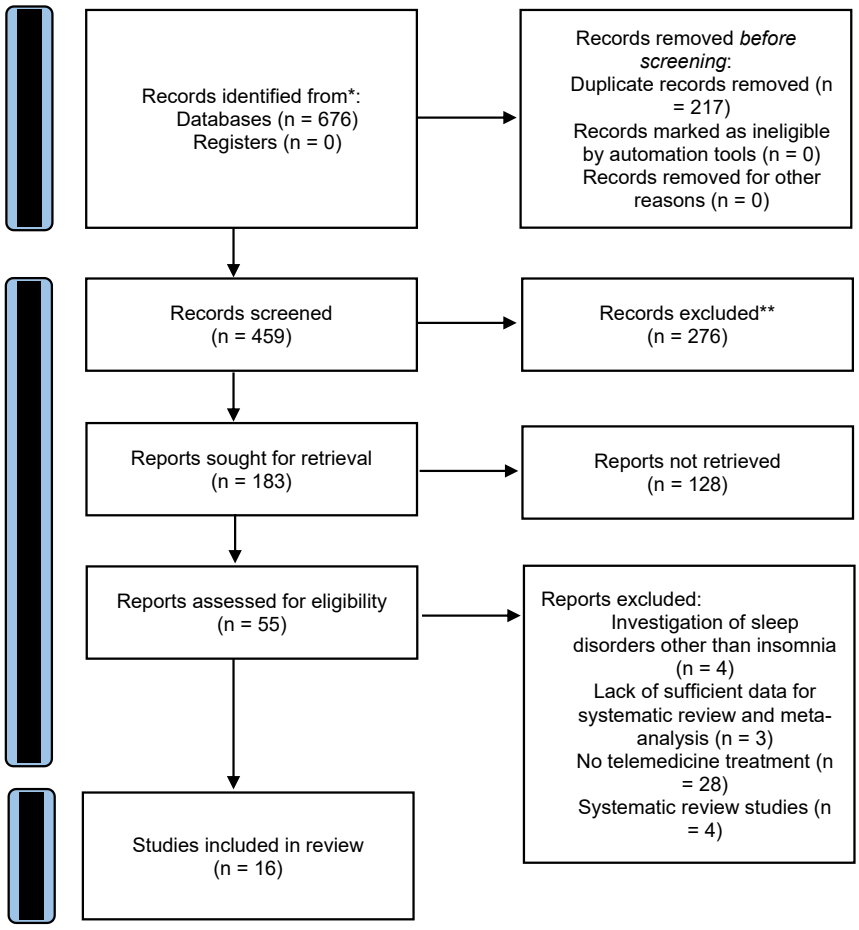


Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) flow diagram.

Study types

The search was conducted without a lower time-limit and until July 12, 2021, and accordingly 16 validated studies were obtained in the period from 2013 to 2021. Among them, one study was conducted in Sweden [12], one study in France [25], one study in the Netherlands [26], one study in Latvia [27], another study in Canada [28] and other studies in the United States [13, 29-38]. Also, the research works were different in terms of implementation method, so that 8 studies [26, 27, 31, 32,

34-37] by intervention method and, 8 other studies [12, 13, 25, 28-30, 33 , 38] were in the form of RCT (Table 1).

Study samples

Studies examined different populations. The lowest sample was observed in the study of Lichstein et al. [35] with 5 patients and the highest in the study of Gehrman et al. [34] with 214 patients. In most articles, people over the age of 18 were examined. There was only one work in which the intervention was performed on children aged 6-12 years [37]. In 5 studies [12, 13, 25, 28, 29] patients with primary insomnia were examined. In these research works, no underlying disease was seen in the participants. In 3 other studies [32-34], the study sample was among veterans with PTSD, 2 studies [26, 36] breast cancer patient, and 2 other studies [35, 38] also examined older adults with depression. One work [27] examined the elderly with emotional sleep disorder, one study [31] chronic migraine, another study [30] among individuals with alcohol use disorder, and finally 1 study [37] sampled children with autism, and their mothers (Table 2).

Table 2: General information of studies included in systematic review and meta-analysis

Row	First Author	Year	Location	Study type	Participants	Sample size	Female (N)	Male (N)	Age (Mean± SD)
1	Arnedt, J. T. [13]	2021	America	RCT	Individuals with chronic insomnia	65	46	19	47.2±16.3
2	Bernstein, A. M. [29]	2017	America	RCT	Adults with primary insomnia	88	74	14	54.3±12.6
3	Blom, K. [12]	2016	Sweden	RCT	Non-depressed adults with insomnia	148	NR	NR	NR
4	Brooks, A. T. [30]	2018	America	RCT	Individuals with alcohol use disorder	30	NR	NR	NR
5	Chapoutot, M. [25]	2021	France	RCT	Chronic insomnia	30	NR	NR	48±10
6	Crawford, M. R. [31]	2020	America	Interventional Study	Individuals with chronic migraines and insomnia	42	42	0	42
7	Dozeman, E. [26]	2017	Netherlands	Interventional Study	Breast cancer patients with insomnia	171	171	0	49.4±8.7
8	Franklin, C. L. [32]	2018	America	Interventional Study	Veterans with insomnia who were diagnosed with PTSD	18	0	18	53.8±12
9	Gehrman, P. [39]	2016	America	Interventional Study	Veterans	214	7	207	57.8±12.9
10	Gehrman, Philip [33]	2020	America	RCT	Veterans with PTSD	95	9	86	55.14±12.2
11	Holmqvist, M. [28]	2014	Canada	RCT	Chronic insomnia	73	55	18	NR
12	Lichstein, K. L. [35]	2013	America	Interventional Study	Older adult with insomnia and depression	5	1	4	65.8±10.4
13	McCarthy, M. S. [36]	2018	America	Interventional Study	Rural breast cancer survivors	18	18	0	57.72± 6.42
14	McCrae, C. S. [37]	2021	America	Interventional Study	Children with autism spectrum disorder	17 children	3	14	8.53±1.7
					Paterns of children with autism spectrum disorder	17 parents	17	0	36.06 ±9.2
15	Roja, I. [27]	2014	Latvia	Interventional Study	Over 65 years of age suffering from chronic emotional sleep disorders	25	15	10	69.44±2.43
16	Scogin, F. [38]	2018	America	RCT	Older adult with insomnia and depression in rural area	40	36	4	>50

SD: Standard Deviation, NR: Not Reported, RCT: Randomized Controlled Trial.

Intervention method:

Different treatment methods were used in the selected research works. Telemedicine Cognitive Behavioral Therapy was observed in two studies [13, 36]. Among these two, 1 work [13] used Face-to-Face CBT method in the control group. In another study, the control group was not examined [36]. CBTI telehealth was observed in several articles. A study [33] in person CBTI was performed in the control group. In another study [28], web-based CBTI was performed for the control group. The other 3 studies [34, 35, 37] were interventional, and the control group was not observed. In 2 pieces of research [25, 38], sessions were conducted using videoconferences. Chapoutot et al. [25] performed the intervention, based on CBT-I enhanced by acceptance and commitment therapy. In this work, no action was taken on the control group and the sample were examined during the study. Scogin et al. [38] performed CBT-I and CBT-D simultaneously in the intervention group. In this study, routine treatments by physicians for the control group were continued. In 1 article [32], researchers used telephone conversations to teach CBT-I to the intervention group. In this study, CBT-I interventions were performed in person in the control group. Some research works used [12, 26] internet CBT for insomnia and 1 [29] web-based CBT study in the intervention group. In another study [30], the intervention was performed based on Sleep Healthy Using The Internet (SHUTI) with CBT-I. Another article [31] reported the use of the digital CBTI method. Finally, in 1 study [27], drug therapy combined with psychotherapy was used to improve insomnia. In this work, valdoxan examination was used on the first day and then cognitive hypnotherapy was used. The training was performed through pre-prepared compact discs (CDs). In this study, the control group received a 25 mg tablet of valdoxan daily (Table 3).

Table 3: Descriptive information table of studies entered in the systematic review

Row	First Author (Year)	Patients	Participants Group 1, Age (Mean ±SD), (Female/Male (N))	Type of Intervention, Session, Duration	Participants Group 2, Age (Mean ±SD), (Female/Male (N))	Type of Intervention, Session, Duration	Tools	Outcome
1	Arnedt, J. T. (2021) [13]	Individuals with chronic insomnia	33, 43.7 ±17.4, (23/10)	Telemedicine (CBT-TM)	32, 50.9 ±14.5, (23/9)	Face-to-face (CBT-F2F)	Insomnia/sleep (ICSD-3, ISI, daily sleep/wake diaries, DBAS-16)	Telemedicine delivery of CBT for insomnia is not inferior to face-to-face for insomnia and yields similar improvements on other sleep and daytime functioning outcomes
2	Bernstein, A. M. (2017) [29]	Adults with primary insomnia	43, 54.9 ±13.0, (38/5)	GTS is a 6-week, online, interactive, CBT-based program	45, 53.6 ±12.3, (36/9)	Control	Insomnia (ISI (primary outcome), PIRS20	Well-constructed online CBT was effective for insomnia program
3	Blom, K. (2016) [12]	Non-depressed adults with insomnia	73, 47 ±15.2, (59/14)	Internet-based treatment for insomnia	75, 49 ±15.6, (57/18)	Active Control Treatment	Insomnia (ISI)	The large improvements in the ICBT-i group were maintained after 36 months, corroborating that CBT for insomnia has long-term effects, after 36 months, the groups did not differ in insomnia severity, but ICBT-ctrl had used more sleep medication and undergone more other additional insomnia treatments during the follow-up period
4	Brooks, A. T. (2018) [30]	Individuals with alcohol use disorder	-	Phase 1: shuti intervention / phase 2: six sessions (“cores”) of shuti intervention	-	Phase 2: insomnia education web-based program	Insomnia (ISI)	This study addresses a critical gap in our understanding of the utility of internet-based CBT-I in a vulnerable population
5	Chapoutot, M.(2021) [25]	Chronic insomnia	15	Videoconferences Act-e-CBT, 4 session, 1 hour per session	15	Wait list control, 12 weeks	ISI, PSQI, Sleep diary	The results showed that the implementation of act is a typical psychotherapy supplement for insomnia. In fact, the results of this study further support "third wave" behavioral therapy and web-based interventions in the treatment of sleep disorders.
6	Crawford, M. R. (2020) [31]	Individuals with chronic migraines	42, 42, (42/0)	dCBT-I (6 weekly sessions delivered over the internet	NR	NR	Sleep diary	The effects of improving insomnia on dCBT-I were observed in migraine.

		and insomnia		by an animated virtual therapist)				94.3% of people were satisfied with the treatment
7	Dozeman, E. (2017) [26]	Breast cancer patients with insomnia	100, 50.1±9, 100	Treatment completed, I-CBT sleep intervention (i-sleep), 6	71, 43.8±8, 71	Treatment not completed, I-CBT sleep intervention (i-sleep), 6	Insomnia (ISI)	The I-CBT intervention i-sleep is feasible, well-accepted, and effective for BRC patients who suffer from insomnia, especially for younger patients and those with more severe insomnia
8	Franklin, C. L. (2018) [32]	Veterans with insomnia who were diagnosed with PTSD	11, -, (0/10)	CBT-I by telephone, six weeks of individual, manualized, 50-minute	7, -, (0/7)	CBT-I in-person, six weeks of individual, manualized, 50-minute	Sleep problems (PSQI)	Telephone-delivered CBT-I may be able to reduce trauma-related insomnia symptoms
9	Gehrman, P. (2016) [34]	Veterans	214, 57.8 ±12.9, (7/207)	CBT-I telehealth (‘‘tele-insomnia’’) program, 6, 60–90-min weekly sessions	-	-	Insomnia (ISI)	Clinical video telehealth technology can be used to deliver group CBT-I in a manner that produces clinically significant improvement.
10	Gehrman, Philip (2020) [33]	Veterans with PTSD	49, 55.63 ±12.08, (4/45)	Telehealth CBT-I, 6 sessions, 90 minutes per sessions	46, 54.61±12.48, (5/41)	In person CBTI	ISI, PSQI	Telehealth video has been shown to support psychotherapy, even in adults with severe insomnia symptoms who have other common illnesses.
11	Holmqvist, M. (2014) [28]	Chronic insomnia	39, (28/11)	Telehealth CBT-I,	34, (27/7)	Web-based CBTI	ISI, sleep diary, PSQI	Web- and telehealth-based delivery are both helpful in treating chronic insomnia in rural dwelling adults.
12	Lichstein, K. L. (2013) [35]	Older adult with insomnia and depression	5(4/1)	Telehealth CBTI (using real-time audio and visual computer-based communication), 10 sessions, 50 minutes per session	NR	NR	ISI, sleep diary	Patients exhibited clinically significant improvement in both insomnia and these gains were well maintained at 2-month follow-up.
13	McCarthy, M. S. (2018) [36]	Rural breast cancer survivors	18, (18/0)	Telemedicine delivered cognitive behavioral therapy	NR	NR	ISI, DBAS-16, sleep diary	The results of this study support the experimental feasibility of a telemedicine intervention by a nurse to reduce insomnia. Participants showed improvements in sleep, fatigue, quality of life, and cognitive and emotional functioning.

14	McCrae, C. S. (2021) [37]	Children with autism spectrum disorder	17, (3/14)	Telehealth cognitive behavioral therapy, 8 sessions, 50 minutes per session	NR	NR	Actigraphy and electronic sleep diaries	Parents found cognitive behavioral treatment for childhood insomnia helpful sleep
		Parents of children with autism spectrum disorder	17(17/0)	Telehealth cognitive behavioral therapy, 8 sessions, 50 minutes per session	NR	NR	Actigraphy and electronic sleep diaries	Telehealth cognitive behavioral treatment for childhood insomnia improved child and parent
15	Roja, I. (2014) [27]	Over 65 years of age suffering from chronic emotional sleep disorders.	15, (10/5)	Valdoxan (25 mg tablet) in first day + cognitive hypnotherapy with cd, 6 sessions, 45 minutes per session	10, (5/5)	Valdoxan: 25 mg tablet – before bedtime,	Sleep diary	The results of the research show that insomnia patterns disappeared for 75% of women and 80% of men employees in group cognitive hypnotherapy + pharmacological treatment, but in group pharmacological treatment, – only for 20% of women employees
16	Scogin, F. (2018) [38]	Older adult with insomnia and depression in rural area	22, 58.32 ±6.69, (18/4)	Videoconferences CBT-D + CBT-I, 10 sessions, 50 minutes per session	18, 59.78±8.50, (18/0)	Usual care (physician-recommended primary care)	ISI	The intervention group had better clinical results than the control group

TM: Telemedicine, F2F: Face-To-Face, CBT: Cognitive Behavioral Therapy, ICDS-3: International Classification of Sleep Disorders-Third Edition, ISI: Insomnia Severity Index, DBAS-16: an abbreviated version of the Dysfunctional Beliefs and Attitudes about Sleep Scale, GTS: "Go! To Sleep[a]", CBT-I: Cognitive Behavioral Therapy for Insomnia, PSQI: Pittsburgh Sleep Quality Index, BRC: Breast Cancer Patient, d-CBT-I: digital cognitive behavioral therapy for insomnia, NR: Not Reported.

The effect of interventions on insomnia

Studies have used a variety of methods to measure insomnia. The most common method used in studies was the use of ISI questionnaire [12, 13, 25, 26, 28, 29, 33-36]. In all these studies, it was observed that the implementation of CBTI telehealth interventions significantly reduces the ISI score and improves insomnia in groups, and individuals. It was also observed that the use of techniques and interventions such tge Internet-based cognitive-behavioral therapy for insomnia (ICBT-i) has a greater effect on improving insomnia than active control therapy (ICBT-ctrl) [12] (Table 4).

Table 4: The effect of therapeutic interventions extracted from studies in systematic review and meta-analysis on insomnia

Row	First Author	Scale	Group 1	Sample Size	Pre-Treatment (Mean ±SD)	Post-Treatment (Mean ±SD)	Group 2	Sample Size	Pre-Treatment (Mean ±SD)	Post-Treatment (Mean ±SD)	study population
1	Arnedt, J. T. (2021)	ISI	Telemedicine - CBT	33	17.5±3.7	8.6±5.5	face to face CBT	32	17.2±3.4	7.9±3.4	chronic insomnia
2	Bernstein, A. M. (2017)	ISI	web based CBT-I	43	17 (range: 15.6-18.5)	9.8 (range: 8-11.5)	control	45	16.6 (range: 5.4-17.8)	15.3 (range: 13.9-16.6)	chronic insomnia
3	Blom, K. (2016)	ISI	internet based CBT-I	73	168±3.8	8.3±4.1	internet based CBT	75	16.5±3.8)	11.8±4.4	insomnia
4	Chapoutot, M. (2021)	ISI	ACT-e-CBT (videoconferences)	15	21±4.4	10.7±5.2	control	15	19.2±3.9	17.2±3.5	chronic insomnia
5	Dozeman, E. (2017)	ISI	Web based CBTI	171	16.5±3.6	9.2±4.9	NR	NR	NR	NR	breast cancer
6	Gehrman, Philip (2020)	ISI	telehealth CBT-I	49	20.75±4.30	15.76±5.45	in person CBTI	46	20.41±4.03	13.96±6.06	veterans with PTSD
7	Holmqvist, M. (2014)	ISI	telehealth CBT-I	34	18.5	10.77	in person CBTI	33	18.64±4.6	11.05±6	chronic insomnia
7	Holmqvist, M. (2014)	ISI	web based CBT-I	38	18.72	12.78	in person CBTI	33	18.64±4.6	11.05±6	chronic insomnia
8	McCarthy, M. S. (2018)	ISI	telemedicine CBT-I	18	14.78±4.63	7.8±5.73	NR	NR	NR	NR	breast cancer
9	Gehrman, P (2016)	ISI	CBT-I telehealth	214	19.8±5.1	14.8±6.3	NR	NR	NR	NR	veterans

10	Lichstein, K. L. (2013)	ISI	telehealth CBT-I	5	15±4.06	5.4±2.97	NR	NR	NR	NR	Older adult with insomnia and depression

CBT: Cognitive Behavioral Therapy, CBT-I: Cognitive Behavioral Therapy for Insomnia, ACT: Acceptance and Commitment Therapy.

Other criteria used to assess participants' insomnia status were Pittsburgh Sleep Quality Index and Dysfunctional beliefs and attitudes about sleep; considering this, 2 studies used the DBAS-16 questionnaire [13, 36]. In the study of Arnedt et al. [13], a significant improvement in insomnia status was observed according to DBAS criteria. However, no significant difference was observed between the research methods in the intervention and control groups. In another work [36], statistically significant changes were observed in the mean score of DBAS-16 (Table 5).

Three other studies [25, 32, 33] examined sleep quality based on PSQI self-expression tools. In all these articles, a significant decrease in the mean score of the PSQI instrument was observed before and after the intervention. This indicates that the implementation of remote interventions has a positive effect on increasing the quality of sleep. Two other studies [28, 35] examined sleep quality rating based on sleep diary's criteria. The results of these studies indicate a significant increase in sleep quality after interventions (Table 5).

Table 5: Assessment of sleep quality scores for studies extracted from systematic review and meta-analysis

Row	First Author (Year)	Group	Sleep Quality (Mean± SD)	
			Pre-Treatment	Post-Treatment
1	Arnedt, J. T. (2020) [13]	CBT-TM	5.2± 1.6	2.5± 1.8
		Face to Face CBT	5.3± 1.2	2.2± 1.5
2	Chapoutot, M. (2021) [25]	ACT-E-CBT	14.7± 4.1	9.1± 3.9
		Control	14.9± 3.1	12.9± 2.8
3	Franklin, C. L. (2018) [32]	Telephone	15.1± 3.3	11.3± 4
		In-person	14.1± 2.7	12.6± 5.2
4	Gehrman, P. (2020) [33]	Telehealth CBTI	14.64 ± 3.36	11.16 ± 3.87
		In person CBTI	14.49 ± 3.36	10.46 ± 4.59
5	Holmqvist, M. (2014) [28]	Web-based	2.59 ± (0.11)	3.16± (0.17)
		Telehealth-based	2.36± (0.12)	2.43± (0.16)
		In-person	2.31± 0.82	2.19± 0.84
6	Lichstein, K. L. (2013) [35]	CBT-I telehealth	2.4± 0.31	2.8± 0.53
7	McCarthy, M. S. (2018) [36]	Telemedicine dCBT	5.79± 1.57	4.27± 1.51

CBT: Cognitive Behavioral Therapy, CBT-I: Cognitive Behavioral Therapy for Insomnia, ACT: Acceptance and Commitment Therapy.

Studies also used sleep diary criteria. The total sleep time criterion was examined in 7 articles [13, 25, 28, 34, 36, 37]. In most studies, it was observed that after the intervention, people's overall sleep time increases. Only 1 article [25] did not report a positive change in participants' overall sleep time. Another criterion that was examined was sleep onset latency. All studies [13, 25, 28, 34-37] reported that interventions including telehealth ones were effective in reducing sleep latency and increasing sleep quality. Wake time after sleep onset, sleep efficiency, and number of nocturnal awaking were other criteria that were examined in the research works. The results of these studies showed that telemedicine interventions have a positive effect on improving insomnia in different groups (Table 6).

Table 6: Mean sleep scores before and after therapeutic interventions extracted from studies included in the systematic review and meta-analysis

Row	First Author (Year)	Group	Total Sleep Time ± SD (SE)		Sleep Onset Latency ± SD (SE)		Wake Time After Sleep Onset ± SD (SE)		Sleep Efficiency ± SD (SE)		Number of Nocturnal Awaking ± SD (SE)	
			Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post Treatment
1	Arnedt, J. T. (2020) [13]	CBT-TM	6± 1.2	6.4± 1	49.2± 25.3m	22.8± 12.9m	104.8± 49.1	49.3± 30	69.3± 11.3	83.8± 7.7	NR	NR
		face to face CBT	6± 1.4	6.4± 0.9	48.9± 36.8m	22± 14.8m	88.4± 48.1	46.9± 27.4	70.8± 11	84.8± 5.8	NR	NR
2	Chapoutot, M. (2021) [25]	ACT-E-CBT	6.6± 0.3	6.5± 0.2	0.6± 0.1 h	0.2± 0.1h	0.8± 0.48h	0.3± 0.3h	76.1± 2.7	85.2± 2.3	1.4±0.3	0.9± 0.4
		Control	6± 0.2	6.3± 0.2	0.7± 0.1	0.6± 0.1	0.6± 0.5	0.6± 0.5	76.9± 2.6	79.1± 2.2	1.3± 0.3	1.7± 0.4
3	Gehrman, P. (2016) [34]	CBT-I telehealth	5.5± 1.6	5.7± 1.6	50.1± 37.2	29.1± 27.1	45.9± 50.8	30.3± 32.7	72.9± 18	81.6± 13.4	NR	NR
4	Holmqvist, M. (2014) [28]	Web-based	5.57± (0.19)	6.14± (0.19)	57.36± (5.36)	33.06± (4.2)	70.62± (6.96)	45.6± (7)	65.8± (2)	78.2± (2.1)	2.57± (0.19)	1.61± (0.18)
		Telehealth-based	5.37± (0.21)	5.94± (0.19)	57.24± (6.24)	32.34± (4.32)	73.32± (7.62)	43.68± (6.9)	62.5± (2.2)	77.4± (2.1)	2.66± (0.21)	1.73± (0.18)
		In-person	4.82± 1.37	4.97± 1.55	67.8± 58	39.83± 36	63.4± 35.9	40.35± 47.9	60.85± 17.1	70.73± 18.4	2.38± 1.91	1.91± 1.94
5	Lichstein, K. L. (2013) [35]	CBT-I telehealth	NR	NR	39.9± 28.56	20.3± 14.26	30.6± 13.3	7.1± 5.35	NR	NR	2.1± 2.26	0.8± 0.89
6	McCarthy, M. S. (2018) [36]	Telemedicine dCBT	NR	NR	36.81± 30.81	16.02± 12.78	44.42± 29.64	25.27± 20.37	77.79± 12.13	880.5± 5.8	2.37± 1.06	1.7± 0.94
7	McCrae, C. S. (2021) (children) [37]	CBT-I telehealth	519.87± 40.47	553.12± 23.56	34.58± 18.73	17.05± 9.23	NR	NR	79.85± 4.59	84.56± 3.43	NR	NR
8	McCrae, C. S. (2021) (parents) [37]	CBT-I telehealth	435.46 ± 56.48	469.90± 44.87	29.45± 7.87	19.22± 7.72	NR	NR	83.54± 4.25	89.48± 3.59	NR	NR

CBT: Cognitive Behavioral Therapy, CBT-I: Cognitive Behavioral Therapy for Insomnia, ACT: Acceptance and Commitment Therapy.

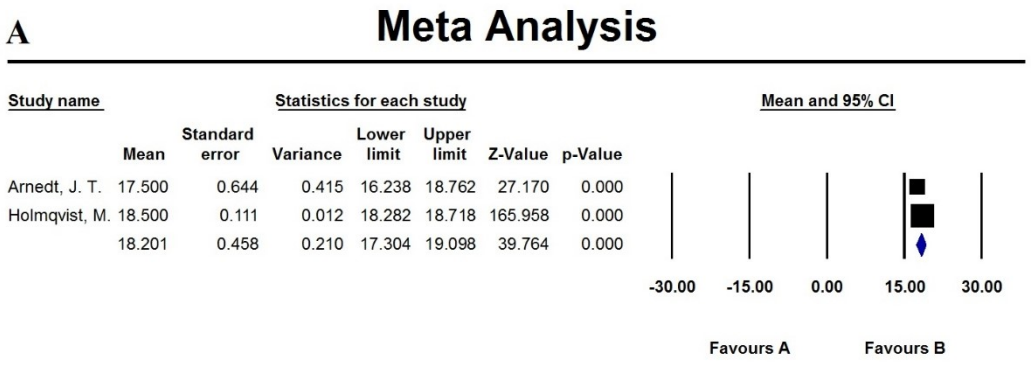
Meta-analysis (non-pharmacological treatment)

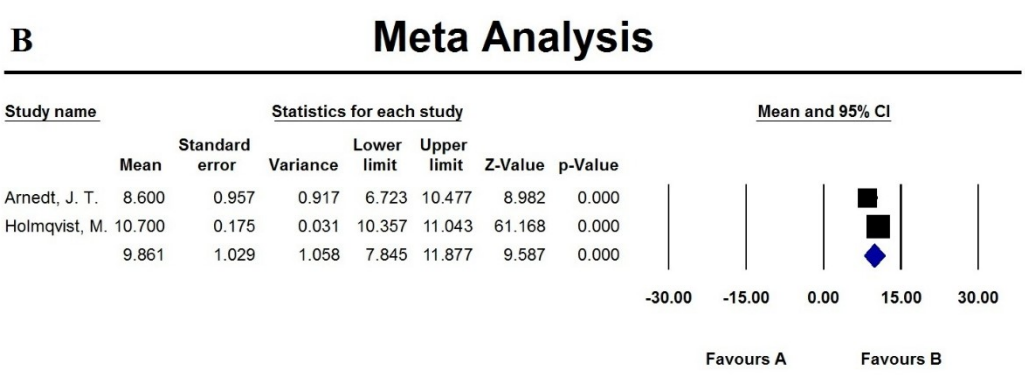
In the selected studies, only quantitative and comparative information in the intervention group of non-drug therapies for insomnia treatment could lead to meta-analysis; such information was divided into two sections of insomnia patients, i.e. without underlying disease and insomnia, and insomnia patients without an underlying disease. Therefore, according to the information obtained, the data could only be meta-analyzed by patients with insomnia without the underlying disease. Moreover, different treatment and intervention methods did not allow meta-analysis.

First non-drug treatment: intervention group (telemedicine with CBT) and control group (face to face CBT)

For a total of 2 studies with a sample size of 67 people (33 people in the intervention group and 34 people in the control group), the result of the I^2 test was obtained to evaluate the mean score of insomnia in the intervention and control groups ($I^2 = 75.5$). Therefore, the random effects model was used for meta-analysis. Due to the fact that only 2 studies were analyzed, Egger's test was not performed to assess the potential publication bias.

Mean and standard deviation of the intervention group (telemedicine with CBT), were obtained 18.2 ± 0.45 before the intervention (Figure 2 (A)) and 9.8 ± 1.02 (Figure 2 (B)) and after the intervention. The mean difference was 5.4 ± 3.6 based on the random effects model (Figure 2 (C)) which shows the positive effect and change of telemedicine intervention with CBT by 5.4 points in improving insomnia in patients. The means and standard deviations of the control group (face to face CBT), were 17.8 ± 0.69 before the intervention (Figure 3 (A)), and 9.3 ± 1.5 after the intervention (Figure 3 (B)). The mean difference was 2.55 ± 0.66 based on the random effects model (Figure 3 (C)). Due to the difference between the reported means of telemedicine intervention with CBT, the method shows a greater effect on improving insomnia than the face to has CBT face.





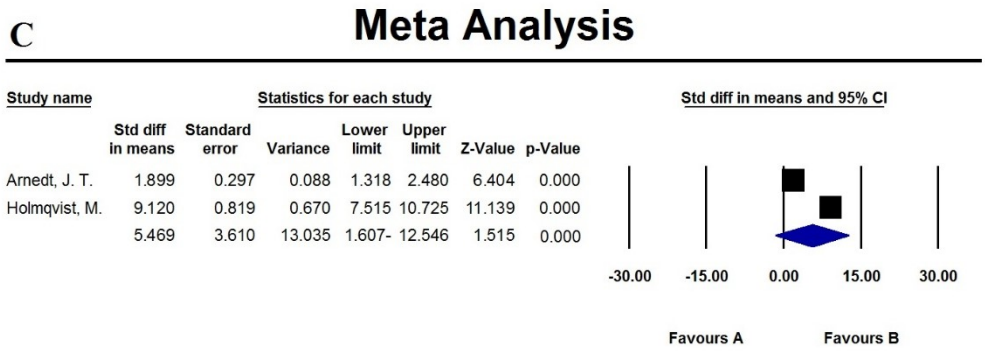
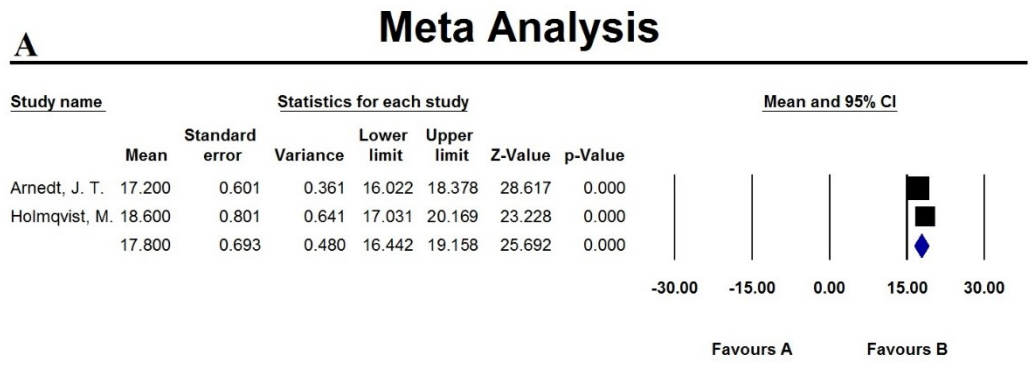
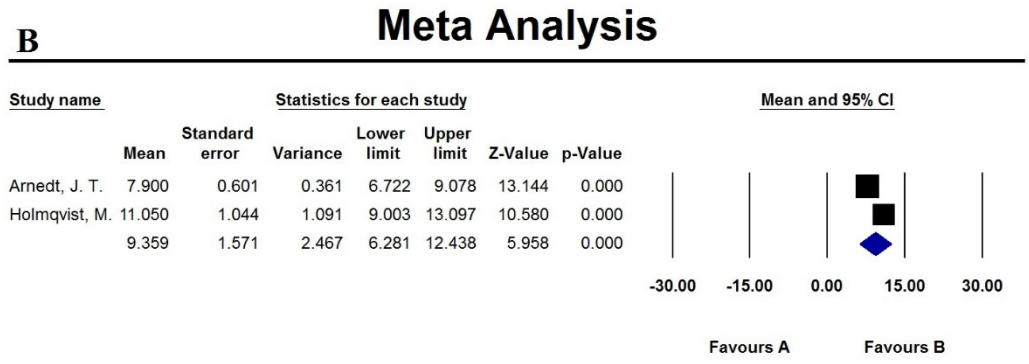


Figure 2: Mean and standard deviation of intervention group (telemedicine with CBT) before intervention (A), after intervention (B), and mean difference before and after intervention





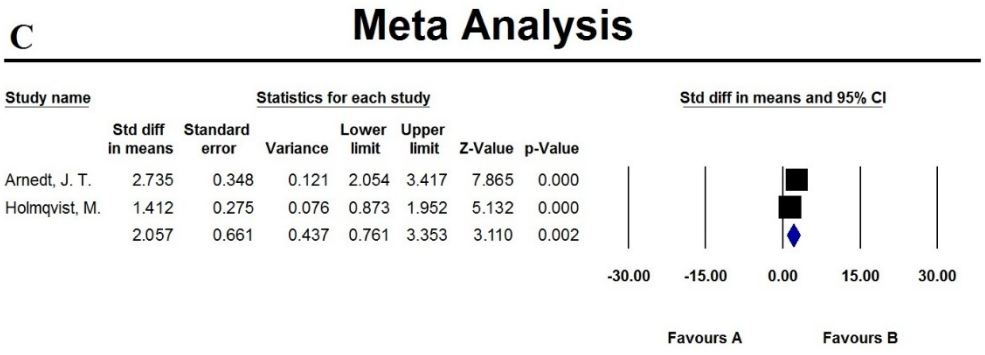


Figure 3: Mean and standard deviation of control group (face to face CBT) before intervention (A), after intervention (B) and, mean difference before and after intervention

Second non-drug treatment: intervention group (telemedicine) and control group (no intervention, blinded)

A total of 2 studies with a sample size of 58 people (43 people in the intervention group and 15 people in the control group), for which the result of I^2 test was obtained to evaluate the mean score of insomnia in the intervention and control groups ($I^2 = 79.6$). They were meta-analyzed and assessed using the random effects model. Due to the fact that only two studies were analyzed, the Egger's test was not performed to examine the publication bias.

Means and standard deviations of the intervention group (telemedicine), before the intervention 18.5 ± 1.9 (Figure 4 (A)), and 9.8 ± 0.44 after the intervention (Figure 4 (B)). The mean was 2.5 ± 0.29 based on the random effects model (Figure 4 (C)), which shows the positive effect and change of telemedicine intervention by 2.5 points in improving insomnia in patients. Mean and standard deviation in the control group (without intervention), before the intervention 17.7 ± 1.2 (Figure 5 (A)), and 16.05 ± 0.92 after the intervention (blinded) (Figure 5 (B)), where the mean difference was 0.65 ± 0.19 based on the random effects model (Figure 5 (C)). Due to the difference between the means, it can be inferred that telemedicine intervention has a greater effect on improving insomnia than the non-intervention group.

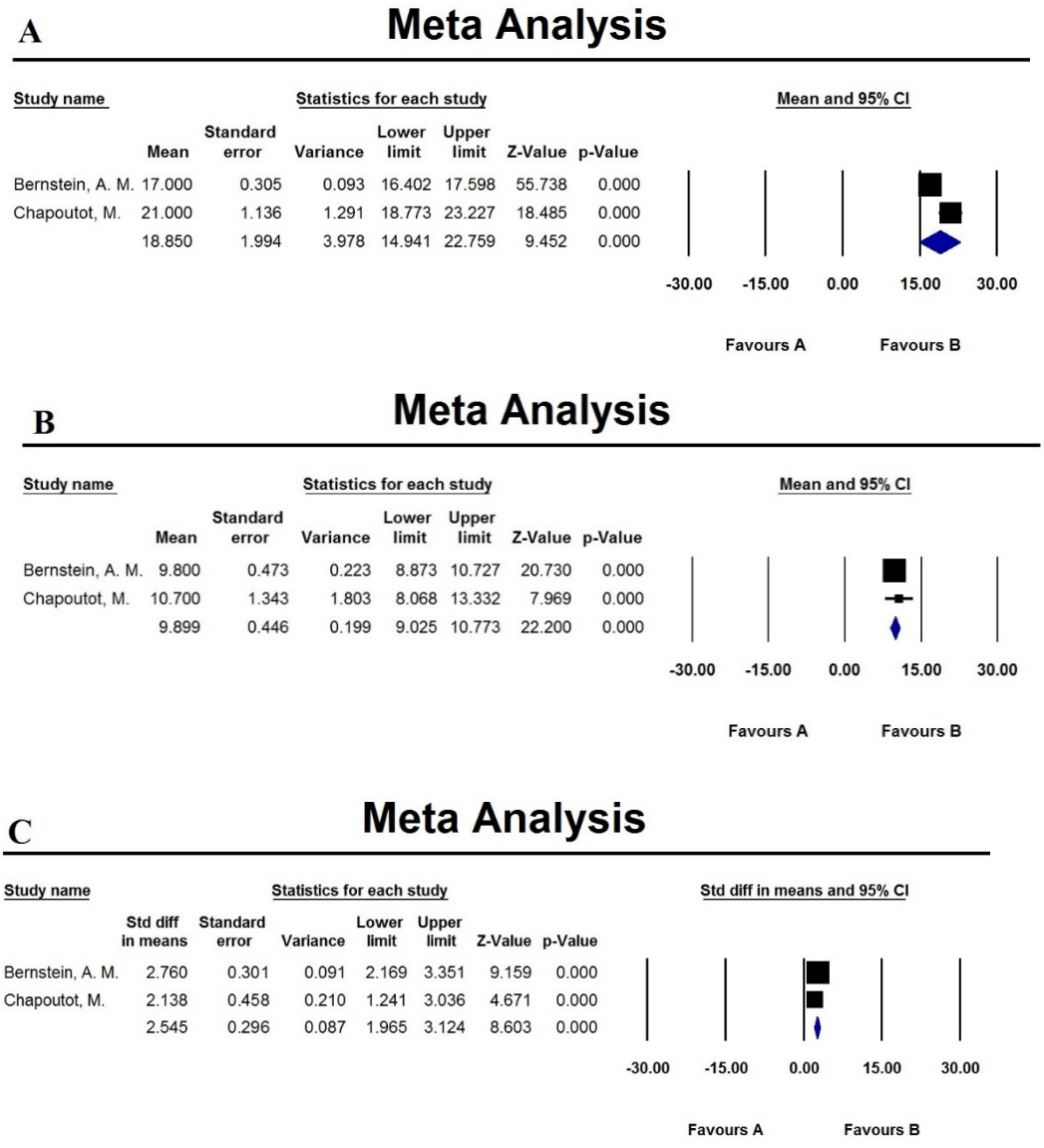


Figure 4: Mean and standard deviation of intervention group (telemedicine) before intervention (A), after intervention (B) and, mean difference before and after intervention

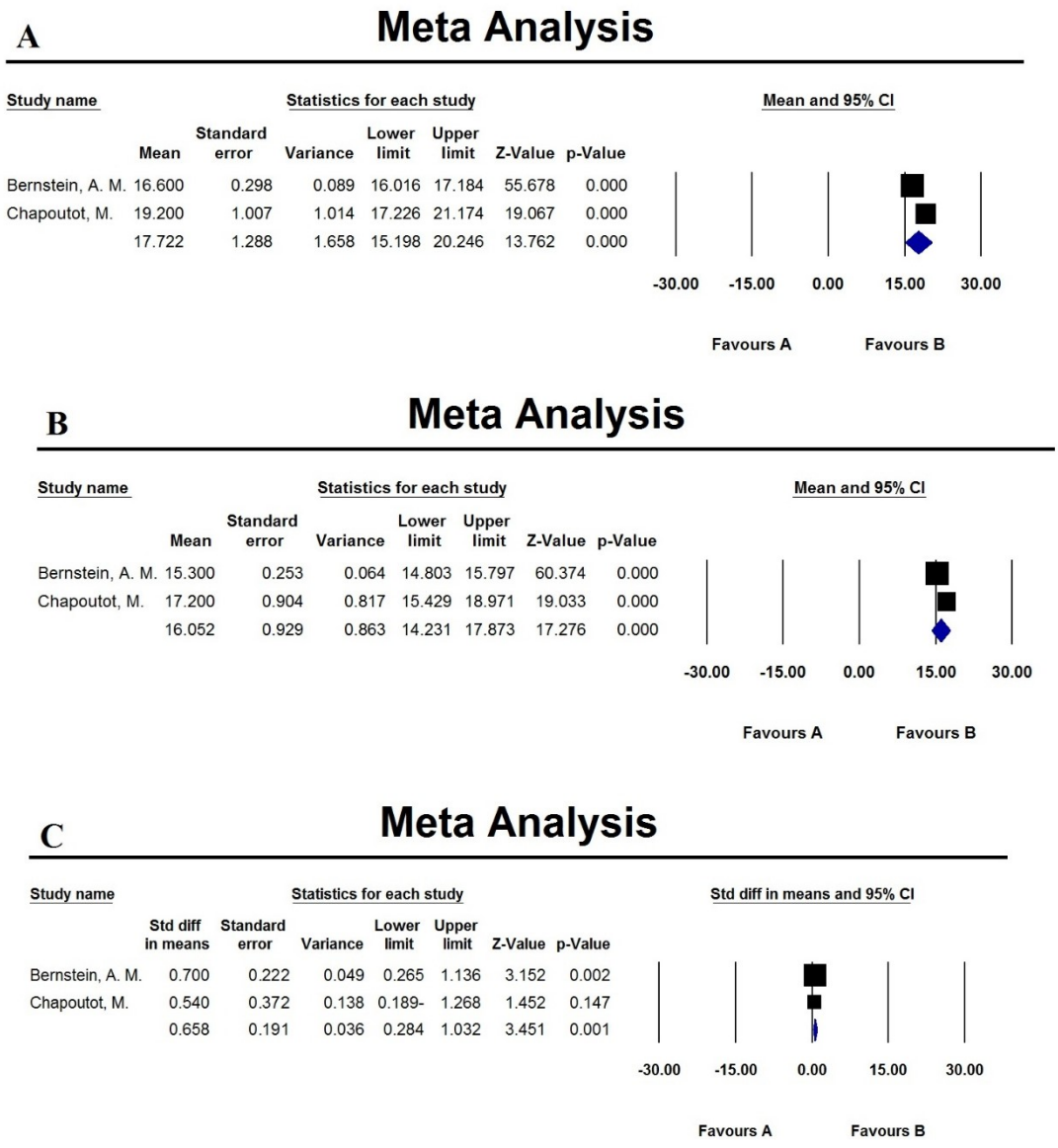


Figure 5: Mean and standard deviation of control group (without intervention, blinded) before intervention (A), after intervention (B), and mean difference before and after intervention

Discussion

The present study was the first systematic review and meta-analysis to investigate telemedicine and insomnia. Analysis of 16 confirmed studies have shown that different telemedicine methods have a positive effect on improving insomnia in different individuals and groups. The results of meta-analysis also showed that CBTI interventions by telemedicine method have a greater effect on improving insomnia among insomnia patients.

Telemedicine is a broad term in health information technology. This concept includes methods for transmitting medical information electronically to improve the health of individuals [40]. Moreover, it expands the boundaries of providing services to patients [41]. Improvement results in conditions such as diabetes, hypertension, stroke and AIDS have been reported using telemedicine. Studies have also shown that telemedicine increases patients' satisfaction and adherence to treatment. Other potential benefits include improved access to healthcare, reduced waiting times for appointments, and reduced care costs [42].

Another positive feature of telemedicine is access to healthcare in an emergency. Today, for instance, the coronavirus (COVID-19) pandemic has created the need and opportunity for remote medical consultation [43]. Considering this, patients' care management are actually performed through non-physical encounters using video conferencing and telephone communication [44]. Telemedicine, while ensuring the safety of patients and healthcare workers in times of crises, has made it possible to provide continuous patient care. These elated telemedicine regulations are expected to continue after the end of the COVID-19 crisis, which is to be welcomed, since telemedicine adds another dimension to healthcare. It can be therefore argued that telemedicine is efficient and cost-effective for patients and healthcare systems [44].

There is ample evidence that demonstrates the important role of telemedicine technologies in enhancing the delivery of health services, including sleep hygiene [42]. Sleep problems occur with increasing age. These problems affect the quality of life of individuals and their families, and can increase the cost of healthcare. Indirect costs of sleep problems, which affect the elderly community entail a range of consequences such as reduced productivity, motor vehicle accidents, hospitalization, increased medical costs of mental illnesses such as depression, and increased alcohol consumption [45]. Among the elderly, medication is often prescribed to treat their health problems. Many of these drugs have many side effects. According to a study by Montgomery et al., Cognitive-behavioral therapies for sleep problems in people aged 60 and older have a mild effect on some aspects of sleep [46]. However, previous studies have shown that mindfulness training, alone or in combination with Cognitive Behavioral Therapy, can improve sleep in adults with an underlying disease (e.g. cancer) or those with ADHD. [45]. With all these interpretations, the lack of experienced practitioners and financial costs are among the barriers that affect such successful sleep interventions [47].

Telemedicine has significant potentials for expanding access to non-pharmacological treatment of insomnia [48]. For example, in an effort to improve access to sleep intensive care, a telemedicine protocol was implemented at the Veterans Administration Medical Center (VAMC), Milwaukee, WI, in 2008. According to the results of the study of Baig et al., the implementation of telemedicine sleep protocol in VAMC Milwaukee was associated with increased efficiency of sleep services [42].

Some paediatric sleep disorders may also be fully evaluated, diagnosed, and treated during virtual video visits, since physical examination findings may add little or no significant additional information. These cases in particular may include circadian rhythm disorders, especially delayed sleep-wake phase disorder, insomnia, and sleep-related movement disorders, such as Restless legs [49]. A systematic review by McLay et al. in 2020 provided evidence of a positive effect of telehealth interventions on sleep problems in children and adolescents [47]. Another study in 2017 showed that the use of telemedicine programs in sleep, changes behavior and improves sleep patterns [50].

Sleep telemedicine refers to the exchange of patient data with the aim of increasing disease management. Data is transmitted over the telephone or the Internet, through video applications and smartphones, and patient feedback is provided in the same way. The main goal of sleep telemedicine is to obtain good quality sleep evidence outside the sleep laboratory [51]. New approaches and initiatives are needed to improve access to quality sleep care. The development and implementation of telemedicine and telehealth application programs for sleep care is an appropriate and creative way to address this vital need for healthcare. Telehealth not only improves access to sleep services, but can also improve the efficiency of health services in terms of time and cost [52].

Limitations

Among the limitations of this study was that only a small number of studies were reviewed. Other limitations include the very high dispersion of studies, which made it impossible to perform meta-analysis. On the other hand, half of our the selected were interventional and did not have a control

group. Therefore, it was not possible to comment with certainty on the positive effect of telemedicine methods compared to other treatments in some patients, such as breast cancer and autism.

Conclusion

According to the results of this study, it can be stated that the answer to the study question i.e. whether telemedicine can be a substitute for face-to-face measures for the diagnosis, follow-up and treatment of insomnia? is positive. Non-pharmacological interventions with telemedicine methods are one of the effective ways to improve chronic insomnia, and insomnia due to other illnesses. The results of meta-analysis showed that telemedicine methods are more effective in treating chronic insomnia than face-to-face methods. Therefore, the treatment of insomnia using telemedicine methods should receive further attention. These methods are very useful in critical situations such as the COVID-19 pandemic and in areas where specialized facilities are not available for face-to-face visits.

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