Assessing digitally delivered sleep interventions: are they feasible and acceptable?

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Chapter 1: Systematic Review

The acceptability of digital cognitive behavioural therapy for insomnia (dCBT-I) interventions: a mixed methods systematic review

Prepared in accordance with the author guidelines for Clinical Psychology Review

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Abstract

Digital cognitive behavioural therapy for insomnia (dCBT-I) is a promising solution to the widely recognised lack of access to CBT-I treatments. Although dCBT-I has been found to be effective, it is unclear how acceptable it is to recipients. This mixed-methods systematic review aimed to ascertain the acceptability of dCBT-I interventions by integrating a range of acceptability data from across quantitative, qualitative and mixed-methods studies. PsycINFO, CINAHL, EMBASE, Medline and The Cochrane Library were systematically searched, yielding 1112 unique citations from which 53 studies were identified for review. 25 studies only reported proxy measures of acceptability, the results of which were extremely varied across studies. Six interrelated themes emerged from acceptability data extracted from the remaining 28 studies: general acceptability, perceived helpfulness, individualised needs, congruence with personal life, functionality and design. There was a trend towards acceptability across several of the identified themes but evidence that dCBT-I interventions are not always congruent with recipients' personal lives nor allow for variability of their individualised needs. Methodological issues with the way acceptability is defined and measured in the literature suggests that improvements are needed to future research design before we can be confident in these findings.

1. Introduction

While estimates vary by country and demographic variables, insomnia is widely considered a common condition, with one recent meta-analysis of international studies suggesting a point prevalence of as high as 22% (Zeng et al., 2020). Insomnia frequently co-occurs with other disorders, particularly mental health disorders such as depression (Baglioni et al., 2011), and there is evidence to suggest the relationship is bidirectional in nature (Alvaro et al., 2013).

Although there are a variety of both pharmacological and non-pharmacological treatments available for the treatment of insomnia, clinical guidelines internationally are consistent in their recommendation that cognitive behavioural therapy for insomnia (CBT-I) be the first line treatment for insomnia (Ree et al., 2017; Riemann et al., 2017). These recommendations are based on robust evidence from a number of randomised controlled trials demonstrating CBT-I is effective at improving outcomes on key sleep variables. For example, one meta-analysis reported a significant reduction with a large effect size (g = 0.98) in scores on the Insomnia Severity Index (ISI; a validated and widely used measure for severity of insomnia symptoms), and moderate effect sizes for the improvement of individual sleep variables such as sleep efficiency (SE; g = 0.71), sleep onset latency (SOL; g = 0.57) and wake after sleep onset (WASO; g = 0.63) (Van Straten et al., 2018). Furthermore, these improved outcomes appear to be maintained over the long term , with one study reporting between 43.7% and 62.7% of participants remaining in remission (scoring <8 on the ISI) at 24 months (Beaulieu-Bonneau et al., 2017). Other studies have indicated that CBT-I can also be effective at lower "doses" than the traditional eight sessions (Morin and Espie, 2007). For example, Edinger at al. (2007), who compared outcomes for the delivery of CBT-I over a varying number of sessions, reported statistically significant improvements in Insomnia Symptom Questionnaire (ISQ) scores at both eight weeks and six months follow-up for participants receiving one and four sessions of CBT-I but not those receiving two or eight sessions. They also reported clinically significant (i.e. either a 50% reduction in Insomnia Symptom Questionnaire scores or a reduction in scores from a "pathological" to "normal" range from baseline compared to eight weeks) improvements in 56.3% and 58.3% of participants receiving one and four sessions respectively, compared to 22.2% and 29.4% of participants receiving two or eight sessions respectively.

Despite the current clinical guidelines and the strength of the evidence base underpinning them, the availability of CBT-I remains low. For example, a recent taskforce linked to the European Insomnia Network and European Sleep Research Society concluded that the availability of access to CBT-I in Europe is severely limited and that this may be linked, in part, to the poor availability of standardised, high-quality training for practitioners (Baglioni et al., 2020). There have been

various other reasons put forward to explain the poor availability of CBT-I, such as insufficient numbers of skilled practitioners providing CBT-I, lack of awareness or motivation in primary care or referring clinicians and a lack of awareness and knowledge of treatment options in patients (Koffel et al., 2018).

One solution to the lack of availability of CBT-I has been to adapt the materials to various forms of digital delivery such as via telephone, the internet and smartphone apps (for a review see Luik et al., 2017b). These approaches have the advantage that they can be delivered in an automated or semi-automated manner, therefore requiring less input from trained professionals. Although some have suggested that digital CBT-I (dCBT-I) is less effective than an in-person approach (Lancee et al., 2016), a recent network meta-analysis comparing a variety of treatment approaches (both digital and non-digital) for insomnia with usual care found that web-based CBT-I produced statistically significant improvements in key areas such as total sleep time (TST), SE, SOL and WASO, and that these were not significantly different to the improvements found in face-to-face approaches (Hasan et al., 2022).

The adoption of digital approaches continues to increase, accelerated by contextual factors such as the coronavirus pandemic (Wosik et al., 2020). Such approaches appear to be viewed increasingly positively by clinical decision-makers (Simon et al., 2021) making research into the implementation of dCBT-I approaches ever more relevant. Studies looking at how healthcare interventions can successfully be implemented in "real-world" settings point to the importance of considering their acceptability (Klaic et al., 2022). However, there is a lack of consensus in the broader literature regarding models and definitions of acceptability in healthcare interventions. Sekhon et al. (2017) conducted an overview of reviews across the acceptability literature and concluded that there was no consistently used definition of acceptability nor did any of the included reviews put forward theories of acceptability as a construct. More recently, similar results were reported by Klaic et al. (2022) who found that of 132 reviews exploring acceptability, only 13 set out a definition of acceptability in advance of conducting their review and only 6 reported using a framework of acceptability. Four of these six studies utilised the Theoretical Framework of Acceptability (TFA), which was proposed by Sekhon et al (2017) to address the deficit of such a model in the literature. The TFA outlines seven core components of intervention acceptability (affective attitude, burden, perceived effectiveness, ethicality, intervention coherence, opportunity costs and self-efficacy), based on the definition of acceptability as "A multi-faceted construct that reflects the extent to which people delivering or receiving a healthcare intervention consider it to be appropriate, based on anticipated or experienced cognitive and emotional responses to the intervention" (Sekhon et al., 2017, p.4). As few other such comprehensively defined, developed and cited frameworks regarding the acceptability of

healthcare interventions exist, the TFA was considered the most appropriate model for the current review.

The acceptability of digital interventions has previously been reviewed in depression (Kaltenthaler et al., 2008), post-traumatic stress disorder (Simon et al., 2019) and broadly across common mental health disorders (Treanor et al., 2021). The recent systematic reviews which have attempted to address this question in the context of insomnia interventions have either not looked at digital approaches specifically (Ho et al., 2015) or have used only drop-out as a measure of acceptability (Zhang et al., 2022; Gao et al., 2022). Several studies (Sekhon et al., 2017; Szafranski et al., 2017; Ortblad et al., 2022) have expressed concern at the sole use of proxy measures, such as drop-out, to assess acceptability, considering them an insufficient measurement of, or conceptually separate from, a multi-faceted construct of acceptability.

This study, therefore, aims to address this gap in the literature by integrating qualitative and quantitative evidence from across the literature base to address the following questions:

1. How acceptable are methods for delivering digital cognitive behavioural therapy for insomnia (dCBT-I) interventions to adults experiencing insomnia?
2. What types of acceptability data are commonly reported? How do these map onto the Theoretical Framework of Acceptability (TFA) proposed by Sekhon, Cartwright & Francis (2017)?

2. Methods

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA; Moher et al., 2015) guidelines were followed throughout the review process. The review protocol was registered on PROSPERO (registration number: CRD42022310268). A PICOS (population, intervention, comparator, outcome, study design) framework was used to develop both the eligibility criteria and search strategy used in this review (see Table 1.1.)

Table 1.1. Review specifications outlined in a PICOS framework

Framework Dimension	Review Specifications
Population	Adults experiencing insomnia or insomnia symptoms
Intervention	Digitally delivered CBT-I (dCBT-I)
Comparator	*(not applicable for review question)*
Outcome	Quantitative or qualitative measures of acceptability
Study Design	Primary research studies of any design (qualitative, quantitative or mixed methods)

2.1. Eligibility Criteria

2.1.1. Inclusion:

a) Working age adults (aged 16-65 years inclusive) whose primary difficulty is insomnia, as captured by validated measures or by questions explicitly reported as based on commonly accepted diagnostic frameworks (e.g. ICD-10, DSM-5, ICSD-3)
b) Cognitive behavioural therapy for insomnia (CBT-I) interventions of which at least 50% of the therapeutic content is digitally delivered (including via telephone) and contains no more than 25% material not related to CBT-I (e.g. behavioural activation for depression or techniques for pain management).
c) Studies which report quantitative or qualitative acceptability data, including proxy or observational measures such as attrition (i.e. drop-out *during* the course of intervention), adherence (e.g. module or homework completion rates).

d) Full-length peer-reviewed articles reporting primary research studies of any design, published in English, in peer-reviewed journals.

2.1.2. Exclusion:

a) Studies involving children (under 16 years of age), elderly people (over 65) and adults with a learning disability, as CBT-I intervention protocols can be modified for these populations.
b) Studies where participants are recruited based on the presence of a specific neurological, medical or physical condition (e.g. cancer, asthma, traumatic brain injury, pregnancy etc.), or whose insomnia is related to sleep breathing difficulties (e.g. sleep apnea).
c) Studies where the only acceptability data reported is drop-out at follow up (i.e. drop out reported at a timepoint some time *after* the completion of the dCBT-I intervention rather than during the intervention or immediately after it was completed) as this is considered less likely to be measuring the acceptability of the intervention specifically.
d) Studies where the acceptability data explicitly pertains to only the intervention content (e.g. whether participants found sleep restriction techniques helpful) as the focus of this review is on the digital delivery method.
e) Studies where the acceptability data cannot be easily extracted for synthesis.

2.2. Information Sources

A search of online literature was completed on 9th April 2022 using the following databases: PsycINFO and CINAHL (via the EBSCOhost platform), EMBASE and Medline (via the OVID platform) and The Cochrane Library. Searches were restricted to human studies but no other restrictions, for example to the publication date, were applied.

2.3. Search Strategy

The search strategy formed from our PICOS framework (see Table 1.1.) was broad to avoid excluding any relevant articles. It utilised both standard terms (e.g. Medical Subject Headings) and Boolean operators to capture the key concepts of insomnia, cognitive behavioural therapy for insomnia and digital platforms. The sections of the search concerning digital platforms were based on search terms developed by Ayiku et al. (2021). The full search strategy for each database searched can be found in Appendix A.1.

2.4. Selection Process

After duplicates were removed, the title and abstract of articles were screened by the lead author using a checklist (see Appendix A.2.) based on the eligibility criteria described in Section 2.1. A portion (25%; n= 278) were independently screened by a second researcher (JL). A high level of inter-rater reliability (k = 0.97; 4/278 studies rated differently) in ratings was found at this stage. Inconsistencies were resolved by discussion with the second researcher and the wider research team. After retrieving the full-text articles, the lead author screened the remaining search results using the eligibility criteria. The second researcher independently completed full-text screening of a portion (n=5) of these studies. Raters were in 100% agreement regarding screening decisions at this stage.

2.5. Data Extraction

The data from included studies were extracted and logged by the lead author and were managed on a shared Microsoft Excel spreadsheet. This included publishing details (e.g. author, year of publication, country), population characteristics (e.g. recruitment source, sample size, demographic variables, comorbidities reported), study design type, intervention characteristics (e.g. digital device used, CBT components included, level of clinician involvement) and acceptability data (e.g. drop-out rate, adherence, survey results). Attempts were made to contact authors for further or missing data where required, however none responded within the timeline required for this submission and therefore only data available as written in the published studies was extracted for synthesis. During the data extraction process, it was noted that a high number (n=25) of these studies only reported proxy measures of acceptability (usually module completion or attrition rates) which, as previously discussed, are insufficient for the purposes of drawing any deeper conclusions about acceptability. Since these studies met our original inclusion criteria, their results have been reported and summarised separately in Section 3.3. However, they were not included in further quality appraisal or data synthesis stages. This decision was taken in order to make pragmatic use of researcher time by focusing the review on types of data which provide richer insight into the issue of acceptability.

2.6. Quality Appraisal

The Mixed Methods Appraisal Tool (MMAT, 2018 version; Hong et al., 2018) was used to assess all included studies on their methodological quality. The MMAT is recommended for systematic mixed methods study reviews and assesses studies across five domains. The focus of these

domains depends on the design of the study being reviewed, with five different study design types (qualitative, quantitative randomised controlled trials, quantitative non-randomised controlled trials, quantitative descriptive and mixed methods) covered by the tool.

All included studies had their quality rated by the lead author. A second researcher independently rated a randomly selected portion (n=5) of the studies to confirm inter-rater reliability. Differences in rating did not exceed one star at this stage. Disagreements were resolved by discussion with the second researcher and the wider research team until a consensus was reached.

2.7. Synthesis Strategy

Several synthesis strategies for mixed methods systematic reviews were considered for this review, for example, convergent integrated and convergent segregated approaches. A convergent segregated approach involves the separate synthesis of qualitative and quantitative data where these represent independent but related facets of a particular area of interest. This review, however, utilised a convergent integrated approach, and followed the methodology for mixed methods systematic reviews recommended in the Joanna Briggs Institute Manual for Evidence Synthesis (Lizarondo et al., 2020). A convergent integrated approach is considered more suitable for research questions such as ours which can be addressed using both quantitative and qualitative study methodologies. In this approach, synthesis of quantitative and qualitative data occurs simultaneously, which is made possible by transforming the extracted data where necessary.

Although guidance from the Joanna Briggs Institute (The Joanna Briggs Institute, 2014) advises transforming quantitative data into "qualitized" data to ensure accurate results, there is currently little further guidance or consensus in the literature regarding the best way to do so. The quantitative data extracted from included studies was therefore transformed into "qualitized" data by the lead author using a pre-agreed protocol designed by the research team (see Appendix A.3.). In summary, this process involved: a) using the study author's own descriptors where possible and logical in order to minimise introducing additional bias to the interpretation of data, b) using any qualitative categories already existing in the literature for any validated measures and c) using consistent qualitative categories created by the research team to describe a value's relative position (e.g. extremely low, low, moderate etc.) on the reported scale. For the purposes of this submission, it was not possible for the transformation protocol to be cross-checked by another member of the team, although this process is being completed retrospectively on a small number (n = 4) of studies for the purposes of publication. The transformed data could then be

integrated via an inductive thematic approach (Pluye and Hong, 2014) whereby similarities and differences were compared and grouped into key concepts by the lead author to create subthemes and themes, before being described narratively.

3. Results

The stages and outcomes from the searching and exclusion process are summarised in Figure 1.1. below. A total of 1112 articles were retained for screening after all duplicates (n=1029) were removed. Title and abstract screening excluded 854 articles, resulting in 258 articles proceeding to full text screening. 203 of these studies did not meet review eligibility criteria and 2 could not be accessed, leaving 53 studies for inclusion in this review. Just under half of these studies (n=25) only reported minimal proxy or observational measures of acceptability and so were treated as outlined in Section 2.5., while the remainder (n=28) proceeded through the quality appraisal and full data extraction process.

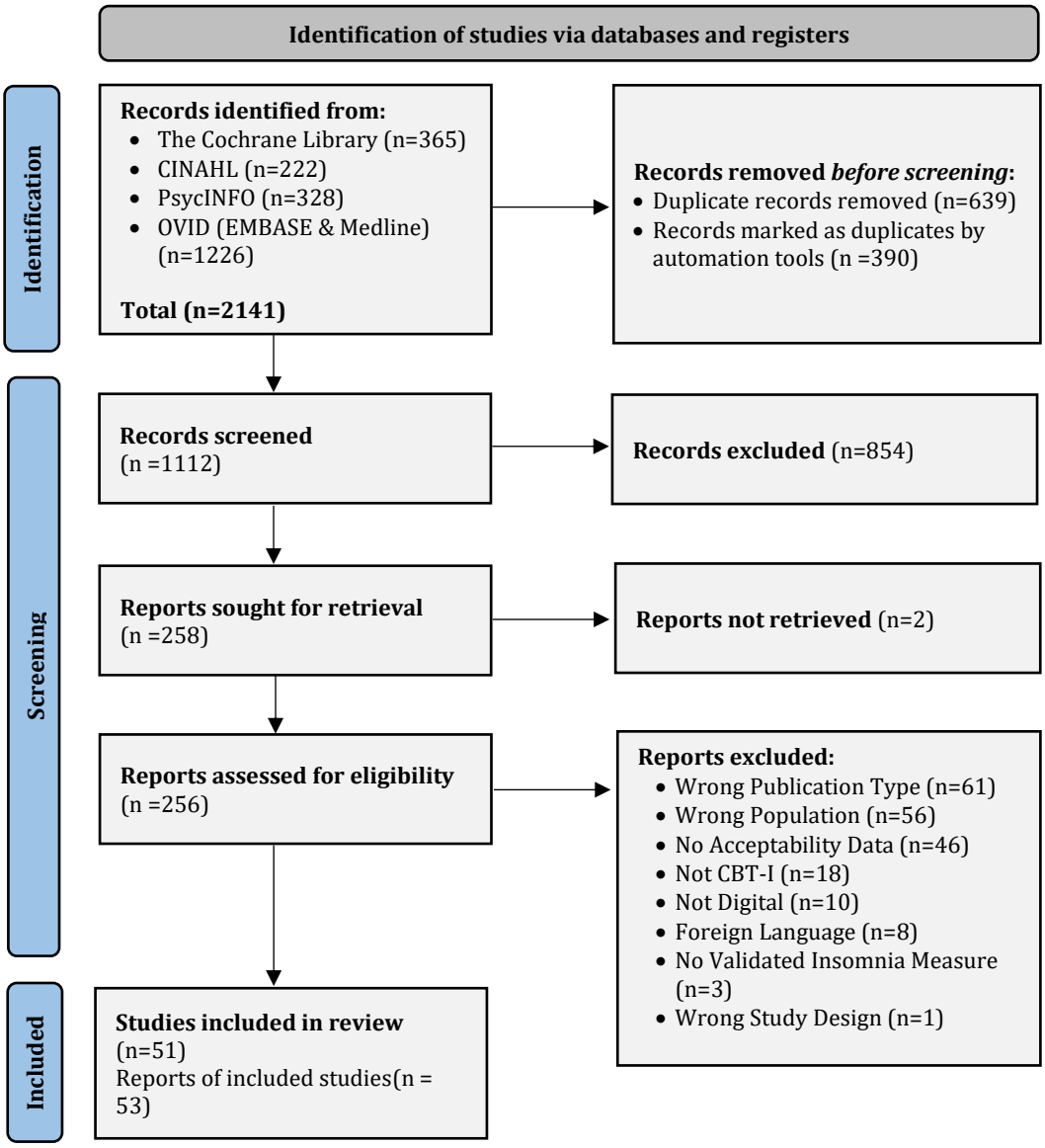

Figure 1.1. PRISMA (2020) flow diagram outlining the study selection process

3.1. Study Characteristics

Table 1.2. summarises the key characteristics of the 28 studies which underwent the full review process. (Study characteristics for the remaining 25 studies which only reported minimal proxy measures of acceptability and were therefore treated as discussed in Section 2.5. are summarised separately in Appendix 4.) Of the 28 studies included for full review 23 were randomised controlled trials, two were uncontrolled pre-post trials, two were qualitative studies and one was a longitudinal case-control study. Two articles included for review were generated from the same study sample as another included article, meaning that the 28 articles represent a sample of 1697 participants who received a dCBT-I intervention across 26 studies. The participants were generally in the 35-49 years age range (full average age range: 19.7 – 59 years old) and were more likely to be female (20 out of 26 studies reporting samples equal to or greater than 65% female). Six studies recruited from populations with specific mental health comorbidities, such as depression.

3.1.1. Design of CBT-I interventions

The majority (n = 23) of studies used the Internet as their digital delivery method, while four used mobile applications and two used teleconferencing (one study compared two forms of digital delivery and a control). The number of modules and length of intervention period varied (range: five to eleven modules and two to ten weeks respectively), with 6 modules being the most common (reported in 16 studies) length of intervention. A large number (n = 11) of studies utilised fully automated interventions which required no clinician involvement in their delivery. Those which were not fully automated reported a range of clinician involvement from minimal online written feedback on homework exercises to fully clinician guided (e.g. when delivered via teleconferencing).

3.1.2. Acceptability Data Collection

All studies collected acceptability data retrospectively (i.e. after the intervention was completed), while four studies also collected acceptability data prospectively and one study collected acceptability data concurrently to the intervention. Acceptability data was collected through proxy (i.e. observational) measures, such as module completion rate and attrition, in 19 studies. Rating scales, either standardised or non-standardised, were used to collect acceptability data in 19 studies (see Table 1.2. for further information on the rating scales used). Two studies did not report the range of the scale used; it was therefore not possible to transform the average scores

reported and these were counted as missing data points (n=2; see Table 1.2. for other details of these studies). Nine studies used qualitative methods, such as interviews and open questions on questionnaires, to collect acceptability data.

Table 1.2. Characteristics of studies included for review

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**	**Intervention Characteristics**	**Acceptability Data Characteristics**
Kuhn et al. (2022) USA	Pilot RCT	**Sample size:** 25 (50) *experimental group (total)* **Average Age:** 44 (7.64) *M (SD)* **Gender:** 56% *% Female* **Comorbidity*:** n/a	**Delivery Method:** Mobile Application **Intervention Period:** 6 weeks **Number of Modules:** non-structured **Module length:** n/a **Clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** retrospective **Collection method:** rating scales (uMARS, SUS) qualitative interview
Arnedt et al. (2021) USA	RCT	**Sample size:** 33 (65) *experimental group (total)* **Average Age:** 43.7 (17.4) *M (SD)* **Gender:** 69.7% *% Female* **Comorbidity*:** n/a	**Delivery Method:** Teleconferencing **Intervention Period:** 6 weeks **Number of Modules:** 6 **Estimated module length:** 30-60 min **Level of clinician involvement:** 100% clinician involvement in material delivery	**Timepoint(s) Gathered:** retrospective **Collection method:** attrition module completion rating scale (CSQ-8)
Chan et al. (2021) Hong Kong	RCT	**Sample size:** 167 (322) *experimental group (total)* **Average Age:** 27.3 (7.25) *M (SD)* **Gender:** 65% *% Female* **Comorbidity*:** depression	**Delivery Method:** Mobile Application **Intervention Period:** 6 weeks **Number of Modules:** 6 **Estimated module length:** 30-60 min **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** retrospective **Collection method:** rating scale
Sveen et al. (2021) Sweden	RCT	**Sample size:** 10 (21) *experimental group (total)* **Average Age:** 49.9 (5.8) *M (SD)* **Gender:** 70% *% Female* **Comorbidity*:** bereavement	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 9 **Estimated module length:** n.r. **Level of clinician involvement:** weekly review of homework & non-instantaneous messaging	**Timepoint(s) Gathered:** retrospective **Collection method:** attrition module/homework completion rating scale (CSQ-8) RDQ

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**	**Intervention Characteristics**	**Acceptability Data Characteristics**
Behrendt et al. (2020) Germany	RCT	**Sample size:** *experimental group (total)* 88 (177) **Average Age:** *M (SD)* 46.1 (9.5) **Gender:** *% Female* 67% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 8 weeks **Number of Modules:** 6 modules **Estimated module length:** 45-60min **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** retrospective **Collection method:** module completion reasons for drop-out rating scale (CSQ-8)
Leonard and Duncan (2020) USA	Uncontrolled Pre-post	**Sample size:** *experimental group (total)* 41 **Average Age:** *M (SD)* 22 (9.42) **Gender:** *% Female* 77% **Comorbidity*:** n/a	**Delivery Method:** Mobile Application **Intervention Period:** 4 weeks **Number of Modules:** non-structured **Estimated module length:** n/a **Level of clinician involvement:** one face to face psychoeducation session	**Timepoint(s) Gathered:** retrospective **Collection method:** self-reported app component usage time spent on app rating scale (uMARS)
Denis et al. (2020) UK	Pilot RCT	**Sample size:** *experimental group (total)* 99 (199) **Average Age:** *M (SD)* 19.73 (2.94) **Gender:** *% Female* 100% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 6 **Estimated module length:** n.r. **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** retrospectively **Collection method:** module completion rating scale (RDQ)
Sunnhed et al. (2020) Sweden	RCT	**Sample size:** *experimental group (total)* 73 (219) **Average Age:** *M (SD)* 51.8 (14.5) **Gender:** *% Female* 69.9% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 10 weeks **Number of Modules:** 10 modules **Estimated module length:** n.r. **Level of clinician involvement:** 15 min telephone call per week	**Timepoint(s) Gathered:** prospective, retrospective **Collection method:** attrition module completion rating scales (CSQ-8, RDQ, TC/EQ¶)

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**	**Intervention Characteristics**	**Acceptability Data Characteristics**
Moloney et al. (2020) USA	Uncontrolled, pre-post, mixed methods trial	**Sample size:** *experimental group (total)* 46 **Average Age:** *M (SD)* 55 (n.r.) **Gender:** *% Female* 100% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 6 **Estimated module length:** 45min **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** retrospective **Collection method:** intervention completion rating scale (RDQ) semi-structured interview
van der Zweerde et al. (2019) Netherlands	RCT	**Sample size:** *experimental group (total)* 52 (104) **Average Age:** *M (SD)* 44.6 (1.82) **Gender:** *% Female* 80.8% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 5 **Estimated module length:** n.r. **Level of clinician involvement:** 40min online guidance total per participant	**Timepoint(s) Gathered:** retrospective **Collection method:** attrition rating scales (RDQ)
Krieger et al. (2019) Switzerland	RCT	**Sample size:** *experimental group (total)* 42 (104) **Average Age:** *M (SD)* 42.17 (12.4) **Gender:** *% Female* 61.9% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 8 weeks **Number of Modules:** 8 **Estimated module length:** n.r. **Level of clinician involvement:** unlimited virtual messaging with allocated "guide"'	**Timepoint(s) Gathered:** retrospective **Collection method:** module completion rating scales (ZUF-8¶, SUS)
Okujava et al. (2019) Georgia	Longitudinal case-control study	**Sample size:** *experimental group (total)* 52 **Average Age:** *M (SD)* 33.5 (n.r.) **Gender:** *% Female* 65% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 10 weeks **Number of Modules:** 6 **Estimated module length:** 30 min **Level of clinician involvement:** virtual messaging to therapist, therapist feedback on homework	**Timepoint(s) Gathered:** retrospective **Collection method:** module completion self-reported reason for drop-out feedback via RDQ

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**		**Intervention Characteristics**	**Acceptability Data Characteristics**
Forsell et al. (2019) Sweden	RCT	**Sample size:** *experimental group (total)* **Average Age:** *M (SD)* **Gender:** *% Female* **Comorbidity*:**	149/51/51 (251) 47.8 (13.9)/ 43.4 (14.3)/ 46.2 (12.5) 65.8%/ 70.6%/ 76.5% n/a	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 11 **Estimated module length:** n.r. **Level of clinician involvement:** Standard: 15 min per week via text messages; Adapted: telephone report and increased text messages	**Timepoint(s) Gathered:** retrospective **Collection method:** rating scale (CSQ-8)
Hagatun et al. (2019) Norway	RCT	**Sample size:** *experimental group (total)* **Average Age:** *M (SD)* **Gender:** *% Female* **Comorbidity*:**	95 (181) 45 (12.4) 64% n/a	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 6 **Estimated module length:** n.r. **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** retrospective **Collection method:** module completion rating scales (IQ, UQ)
Heim et al. (2018) Multi-site (Switzerland, Germany, Austria)	RCT	**Sample size:** *experimental group (total)* **Average Age:** *M (SD)* **Gender:** *% Female* **Comorbidity*:**	29 (56) 41.72 (17.31) 72% n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 6 **Estimated module length:** 10-20min **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** concurrent, retrospective **Collection method:** rating scales (BPSR, RDQ, TC/EQ)
Chan et al. (2017) Australia	Qualitative Study	**Sample size:** *experimental group (total)* **Average Age:** *M (SD)* **Gender:** *% Female* **Comorbidity*:**	39 59 (n.r.) 0% depression	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 6 **Estimated module length:** 45-60min **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** retrospective **Collection method:** online survey semi-structured interview

Publishing Details *(author, year, location)*	Design	Sample Characteristics	Intervention Characteristics	Acceptability Data Characteristics
Lancee et al. (2016) Netherlands	RCT	**Sample size:** 30 (90) *experimental group (total)* **Average Age:** 41.2 (14.1) *M (SD)* **Gender:** 86.7% *% Female* **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 8 weeks **Number of Modules:** 6 **Estimated module length:** n.r. **Level of clinician involvement:** 15-20min online feedback per week	**Timepoint(s) Gathered:** prospective, retrospective **Collection method:** treatment preference module completion satisfaction rating
Blom et al. (2016) Sweden	Qualitative Study (based off RCT sample, see Blom et al., 2015)	**Sample size:** 18 (35) *experimental group (total)* **Average Age:** n.r. *M (SD)* **Gender:** n.r. *% Female* **Comorbidity*:** depression	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 8 **Estimated module length:** n.r. **Level of clinician involvement:** approx 15 min per week written weekly feedback on homework tasks, option for patient to ask questions, text reminders where no response	**Timepoint(s) Gathered:** retrospective **Collection method:** semi-structure interview RDQ
Blom et al. (2015) Sweden	RCT	**Sample size:** 22 (43) *experimental group (total)* **Average Age:** 46.1 (13.6) *M (SD)* **Gender:** 36% *% Female* **Comorbidity*:** depression	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 8 **Estimated module length:** n.r. **Level of clinician involvement:** approx 15 min per week written weekly feedback on homework tasks, option for patient to ask questions, text reminders where no response	**Timepoint(s) Gathered:** retrospective **Collection method:** module completion rating scales (CSQ-8, RDQ)
Kaldo et al. (2015) Sweden	RCT	**Sample size:** 73 (148) *experimental group (total)* **Average Age:** 47 (15.2) *M (SD)* **Gender:** 81% *% Female* **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 8 weeks **Number of Modules:** 8 **Estimated module length:** n.r. **Level of clinician involvement:** written weekly feedback on homework tasks, text reminders where no response	**Timepoint(s) Gathered:** retrospective **Collection method:** module completion rating scale (CSQ-8) RDQ

Publishing Details *(author, year, location)*	Design	Sample Characteristics	Intervention Characteristics	Acceptability Data Characteristics
Yeung et al. (2015) Hong Kong	RCT (secondary data analysis, see Ho et al., 2014)	**Sample size:** *experimental group (total)* 104/104 (312) **Average Age:** *M (SD)* 38.5 (12.5) **Gender:** *% Female* 71.2% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 6 **Estimated module length:** n.r. **Level of clinician involvement:** 15 min telephone call with therapist ("ICBT-I + support" group only)	**Timepoint(s) Gathered:** retrospective **Collection method:** attrition rating scale (ITAS)
Babson et al. (2015) USA	Pilot RCT	**Sample size:** *experimental group (total)* 2 (4) **Average Age:** *M (SD)* 47 (16.31) **Gender:** *% Female* 0% **Comorbidity*:** SUD	**Delivery Method:** Mobile Application **Intervention Period:** 2 weeks **Number of Modules:** non-structured **Estimated module length:** n/a **Level of clinician involvement:** Once weekly reminder call	**Timepoint(s) Gathered:** retrospective **Collection method:** interview
Thiart et al. (2015) Germany	RCT	**Sample size:** *experimental group (total)* 64 (128) **Average Age:** *M (SD)* 48.4 (9.9) **Gender:** *% Female* 67.2% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 6 **Estimated module length:** n.r. **Level of clinician involvement:** brief, weekly feedback via email on exercises in completed modules	**Timepoint(s) Gathered:** retrospective **Collection method:** module completion RDQ
Holmqvist et al. (2014) Canada	RCT	**Sample size:** *experimental group (total)* 39/34 (73) **Average Age:** *M (SD)* n.r. **Gender:** *% Female* 71.8%/79.4% **Comorbidity*:** n/a	**Delivery Method:** Internet/ Telehealth **Intervention Period:** 6 weeks **Number of Modules:** 5 **Estimated module length:** n.r. **Level of clinician involvement:** none/fully automated (Internet group); 100% clinician involvement in material delivery (Telehealth group)	**Timepoint(s) Gathered:** prospective, retrospective **Collection method:** treatment preferences exclusion reasons attrition module completion rating scale (CSQ-8)

Publishing Details *(author, year, location)*	Design	Sample Characteristics		Intervention Characteristics	Acceptability Data Characteristics
Ho et al. (2014) Hong Kong	RCT	**Sample size:** *experimental group (total)* **Average Age:** *M (SD)* **Gender:** *% Female* **Comorbidity*:**	104/104 (312) 38.5 (12.5) 71.2% n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 6 **Estimated module length:** n.r. **Level of clinician involvement:** 15 min telephone call with therapist ("ICBT-I + support" group only)	**Timepoint(s) Gathered:** retrospective **Collection method:** module completion rating scales (RDQ, ITAS)
van Straten et al. (2014) Netherlands	RCT	**Sample size:** *experimental group (total)* **Average Age:** *M (SD)* **Gender:** *% Female* **Comorbidity*:**	59 (118) 48.7 (13.8) 59.3% n/a	**Delivery Method:** Internet **Intervention Period:** 6 **Number of Modules:** 6 **Estimated module length:** n.r. **Level of clinician involvement:** online feedback 15-20 mins per week	**Timepoint(s) Gathered:** retrospective **Collection method:** attrition reasons for drop-out RDQ
Thorndike et al. (2008) USA	RCT	**Sample size:** *experimental group (total)* **Average Age:** *M (SD)* **Gender:** *% Female* **Comorbidity*:**	22 (45) 44.68 (10.61) 82% n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 6 **Estimated module length:** 45-60min **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** retrospective **Collection method:** rating scale (UQ)
Strom et al. (2004) Sweden	RCT	**Sample size:** *experimental group (total)* **Average Age:** *M (SD)* **Gender:** *% Female* **Comorbidity*:**	54 (109) 46.2 (n.r.) 65% n/a	**Delivery Method:** Internet/ Email **Intervention Period:** 5 weeks **Number of Modules:** 5 **Estimated module length:** n.r. **Level of clinician involvement:** none (fully automated)	**Timepoint(s) Gathered:** prospective, retrospective **Collection method:** module completion rating scale (TC/EQ) RDQ

Abbreviations: n/a – not applicable; n.r. – not reported; RCT – randomised controlled trial; uMARS – Mobile Apps Rating Scale-User Version; SUS – System Usability Scale; CSQ-8 – Client Satisfaction Questionnaire-8 item; RDQ – researcher designed questionnaire (unique to study); TC/EQ – Treatment Credibility/Expectancy Questionnaire; ZUF-8 – translated/modified Client Satisfaction Questionnaire; IQ – Internet Intervention Impact Questionnaire; UQ – Internet Intervention Utility Questionnaire; BPSR – Bern Post Session Report; ITAS – Internet Treatment Acceptability Scale; SUD – substance use disorder.

*refers to whether participants were recruited based on a population with a specific comorbidity; ¶ missing data (see Section 3.1.2. for further information)

3.2. Quality Appraisal

Table 1.3. shows a summary of quality appraisal ratings made using the MMAT, which was moderate overall. Only one (Blom et al., 2016) of the 28 included studies received the highest five-star rating; six studies (all randomised controlled trials; RCTs) received a lower two-star rating. Assessing trends across the studies suggests that poor reporting was the most common issue, with 22 studies receiving at least one "can't tell" rating. Studies with an RCT design (n = 23) generally had appropriate randomisation processes and outcome and adherence rates for the field; the blinding of outcome assessors was typically reported as not completed or not possible in these studies. Qualitative (n = 2) and mixed-method (n = 1) studies were conducted appropriately on the whole; It was not clear whether the non-randomised (n = 1) and mixed-method (n = 1) studies had representative samples and that they minimised confounds or sources of bias.

Table 1.3. MMAT quality appraisal ratings

Authors	**Khun et al.**	**Arnedt et al.**	**Chan et al.**	**Sveen et al.**	**Behrendt et al.**
Year	2022	2021	2021	2021	2020
Design	RCT	RCT	RCT	RCT	RCT
Rating	***(**)	**(**)	**(**)	**(*)	**(*)
Authors	**Denis et al.**	**Sunnhed et al.**	**van der Zweerde et al.**	**Krieger et al.**	**Forsell et al.**
Year	2020	2020	2019	2019	2019
Design	RCT	RCT	RCT	RCT	RCT
Rating	***(*)	***(**)	****	***(*)	***(*)
Authors	**Hagatun et al.**	**Heim et al.**	**Feuerstein et al.**	**Blom et al.**	**Kaldo et al.**
Year	2019	2018	2017	2015	2015
Design	RCT	RCT	RCT	RCT	RCT
Rating	****	***	***(*)	****	****(*)
Authors	**Yeung et al.**	**Babson et al.**	**Thiart et al.**	**Holmqvist et al.**	**Ho et al.**
Year	2015	2015	2015	2014	2014
Design	RCT	RCT	RCT	RCT	RCT
Rating	***(*)	**(*)	***(*)	***(**)	****
Authors	**van Straten et al.**	**Thorndike et al.**	**Ström et al.**	**Chan et al.**	**Blom et al.**
Year	2014	2008	2004	2017	2016
Design	RCT	RCT	RCT	QL	QL
Rating	***(*)	***(**)	**(***)	***(*)	*****
Authors	**Leonard et al.**	**Okujava et al.**	**Moloney et al.**		
Year	2020	2019	2020		
Design	NRS	QD	MM		
Rating	***(*)	***(**)	****		

Abbreviations: QL – qualitative studies; RCT – randomised controlled trial; NR – non-randomised studies; QD – quantitative descriptive studies; MM – mixed method studies. **Note:** star ratings range from * to ***** ; the use of brackets denotes where studies have received a "can't tell" response.

3.3. Proxy Measures of Acceptability

Table 1.4. summarises results from studies which only reported proxy measures of acceptability; a table of study characteristics can be found in Appendix A.4.. The most consistently (n = 22 studies) reported proxy measure of acceptability was the proportion of the sample completing all intervention modules. The percentage of participants completing all intervention modules was highly variable, ranging between 18-100%. However, the median percentage of participants completing all intervention modules was high at 67.8%. Two studies only reported the proportion of participants who completed what the researchers deemed a significant amount of the intervention. For both studies this was four out of six modules and ranged between 47-100% (*Mdn* = 74%) of participants. Finally, Wogan et al. (2021), who used an unstructured intervention delivered via a mobile application, only reported that 56.3% of their programme was viewed, on average.

Table 1.4. Results from studies reporting only proxy measures of acceptability

Study	% Sample*
Completed 100% Modules	
Mahoney et al. (2022)	34.9%/26.4%¶
Baka et al. (2022)	68%
Kallestad et al. (2021)	63%
Reilly et al. (2021)	88.2%
Jernelov et al. (2021)	44.7%
Nam et al. (2021)	43%
Okajima et al. (2020)	100%
van der Zweerde et al. (2020)	68%
Chinyere et al. (2020)	76%
Glozier et al. (2019)	55.5%
Kyle et al. (2019)	48.4%
Sato et al. (2019b)	100%
Lopez et al. (2019)	78.3%
Taylor et al. (2017)	87.9%
Feuerstein et al. (2017)	83.3%
Ritterband et al. (2017)	60.3%
Freeman et al. (2017)	18%
Luik et al. (2017a)	73.5%
Christensen et al. (2016)	43%
Lancee et al. (2015)	47.2%
Arnedt et al. (2013)	83.3%
Vincent and Lewycky (2009)	67.8%
Completed ≥ 4/6 Modules	
Lorenz et al. (2019)	100%
Bostock et al. (2016)	47%
Mean % Programme Viewed	
Wogan et al. (2021)	56.3%

* see Appendix X.x. for sample sizes;
¶ study reports results for multiple groups receiving dCBT-I intervention

3.4. Acceptability

The 28 included studies generated 197 data points, 127 (64%) of which were qualitized data. Only one study (Babson et al., 2015) required no data transformation. Six themes were identified from the combined qualitized and quantitative data points (n = 197): general acceptability, perceived helpfulness, individualised needs, congruence with personal life, functionality and design (see Table 1.5.).

3.4.1. General Acceptability

A theme of general (or non-specific) acceptability emerged from 62 data points and included sub-themes on participants' satisfaction with their overall treatment and with the digital delivery method specifically, on behavioural measures of engagement, on their intention for ongoing use and on their emotional response to treatment. The key findings across these sub-themes were mixed, with some indicating excellent general acceptability (overall satisfaction, intention for ongoing use and emotional response) while others indicate a more moderate (satisfaction with delivery method) or varied (behavioural engagement) picture of general acceptability.

3.4.2. Perceived Helpfulness

The theme of perceived helpfulness emerged from 35 data points. Broadly speaking, participants perceived dCBT-I to be useful and effective and would recommend such interventions to others. This was despite subthemes emerging which suggested that participants found the treatment recommendations difficult and that they had limited expectations that dCBT-I would prove successful at improving their sleep difficulties.

3.4.3. Individualised Needs

20 data points were grouped into the theme regarding participants' individual needs. While participants appeared to find the level of support offered in dCBT-I interventions acceptable, this appeared to be true for both automated and guided approaches. Furthermore, participants' preferences for any digital delivery method and across difference types of digital delivery method varied considerably. There was a small amount of evidence to suggest treatment preferences remained stable after being assessed both before and after an intervention.

3.4.4. Congruence with Personal Life

29 data points contributed to a theme which emerged regarding dCBT-I interventions' congruency with the participants' personal lives. While some data suggested that participants valued the convenience and flexibility afforded by digital approaches, a stronger trend in the data suggested that dCBT-I interventions are often not congruent with participants lives. Subthemes

regarding this were participants lack of time and practical or personal issues creating barriers to participants engaging; examples of the latter include limited access to digital devices, having a busy working life or being a caregiver.

3.4.5. Functionality

28 data points were grouped into the "Functionality" theme, and these suggest that generally participants find the functionality of dCBT-I acceptable; usability ratings were high and some studies reported participants as having few technical difficulties. However, a small subset of participants reported technical difficulties, such as a lack of platform compatibility across devices or elements of the platform not functioning as participants would like.

3.4.6. Design

21 data points were grouped into the "Design" theme, and these suggest that generally participants find the design of dCBT-I interventions acceptable. Participants reported dCBT-I interventions were visually and aesthetically pleasing and clear or understandable. Lastly, although participants found the design of dCBT-I interventions engaging overall, a subset of the data suggest that some participants would prefer less textual content.

3.5. Comparison with TFA

Five subthemes (overall satisfaction, delivery method satisfaction, emotional response, support) were thought to be associated with the domain "affective attitude". Eight subthemes (behavioural engagement, difficulty of treatment, lack of time, convenience, usability, technical issues, visual/aesthetic, engaging format) were associated with "burden" and four (intention for ongoing use, utility, expectations, effectiveness of treatment) were associated with "perceived effectiveness". One subtheme was associated with each of the "intervention coherence" and "opportunity costs" domains (clarity/understanding and practical/other difficulties respectively). No subthemes were thought to be associated with the "ethicality" or "self-efficacy" domains.

Table 1.5. Themes, categories and trends extracted from included studies regarding the acceptability of dCBT-I interventions

Sub-theme	Summary of Findings	Studies	Proposed TFA Domain
General Acceptability			
Satisfaction (overall)	Participants were highly satisfied with the intervention overall.	Kuhn et al. (2022), Arnedt et al. (2021), Chan et al. (2021), Sveen et al. (2021), Behrendt et al. (2020), Leonard et al. (2020), Denis et al. (2020), Sunnhed et al. (2020), van der Zweerde et al. (2019), Forsell et al. (2019), Lancee et al. (2016), Blom et al. (2015), Kaldo et al. (2015), Thiart et al. (2015), Holmqvist et al. (2014), Ho et al. (2014), van Straten et al. (2014)	AA
Satisfaction (delivery method)	Participants were moderately satisfied with the digital delivery method.	van der Zweerde et al. (2019), Blom et al. (2016), Yeung et al. (2015), Babson et al. (2015), Ho et al. (2014)	AA
Behavioural Engagement (e.g. module completion, attrition, homework completion, time spent)	Participants varied widely in their behavioural engagement with dCBT-I interventions across studies.	Arnedt et al. (2021), Sveen et al. (2021), Behrendt et al. (2020), Leonard et al. (2020), Denis et al. (2020), Sunnhed et al. (2020), Moloney et al. (2020), van der Zweerde et al. (2019), Krieger et al. (2019), Okujava et al. (2019), Hagatun et al. (2019), Lancee et al. (2016), Blom et al. (2015), Kaldo et al. (2015), Thiart et al. (2015), Holmqvist et al. (2014), Ho et al. (2014), van Straten et al. (2014), Ström et al. (2004)	B
Intention for ongoing use	Participants indicated a desire to continue using available digital methods to support their sleep.	Chan et al. (2021), Babson et al. (2015)	PE
Emotional Response	Participants reported positive emotional responses to dCBT-I	Moloney et al. (2020), Hagatun et al. (2019), Heim et al. (2018), Thorndike et al. (2008)	AA
Perceived Helpfulness			
Utility	Participants found dCBT-I interventions useful, although the factors which were most useful varied across participants.	Kuhn et al. (2022), Chan et al. (2021), Leonard et al. (2020), Moloney et al. (2020), Hagatun et al. (2019), Chan et al. (2017), Babson et al. (2015), Thorndike et al. (2008)	PE
Expectations	Participants had varied expectations of dCBT-I approaches being successful in helping their sleep difficulties.	Kuhn et al. (2022), Heim et al. (2018), Chan et al. (2017)	PE

Sub-theme	Summary of Findings	Studies	Proposed TFA Domain
Effectiveness of Treatment	Participants perceived dCBT-I interventions as effective, although some participants felt further treatment was required.	Behrendt et al. (2020), Okujava et al. (2019), Hagatun et al. (2019), Heim et al. (2018), Blom et al. (2016), Blom et al. (2015), Thorndike et al. (2008), Ström et al. (2004)	PE
Difficulty of Treatment	Participants found the strategies presented in dCBT-I difficult to implement.	Kuhn et al. (2022), Sveen et al. (2021), Sunnhed et al. (2020)	B
Recommended to others	Participants reported being willing to recommend dCBT-I approaches to others.	Sveen et al. (2021), Moloney et al. (2020)	PE
Individualised Needs			
Support	Participants were satisfied with the amount of support they received, in both automated and guided dCBT-I approaches.	Sveen et al. (2021), Sunnhed et al. (2020), Moloney et al. (2020), Heim et al. (2018), Blom et al. (2016), Yeung et al. (2015), Ström et al. (2004)	AA
Preferences	Participants preferences for delivery methods varied across studies and delivery types, with more limited evidence that preferences may also vary across time points.	Chan et al. (2017), Lancee et al. (2016), Blom et al. (2016), Holmqvist et al. (2014)	AA
Congruency with Personal Life			
Lack of time	Participants reported that they either lacked time or that the intervention was too long.	Sveen et al. (2021), Behrendt et al. (2020), Moloney et al. (2020), van der Zweerde et al. (2019), Okujava et al. (2019), Chan et al. (2017), van Straten et al. (2014)	B
Convenience	Participants found dCBT-I approaches convenient and that they afforded greater flexibility.	Moloney et al. (2020), Hagatun et al. (2019), Chan et al. (2017), Blom et al. (2016), Thorndike et al. (2008), Ström et al. (2004)	B
Practical/Other Difficulties	Participants reported various personal and practical issues which interfered with or stopped them from engaging with dCBT-I interventions.	Kuhn et al. (2022), Moloney et al. (2020), van der Zweerde et al. (2019), Chan et al. (2017), Holmqvist et al. (2014)	OC

Sub-theme	Summary of Findings	Studies	Proposed TFA Domain
Functionality			
Usability	Participants found digital platforms easy to use and navigate.	Kuhn et al. (2022), Chan et al. (2021), Behrendt et al. (2020), Leonard et al. (2020), Moloney et al. (2020), van der Zweerde et al. (2019), Krieger et al. (2019), Okujava et al. (2019), Hagatun et al. (2019), Chan et al. (2017), Kaldo et al. (2015), Babson et al. (2015), Thorndike et al. (2008)	B
Technical Issues	Participants varied in their experiences of having technical issues.	Moloney et al. (2020), van der Zweerde et al. (2019), Chan et al. (2017)	B
Design			
Visual/Aesthetic	Participants enjoyed the visual nature of the dCBT-I intervention components and found them aesthetically pleasing.	Kuhn et al. (2022), Leonard et al. (2020), Chan et al. (2017)	B
Clarity/Understandability	Participants found the information presented in dCBT-I interventions extremely clear and easy to understand.	Kuhn et al. (2022), Chan et al. (2021), Leonard et al. (2020), van der Zweerde et al. (2019), Okujava et al. (2019), Hagatun et al. (2019), Chan et al. (2017), Thorndike et al. (2008)	IC
Engaging Format	Participants found dCBT-I interventions to be generally engaging. There were varied opinions about whether dCBT-I interventions contained too much text.	Kuhn et al. (2022), Leonard et al. (2020), Sunnhed et al. (2020), Okujava et al. (2019), Chan et al. (2017)	B

Abbreviations: TFA – Theoretical Framework of Acceptability (Sekhon et al., 2017); The following abbreviations are TFA domains: SE = "Self-efficacy", PE = "Perceived effectiveness", "OC = Opportunity Costs", IC = "Intervention Coherence", E = "Ethicality", B = "Burden", AA = "Affective Attitude".

4. Discussion

This mixed methods systematic review aimed to assess the acceptability of dCBT-I interventions, as well as providing an overview of how acceptability is measured and reported in the literature base. Results suggest that dCBT-I interventions are broadly acceptable to participants in terms of their functionality, design, perceived helpfulness and on most general measures of acceptability; this seems to be in contrast with their behavioural engagement, which varied considerably between studies. Participants' preferences for dCBT-I interventions also vary, and such interventions are not always congruent with participants' personal lives. However, acceptability was typically assessed retrospectively and using heterogeneous methods with the results reported inconsistently, suggesting that the findings of this review should be interpreted with caution. Comparison with one model of acceptability (the Theoretical Framework of Acceptability; Sekhon et al., 2017) suggests that current measurements of acceptability do not address all facets of the acceptability construct.

4.1. Key acceptability themes

Acceptability in many aspects of general acceptability, in perceived helpfulness, design and functionality was high. In contrast, the data grouped into the subtheme of behavioural engagement was highly variable, as has been reported in digital interventions broadly (Donkin et al., 2011). Unfortunately, studies are often inconsistent in their reporting regarding participants' reasons for drop out or lack of adherence (Mellor et al., 2022; Treanor et al., 2021) making it difficult to know the cause of this. Care should be taken not to make assumptions about participants' reasons for drop-out, as it could stem from various factors including people getting better, their personal attributes and other competing demands (Szafranski et al., 2017; Hermes et al., 2019). Similarly, our findings suggest that dCBT-I interventions are not always congruent with personal life and, as such, contextual issues may account for some of the variability in behavioural engagement, a point which has been identified in other studies (Cheung et al., 2017; Roth et al., 2011). Future studies may wish to expand on both these findings and work done regarding traditional CBT-I (Stinson et al., 2006) by assessing acceptability prospectively and concurrently to ascertain whether participants anticipated or planned for how the demands of interventions could be met within the current demands of their daily life. Lastly, our results, which show that participants have individualised needs and vary in terms of their treatment preferences (including their preference or need for support), are also in line with other studies in the literature (Cheung et al 2017; Koffel et al. 2020; Sato et al., 2019a).

4.2. Acceptability themes compared to TFA

We attempted to map TFA domains onto the emergent subthemes produced during the review. However, this was challenging due to the frequent use of broad (e.g. overall satisfaction rating scales) and proxy measures of acceptability (e.g. module completion). These kinds of data do not produce nuanced information or correspond well with the TFA and it has been suggested that they may represent separate, though related, constructs to acceptability (Ortblad et al., 2022). The "burden" TFA domain was the most commonly addressed domain across the studies included in this review, while "self efficacy" and "ethicality" domains were the most poorly addressed. The latter may reflect the current evidence base, which lacks studies examining the fit of digital interventions into participants' value systems. One recent study looking to adapt generic CBT to a non-Western context, assessed how well CBT was perceived to fit across participants' value systems and found that it was generally rated highly (Bouman et al., 2022). Further research is required to address these gaps in understanding, especially as research practice moves towards adopting theory-driven models of acceptability such as the TFA.

4.3. Methods of assessing acceptability

An important outcome of this review was the data suggesting methodological issues with the way data on acceptability is gathered and reported. The most concerning of these is that acceptability is commonly only assessed retrospectively (23 out of 28 studies reviewed) and rarely prospectively (four studies reviewed) or concurrently (one study reviewed). While this is to be expected to a degree (participants must experience some aspects of interventions before they can comment on them, particularly where they are complex), when considered alongside other factors it must make us carefully consider the accuracy of our estimates. For example, high levels of attrition (i.e. during treatment drop-out) are typically observed in these kinds of studies (Hebert et al., 2010; Gao et al., 2022), opening the findings up to attrition bias; it is possible that those participants remaining at the end of such studies were a self-selecting group who are more likely to have found the dCBT-I interventions acceptable. While there are findings which refute this (Blom et al., 2016), there is not yet enough evidence to comment conclusively on the matter. Future studies should consider introducing measures of prospective or concurrent acceptability to be more confident in their assessment of treatment acceptability.

A related methodological concern was the variability in methods used to collect acceptability data and the lack of a widely adopted definition or model of acceptability which methods are based on

(Sekhon et al., 2017; Klaic et al., 2022). Many of the studies included were randomised controlled trials which used non-standardised or cursory rating scales, while there were comparatively few qualitative or mixed-methods studies concerned with acceptability. These issues are not confined to the field of insomnia; many of the same concerns have recently been raised, for example, in the prevention and treatment of HIV (Ortblad et al., 2022). While the mixed-methods approach adopted in this review was specifically chosen to mitigate some of the difficulties associated with synthesising heterogeneous data, a move towards a) a consensus on the most rigorous methods of measuring and reporting acceptability data and b) creating and adopting a standardised measure formed using a theory-based model of acceptability, such as the TFA, can only be of advantage to future researchers by allowing results to be compared easily between studies. While recent progress has been made to develop a theory-based acceptability questionnaire (Sekhon et al., 2022), ongoing work is required to validate and refine this.

4.4. Limitations

In addition to the methodological issues mentioned above, there are additional limitations which should be considered when interpreting this study. Firstly, that, in anticipation of the heterogeneity present in the types of acceptability data we expected to extract, we took a more exclusive approach towards our inclusion criteria. While this aided in the focus and clarity of our findings, there were occasions where studies which would have been relevant to our research question were excluded. The most frequently encountered example of this was studies using mixed age samples, followed by a small number of studies where the relevant acceptability data were either not reported in a useable format (for example, in studies utilising network analysis such as Scott et al., 2022) or, in some instances, not reported at all (for example, where an acceptability measure was mentioned but the outcome not included in the results, or it was not possible to calculate module completion from the information provided). These issues echo the findings from our quality appraisal which suggested a lack of clear reporting in the literature. Had studies reported their results for age groups separately or provided links to supplementary information, these studies could possibly have been included. The exclusive approach taken also resulted in the decision to focus the quality appraisal and synthesis on studies which reported more detailed acceptability data than just proxy data, limiting our understanding of the role of proxy measures of acceptability within the wider construct of acceptability or the relative quality of studies reporting only proxy data.

Secondly, we did not analyse fully automated and guided interventions separately as subgroups. There is evidence, including from the results of this review, that having access to and support

from a professional is often, though not always, desirable (Koffel et al., 2019; Hermes et al., 2019) and therefore has the potential to impact on the acceptability of interventions. While some of our identified themes appeared to relate to constructs distinct from receiving support (for example, design, functionality and congruence with personal life), others were either directly (individualised needs) or potentially (general measures of acceptability and perceived helpfulness) linked to participants' perception or experience of receiving support from a professional. It is not clear from our analysis if or how the level of support received by participants may have influenced acceptability, but this may be a source of variance in our findings and something which future studies may wish to explore further.

Finally, in the absence of a current consensus on how best to "qualitize" quantitative data, our research team used a novel transformation protocol. As discussed above, a large proportion of the studies included in this review were randomised controlled trials producing quantitative data, which resulted in over half (64%; 127/198 data points) of our data points consisting of data transformed using the novel protocol. As this approach has not been used in other mixed methods systematic reviews, it is unclear whether this transformation protocol produces reliable results, limiting the confidence we can have in the results described in this review.

4.5. Conclusion

This was the first systematic review in this area adopting a mixed-methods approach to assess the acceptability of dCBT-I approaches, allowing for a more cohesive integration of a greater range of heterogeneous results than has been achieved in other studies. While there are indicators that dCBT-I is acceptable to participants, the concept of acceptability is poorly defined and inconsistently measured across the current literature base. Future research directions should focus on addressing these methodological concerns to increase our confidence in the acceptability of digital CBT-I approaches.

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Chapter 2: Major Research Project

Assessing the feasibility and acceptability of a single session sleep intervention for postgraduate students delivered via videoconferencing technology.

Prepared in accordance with the author guidelines for Frontiers in Psychology
(https://www.frontiersin.org/guidelines/author-guidelines)

Plain Language Summary

Title: Assessing the feasibility and acceptability of delivering a single session sleep intervention for postgraduate students via videoconferencing technology.

Background: Sleep difficulties seem to be more common amongst university students than in the general population and have been linked to poorer outcomes including increased suicidality. However, research covering the postgraduate student population specifically is limited. Cognitive behavioural therapy for insomnia (CBT-I) is a psychological treatment shown to be efficient at treating sleep difficulties when delivered digitally (van Straten et al., 2018). Some recent studies have suggested that a single CBT-I session can be helpful (Ellis, Cushing & Germain, 2015). Delivering a single CBT-I session live online could be a practical way to help postgraduate students to improve their sleep.

Aims and Questions: The aim of this study was to assess whether using a videoconferencing delivery method for a single session sleep intervention for postgraduate students is: a) feasible (i.e. practical and straightforward) and b) acceptable to recipients.

a) Feasibility: are there aspects of this study design (for example, drop-out rates) which mean it is not practical to use again?
b) Acceptability: Did participants feel the delivery method was acceptable? What did they identify as the positives and negatives of this delivery method?

Methods:

Participants: Participants were postgraduate researchers matriculated at the University of Glasgow. ***Recruitment:*** Participants were recruited via an email circulated by a University of Glasgow postgraduate support team. ***Design of study:*** We counted the number of participants at each stage of the study to show how many it was possible to recruit and what percentage filled out sleep diaries and came to the sleep session. We also asked people for their views on how acceptable the delivery method was by a questionnaire. ***Data collection:*** Participants were asked to fill out questionnaires on their lifestyle and wellbeing and on how acceptable they considered the sleep session. They filled out these questionnaires before and after attending a sleep session of approximately 60-70 minutes. They were also asked to fill out a sleep diary for seven days both before and after attending the sleep session.

Main Findings & Conclusions: Both the topics covered by the sleep session and the videoconferencing platform used to deliver it were mostly acceptable to participants. Participants would have liked more time to ask questions and found it harder to do so online. The facilitators

felt that running the sleep session online via videoconferencing was feasible. Several factors seem to have made feasibility worse, such as problems with software and working with another team. The impact of these was lower after changes to the way the study was run.

References:

Ellis, J. G., Cushing, T., & Germain, A. (2015). Treating acute insomnia: a randomized controlled trial of a "single-shot" of cognitive behavioral therapy for insomnia. *Sleep*, *38*(6), 971-978.

van Straten, A., van der Zweerde, T., Kleiboer, A., Cuijpers, P., Morin, C. M., & Lancee, J. (2018). Cognitive and behavioral therapies in the treatment of insomnia: a meta-analysis. *Sleep Medicine Reviews*, *38*, 3-16.

Abstract

Background & Objectives: Sleep difficulties have been estimated to be higher amongst university students than in the general population and have been linked to poorer outcomes including increased suicidality. However, research covering the postgraduate population specifically is limited. CBT for insomnia (CBT-I) is a psychological treatment shown to be effective for treating sleep difficulties, including when delivered digitally. Some recent studies have shown promising results exploring the efficacy of a single CBT-I session. Combining a single CBT-I session with the use of digital technologies has the potential to be an efficient and effective way to help postgraduate students improve their sleep. This study's aim is to assess whether a videoconferencing delivery method for a single session intervention for postgraduate students is: a) a feasible method of delivery and b) acceptable to recipients. To inform the design of future large-scale studies into the efficacy of single session digitally delivered CBT-I, this study also aims to explore the feasibility of running a study of this design and with this population.

Participants & Methods: Participants were postgraduate students matriculated at the University of Glasgow. They were asked to fill in a battery of lifestyle, wellbeing and acceptability questionnaires and seven days of a sleep diary prior to attending an approximately 60-minute-long sleep session via Zoom. They completed further questionnaires upon completion of and three weeks after the sleep session, in addition to completing a further seven days of a sleep diary.

Results: Our findings suggest that both the intervention and delivery method, assessed via questionnaires both prospectively and retrospectively, were generally acceptable to recipients. Furthermore, facilitator feedback indicated that running the sleep session online via videoconferencing was a feasible method of delivery. However, several factors such as collaboration issues with teams external to the research team and the most optimal use of available software appear to have negatively impacted on areas of feasibility such as recruitment and outcome completion rates. Data gathered after the adaptation of research process halfway through the study suggest that it is possible to mitigate the negative impact of these factors.

Conclusions: Using videoconferencing to deliver a single session of CBT-I is both feasible and acceptable to recipients. Factors which appear to impact on recruitment and outcome completion rates include the software used and reliance on other professionals for recruitment. Future researchers wishing to complete large-scale research utilising this study design may wish to take this and further feedback from facilitators into account.

1. Introduction

The prevalence of insomnia among students has been estimated to be high (Chowdhury et al., 2020; Jahrami et al., 2020), possibly even double that found amongst the general population (18.5% compared to 7.4%; Jiang et al., 2015a) A variety of factors have been shown to impact on student sleep including stress (Beiter et al., 2015; Gardani et al., 2021) and higher levels of substance use (Kenney et al., 2012; Taylor et al., 2013). Sleep difficulties in students have been linked to poorer academic performance (Gaultney, 2010), difficulties with emotional regulation (Tavernier and Willoughby, 2015) and increased suicide risk (Akram et al., 2020; Russell et al., 2019).

Much of the research conducted so far has used either samples from the undergraduate population only or has sampled broadly across all levels of higher education. More research is required which focuses on the postgraduate population specifically as they appear to differ from undergraduates in several ways. For example, they occupy unique social and organisational roles within Higher Education Institutions (Grady et al., 2014), are more likely to use substances to cope with stress (Zvauya et al., 2017), and may experience greater overall stress levels (Wyatt and Oswalt, 2013). Postgraduate researchers specifically (as opposed to taught postgraduate students) have been estimated to be more than twice as likely to develop common psychiatric disorders than highly educated individuals in the general population (Levecque et al., 2017). One recent online survey of 479 postgraduate researchers found 37.4% reported difficulties with their sleep in the past year, while 23.4% reported thoughts of suicide or self-harm in the past two weeks (Milicev et al., 2021).

The most extensively researched and supported non-pharmacological intervention for sleep difficulties is currently cognitive behavioural therapy for insomnia (CBT-I), originally designed as an eight-session treatment (Espie et al., 2001). Subsequent research has suggested that four sessions may be the optimal treatment duration and even a single session can produce significant improvements in global insomnia symptoms (Edinger et al., 2007). To our knowledge, only a handful of studies have looked at the provision of a "one-shot" (single session) CBT-I intervention for sleep (Boullin et al., 2016; Ellis et al., 2015; Randall et al., 2018) but these studies have shown promising results. Further preliminary research in this area, conducted in-person with postgraduate students, found that a single session is acceptable to participants and feasible for facilitators to run (Smilie and Gardani, 2019). However, the sample size of that study was small, with only 12 participants.

In an effort to disseminate CBT-I more widely in a cost-effective manner (something which has previously been identified as a challenge; see Morin, 2015), it has been successfully adapted to be digitally delivered via the internet (Seyffert et al., 2016), smartphone apps (Horsch et al., 2017), and telephone (Arnedt et al., 2013). "Digitally delivered" is a broad term, encompassing web-, mobile app-, videoconferencing- and telephone-delivered interventions. Digitally delivered CBT-I (or dCBT-I) can be delivered with varying levels of input from qualified professionals: as a support tool to a primarily face-to-face intervention, as a guided intervention or as fully automated (Luik et al., 2017). A recent systematic review and network meta-analysis compared a variety of dCBT-I approaches and found digital approaches had a significant beneficial effect on key sleep outcomes and that web-based CBT-I with a real or virtual therapist was the optimum approach (Hasan et al., 2022). To our knowledge, no exploration of digitally delivered single session CBT-I interventions has taken place to date and addressing this deficit could improve our understanding of how best to increase dissemination of CBT-I interventions.

In addition to assessing effectiveness, recent Medical Research Council guidance reinforces the importance of completing feasibility and acceptability studies when developing novel treatment approaches (Skivington et al., 2021). For the purposes of this review, acceptability is defined as "A multi-faceted construct that reflects the extent to which people delivering or receiving a healthcare intervention consider it to be appropriate, based on anticipated or experienced cognitive and emotional responses to the intervention" (Sekhon et al., 2017, p.4). To our knowledge, no research has assessed the acceptability of dCBT-I interventions in the student population, either undergraduate or postgraduate, while the assessment of acceptability in the general adult population has produced mixed results. For example, some studies report patients showing a significant preference for face-to-face approaches (Lancee et al., 2016), while other studies have reported qualitative findings which suggest participants hold positive views towards digital approaches (Quante et al., 2019). A recent systematic review comparing CBT-I outcomes for different delivery methods concluded that digital delivery methods were less acceptable to participants than other methods (Gao et al., 2022). However, this was based only on drop-out during the treatment period, a proxy measure of acceptability which may not always reflect that participants are dissatisfied with an intervention (Szafranski et al., 2017). The reliance on proxy measures of acceptability, along with several other concerns about how acceptability is defined and assessed, is a recognised limitation of the literature on acceptability to date (Sekhon et al., 2017; Klaic et al., 2022; Simon et al., 2019). The Theoretical Framework of Acceptability (TFA; Sekhon et al., 2017) has been proposed in an effort to begin addressing these limitations and outlines seven domains of intervention acceptability (affective attitude, burden, perceived effectiveness, ethicality, intervention coherence, opportunity costs and self-efficacy).

In summary, postgraduate students are a unique and under-served population who would benefit from easily accessible treatments for sleep difficulties. A single CBT-I session, delivered digitally, has the potential to be an efficient and effective way to address this issue. The first step towards developing such an intervention is to assess aspects of acceptability and feasibility which may inform future large-scale research into their efficacy.

2. Aims & Research Questions

2.1. Aims:

Firstly, this study aims to assess whether a videoconferencing delivery method for a single session intervention for postgraduate students is: a) a feasible method of delivery and b) acceptable to recipients. Secondly, to inform the design of future large-scale studies into the efficacy of single session dCBT-I, this study also aims to explore the feasibility of running a study of this design and with this population.

2.2. Research Questions:

a) Feasibility:
   i. Recruitment: How many participants is it possible to recruit using the selected recruitment channels?
   ii. Response: Of all those who signed up to a sleep session (both participants in the study and non-participants), what was the attendance rate? For those who participated in the study, what were the questionnaire and sleep diary completion rates?
   iii. Facilitators: What skills, training and resources do the facilitators believe themselves to require in order to run the session via videoconferencing? Does the delivery method create any additional challenges or advantages for the facilitators?

b) Acceptability:
   i. Did the participants and facilitators feel the delivery method was acceptable? What did they identify as the advantages or disadvantages of this delivery method?
   ii. Did the participants and facilitators feel the content of the session was suitable and appropriate for online delivery?

3. Materials and Methods

3.1. Design

This study assessed the feasibility and acceptability of an intervention study which utilised a pre-post study design. A control group was not deemed necessary due to the focus on feasibility and acceptability.

3.2. Ethical Approval

Ethical approval (Application number: 300210012; see Appendix B.2.1.) was given by the College of Science and Engineering Ethics Committee at the University of Glasgow on 18th August 2021. A subsequent amendment was approved on 1st November 2021 (see Appendix B.2.2.).

3.3. Participants

To be included in the study, participants were required to be a student at the University of Glasgow and enrolled on a postgraduate research programme (of any discipline). No other exclusion criteria were applied.

3.4. Sample Size

As it was unclear how many participants it would be possible to recruit, this formed one of the aims of this research study. A previous study with this population and design by Smilie and Gardani (2019) reported recruitment rates as around 30%, retention rates varying between 50-100% and measured completion and adherence to be adequate in 60% of their sample. Lancaster et al. (2004) suggest that pilot or feasibility studies consider aiming for a sample size which would be useful for power calculations in future research. Various sample sizes have been recommended for this purpose, usually between 24 and 50 participants (Sim and Lewis, 2012), and we therefore aimed to recruit a minimum sample size of 24 participants.

3.5. Recruitment

Participants were recruited via a separate University of Glasgow postgraduate support team who have had previous involvement in recruitment for studies of this type. The internal team sent study advertisement emails (see Appendix B.3.) to a distribution list which includes all postgraduate researchers at the University of Glasgow.

3.6. Materials & Measures

3.6.1. Intervention materials:

The materials used to deliver the session were 30 PowerPoint slides based on core CBT-I principles, as used in Smilie & Gardani (2019) which were adapted from the slides used in the Ellis et al. (2015) study to be appropriate for this population.

3.6.2. Demographic, Wellbeing and Sleep Measures:

A battery of questionnaires was administered via Microsoft Forms available as part of the Office 365 suite (hereafter referred to as "Forms") to assess the demographic, wellbeing and sleep disorder profile of participants.

This included the following standardised measures:

- Generalised Anxiety Disorder Questionnaire (GAD-7) (Spitzer et al., 2006)
- Patient Health Questionnaire (PHQ-9) (Kroenke et al., 2001)
- Perceived Stress Scale (PSS) (Cohen et al., 1994)
- UCLA Loneliness Scale (ULS) (Russell, 1996)
- Sleep Condition Indicator (SCI) (Espie et al., 2014)
- Consensus Sleep Diary (CSD) (Carney et al., 2012)

A questionnaire (see Appendix B.4.1.) was also designed by the research team to collect demographic and lifestyle factors (e.g. age, gender identity, ethnicity, social media use, and the consumption of alcohol, caffeine and other substances) and academic characteristics (e.g. type of programme enrolled on, academic field).

3.6.3. Acceptability and Feasibility Measures: Acceptability questionnaires for each of the pre-session, post-session and follow-up stages were novel measures designed by the research team (see Appendix B.4.1.) and were administered via Forms. The acceptability questionnaires were designed to include questions at every stage which address the domains identified in the Theoretical Framework of Acceptability (TFA; Sekhon et al., 2017): "Self-efficacy", "Perceived effectiveness", "Intervention Coherence", "Ethicality", "Burden" and "Affective Attitude". As no such measure based on TFA domains existed at the time of development, items were designed through discussion as a research team.

Facilitator feedback was gathered via an audio recording of discussions between the author of this thesis (NT) and each of the other facilitators (MG, JL) separately, using the research questions as prompts. At the time of running the study, there was a mix of ability levels across the facilitators: NT (the author of this thesis) was completing her doctoral-level training in the field

of clinical psychology, MG is an advanced postdoctoral researcher in the field of sleep who supervised the project and JL was an undergraduate student studying Psychology. BC is the research director for the University of Glasgow Doctorate in Clinical Psychology programme and provided additional research supervision and guidance to ensure the specific needs of a DClinPsy programme were met throughout. Please see Table 2.1. below for an outline of the role of different members of the research team throughout the study.

Table 2.1. Role and contribution of research team members throughout the research project

Stage of Project	Researcher(s) Involvement
Initial development *(e.g. preliminary literature searches, defining research questions, writing research proposal, creation of novel acceptability measure)*	• NT: lead role • MG: supervision, provision of general research topic • BC: supervision
Ethics *(e.g. Creation of participant information and consent forms, data management plan, risk management protocols, ethics application and correspondence)*	• NT: lead role • MG: supervision • BC: supervision
Recruitment *(e.g. collaboration with postgraduate research team, responding to participant emails, generating links to electronic platforms)*	• NT/MG: shared role • BC: supervision
Research Processes/Data Collection *(e.g. Conversion of measures to Excel/Forms format, creating and monitoring research administrative processes, responding to participant emails)*	• NT: lead role • MG: supervision • JL: administrative support • BC: supervision
Sleep Sessions	• MG: delivery of session and provision of session slides • NT: supportive role (e.g. introducing session, answering questions on chat function)
Data Analysis *(e.g. collating, organising and cleaning data, completion of relevant analyses)*	• NT: primary responsibility for data extraction, organisation and cleaning via excel, and analysis of feasibility and acceptability data. • JL: analysis of sleep diaries and other validated measures • MG: supervision • BC: supervision

3.7. Procedure

Table 2.2. outlines the key events in the study timeline and the associated procedures which were maintained across the entirety of the study. However, due to low recruitment and response, the procedure of the study was adapted in two main ways as the study progressed: a) how the sessions were advertised and accessed and b) what platform the sleep diaries were provided on.

Table 2.2. Outline showing key events in the study timeline

1. Consent	Participant information was made available and consent was completed via Forms.
2. Pre-session Questionnaire Battery	If participants correctly completed consent, Forms was programmed to immediately redirect participants on to complete the Pre-session Questionnaire Battery which included the demographics and lifestyle questionnaire, GAD-7, PHQ-9, PSS, SCI, ULS and the pre-session acceptability questionnaire. This was designed to take between 20-30 minutes to complete.
3. Pre-session Sleep Diary	Eight days prior to the session, participants were sent calendar reminders for the sleep diaries via Microsoft Outlook. Simultaneously, an email was distributed to participants with a summary of the task and a request to complete the sleep diaries daily for the next seven days.
4. Sleep Session	Each sleep session ran for approximately 60-70 minutes and was delivered live by MG (an expert in the sleep field who has delivered these sessions before) using the videoconferencing platform "Zoom".
5. Acceptability Questionnaire	After the sleep session, participants were asked to complete the Post-session Acceptability Questionnaire, which was designed to take approximately 10-15 minutes to complete. The questionnaire was available for seven days after the sleep session.
6. Post-session Sleep Diary & Questionnaire Battery	20 days after the sleep session, the procedure used for the Pre-session Sleep Diaries was repeated, with sleep diaries entry available between 21-30 days. The email distributed included an additional request for participants to complete the Follow-up Questionnaire Battery, which was made available for the same period as the sleep diaries. This battery was identical to the Pre-session Questionnaire Battery, except the Follow-up Acceptability Questionnaire which was substituted for the Pre-session Acceptability Questionnaire.

Abbreviations: GAD-7 = Generalised Anxiety Disorder Questionnaire, PHQ-9 = Patient Health Questionnaire, PSS = Perceived Stress Scale, ULS = UCLA Loneliness Scale, SCI = Sleep Condition Indicator

3.7.1. Amendments to Advertisement and Access Procedure

The sleep sessions had been run on multiple occasions as part of a planned programme of events available to all postgraduate researchers before the commencement of this study. Therefore, the sleep sessions were initially open to all postgraduates who were interested in attending, regardless of their participation in the study. The advertisement email contained a description of

the sleep session, the date that the session was running and a link to an event page on the "Bookitbee" platform, where all prospective attendees booked on to attend. All those who signed up via this platform were then emailed closer to the date of the sleep session with a copy of the participant information sheet, an invitation to participate in research and the necessary link to Forms which allowed interested individuals to provide consent to participate. Attendees were emailed the Zoom link for the session either the day before or day of the sleep session. These processes were all completed and monitored by the postgraduate support team in liaison with the research team.

Recruitment during the first two sleep sessions of the study was poor due to a) low opt-in rates among the attendees and b) collaboration difficulties between the postgraduate support team and the research team leading to the Zoom link not being properly distributed to the sign-up list of the second sleep session. To address these issues an ethics amendment (see Appendix B.2.2.) was sought and granted which allowed all subsequent sessions to run on a "closed" basis where only participants who opted in to the research study were allowed to attend. Due to time constraints, it was not possible to offer further open sleep sessions to non-participants after this point. The advertisement emails (which were still distributed by the internal postgraduate support team to all postgraduate researchers) were therefore amended to include a summary of the research project, the participant information sheet and the necessary link to Forms. The use of the Bookitbee platform was discarded and all other processes, as outlined in Table 2.2., were completed and monitored by the research team.

3.7.2. Amendments to Sleep Diary Procedure

Initially, sleep diaries were created as a live Microsoft Excel document hosted on Microsoft OneDrive. A copy was made for each participant and shared with them using a unique access link. The link was distributed to participants by inserting it into the description box of the Microsoft Outlook reminders sent to each participant prior to the sleep session.

After the running of the first sleep session, the sleep diaries were converted to a single form on Forms, which all participants could use. This overcame two challenges: a) it eliminated the need for participants to have Microsoft apps on their mobile device (Forms opens in the default browser app) and b) it solved an identified issue where participants saved copies of the diary locally to their device (rather than on the shared cloud location) which meant researchers could not access their sleep diary data. The form was accessed via a single link which was distributed via both the Outlook reminders and the summary email.

3.8. Data Analysis

3.8.1. Background Data

Key quantitative outcome data were summarised using descriptive statistics (e.g. the average age of participants, average hours of sleep per night reported). 95% confidence intervals were also computed, where appropriate, to reflect the uncertainty in these estimates as a representation of the population.

3.8.2. Feasibility Data

Participant numbers at each stage of the study were summarised in a flowchart. To provide recommendations for future studies, key feasibility variables (for example, the rate of recruitment, retention and completion rates) were calculated. Notes were made from the audio recordings of facilitator feedback and the key points were summarised in tables.

3.8.3. Acceptability Data

Rating scale data were collated across all participants combined to provide insight into the typical opinions from the sample as a whole. These were analysed using summary statistics (median and interquartile range, or frequency and percentage, as appropriate). Comments provided on the acceptability questionnaires were collated and summarised descriptively by theme. However, it was beyond the scope of this study to complete a formal, in-depth qualitative analysis.

4. Results

Figure 2.1. shows the overall number of participants and non-participants involved in each stage of the study (see Table 2.4. in Section 4.3.1. for a more detailed description of each study group). Hereafter, "participants" refers to people who were part of the research study and "non-participants" refers to those who signed up for the sleep session but did not consent to take part in the research; only information about sign-up and attendance at the sleep session is reported for the latter.

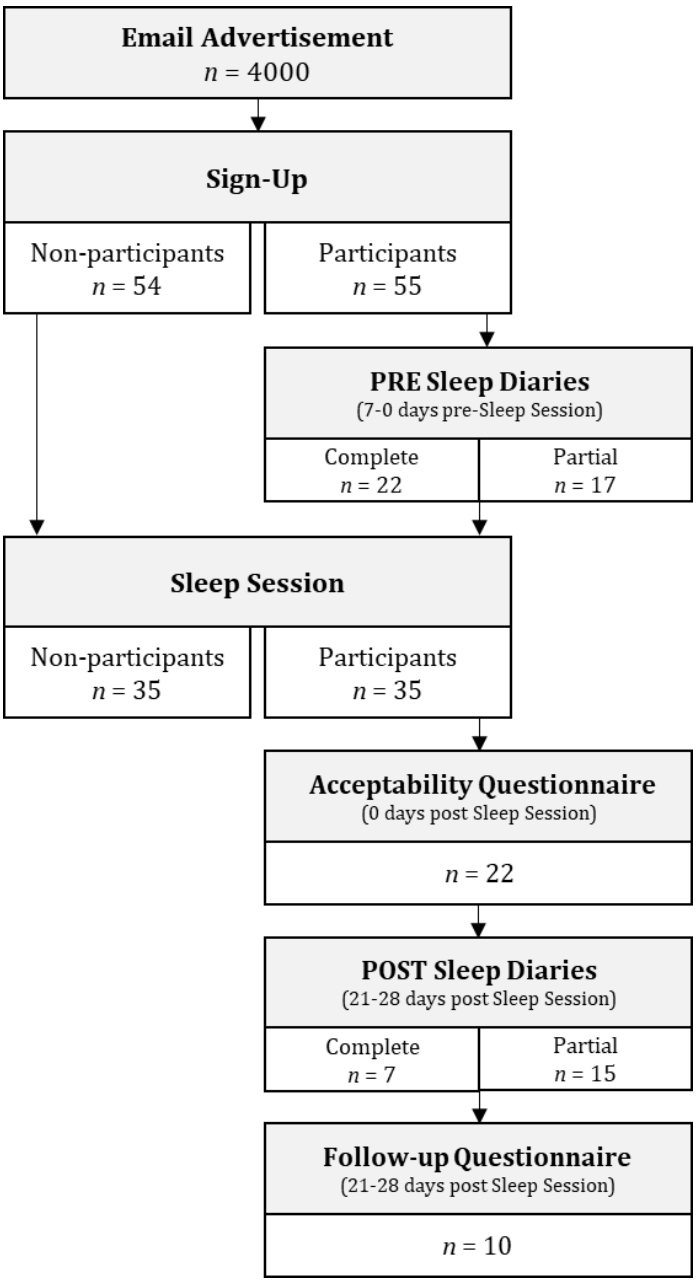

Figure 2.1. Flow diagram showing number of participants and non-participants involved at each stage of the study.
"Participants" refers to people who were part of the research study and "non-participants" refers to those who signed up for the sleep session but did not consent to take part in the research.

4.1. Participant Characteristics

Table 2.3. shows the demographic characteristics of participants. The majority of participants were in the first two years of a PhD programme (72%) and identified as white (58.8%) and female (59%).

Table 2.3. Table showing the demographic characteristics of participants (n = 51*)

Age (Mean, std)		28 (6.58)
Gender (*n*, %)		
Male		11 (22)
Female		30 (59)
Gender fluid		1 (2)
Non-binary		1 (2)
Prefer not to say/ unanswered		8 (16)
Ethnicity (n, %)		
Unanswered/ missing data		3 (5.9)
Mixed		3 (5.9)
Asian		2 (3.9)
South East Asian		6 (11.8)
African		3 (5.9)
Black		1 (2)
White/ Caucasian		14 (27.5)
White (other)		3 (5.9)
White British		13 (25.4)
British		2 (3.9)
Kurdish		1 (2)
Academic (n, %)		
Type	**Year**	
PhD	1	20 (39)
	2	17 (33)
	3	6 (12)
	4	4 (8)
EdD	5	1 (2)
DClinPsy	3	1 (2)
MRes	1	1 (2)
MD	2	1 (2)

*4 study participants completed the Acceptability Questionnaire only and therefore did not provide demographic information

4.2. Outcome measures

Wellbeing and lifestyle data from all groups were analysed. Due to the low response rate from participants signed up to attend open sleep sessions, it was only possible to calculate sleep outcome data for the closed sleep session groups. As the data from outcome measures were not the key focus of this study, a summary of these data has been included in Appendix B.5.1. These data were analysed in full and utilised by another member of the research team (JL) as part of their undergraduate dissertation.

4.3. Feasibility

4.3.1. Recruitment & Response

Table 2.4. shows the number and percentage of participants retained at each stage of the study, for both individual groups and the study overall. At the "Sign-up" stage, the number of participants recruited was higher for the closed sleep sessions (21 and 24) compared to the open sleep sessions (8 and 2). In Session 1, a higher number of non-participants (54) than participants (8) signed up; participants in this session only accounted for 12% of the total sign-ups (62). It is unknown how many non-participants signed up to Session 2 as this information was not provided by the postgraduate support team co-ordinating sign-up for the open sleep sessions.

After the distribution method for the sleep diaries was altered for Sessions 2-4, the percentage of participants who returned fully completed (i.e. seven days' worth of) Pre-Session Sleep Diaries ranged between 46-50%, while the percentage of participants who returned partial (i.e. between 1-6 days' worth of) Pre-Session Sleep Diaries ranged between 33-50%. When collated data from across the study was considered, 40% and 31% of participants returned fully and partially completed Pre-Session Sleep Diaries respectively.

There was a higher variability in Post-Session Sleep Diary completion. The percentage of participants who returned fully completed (i.e. seven days' worth of) Post-Session Sleep Diaries ranged between 0-50%, while the percentage of participants who returned partial (i.e. between 1-6 days' worth of) Post-Session Sleep Diaries ranged between 0-25% of those who signed up in Sessions 2-4. When collated data from across the study was considered, 13% and 27% of participants returned fully and partially completed Post-Session Sleep Diaries respectively.

The percentage of participants who attended the sleep session, out of those who signed up, was also variable between Session groups and ranged between 50-87.5% of those who signed up. When collated data from across the study was considered, 52% of participants who had signed

up attended a Sleep Session. In Session 1, 59.3% of non-participants who signed up attended the Sleep Session.

The response to the Acceptability Questionnaire was mixed. The percentage of participants who completed the Acceptability Questionnaire ranged between 0-50% of those who signed up. When collated data from across the study was considered, 41% of participants completed the Acceptability Questionnaire.

The percentage of participants completing the Follow-up Questionnaire was low, ranging between 0-25% of those who signed up. When collated data from across the study was considered, 18% of participants completed the Follow-up Questionnaire.

Table 2.4. The number and percentage of participant response across study stages for each sleep session group and for the study as a whole.

	Session 1 Open Sleep Session		Session 2 Open Sleep Session		Session 3 Closed Sleep Session		Session 4 Closed Sleep Session		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Sign Up										
Participants	8	100%	2	100%	21	100%	24	100%	55	100%
Non-participants	54	100%	*	-	-	-	-	-	-	-
PRE Sleep Diaries										
Complete (7 days)	0	0%	1	50%	10	48%	11	46%	22	40%
Partial (1-6 days)	0	0%	1	50%	8	38%	8	33%	17	31%
Sleep Session										
Participants	7	87.5%	1	50%	15	71%	12	50%	35	64%
Non-participants	32	59.3%	3	-	-	-	-	-		
Acceptability Questionnaire	4	50%	0	0%	7	33%	11	46%	22	40%
POST Sleep Diaries										
Complete (7 days)	0	0%	1	50%	3	14%	3	12.5%	7	13%
Partial (1-6 days)	2	25%	0		4	19%	9	37.5%	15	27%
Follow-Up Questionnaire	1	12.5%	0	0%	3	14%	6	25%	10	18%

Notes: * missing data; - not applicable; "participants" refers to people who were part of the research study and "non-participants" refers to those who signed up for the sleep session but did not consent to take part in the research. Percentages are calculated from the number of participants or non-participants (as applicable) present at the "Sign Up" stage.

4.3.2. Facilitator Perceptions

Table 2.5. shows a summary of the perceptions of the three facilitators regarding aspects of study feasibility. Points which were raised by only one facilitator are denoted by their initials.

Table 2.5. Table summarising facilitator perceptions regarding aspects of study feasibility.

What skills, training and resources do the facilitators believe themselves to require to run the session via videoconferencing?

Skills:
• Therapist-level skills not required to deliver the session
• Background knowledge on the topic of sleep needs to be *higher* than just the slide content to be able to explain topics well or answer questions thoroughly (e.g. medications, other sleep disorders, mechanisms of sleep/ sleep interventions)
• Skills in:
  - Presenting (including time management and being engaging)
  - Communicating boundaries/ limits of the session
  - Use of technology
 	
Training:
Facilitators felt this was dependent on their existing level of knowledge but identified the following:
• The use of technology generally in the study (JL)
• The specific slides used and their content (NT)
 	
Resources:
• Common resources often required to run virtual interventions: a quiet space, access to stable internet connection, access to relevant computer software
• Appropriate amounts of time to develop slides and supplementary resources (MG)

Does the online delivery method create any additional challenges or advantages for the facilitators?
Challenges: Although the facilitators identified a number of challenges, these were agreed to largely be surmountable with careful consideration or the opportunity for further development of processes and resources. • More difficult to make the session engaging for attendees • Decreased natural human interactions, connection and warmth • Harder to provide participants with space to ask private questions (MG) • To use chat function well requires two facilitators and makes it harder to respond to complex questions (if one facilitator typing responses) • Risk management protocols need to be more robust using digital platforms • Technology failures can create unnecessary barriers for participants and have more of an impact on virtual than in-person sessions **Advantages:** • Decreased logistical challenges (e.g. timing, location, size of the room, co-ordination between facilitators) • Benefits for recruitment, for example fewer or no constraints on numbers of participants (MG) • Increased flexibility for research team (e.g. the change of sleep diary delivery method) (JL)

- Increased efficiency by:
  - Reduction of confusion or duplication in effort by collaborating using shared documents or folders
  - Eliminating the time and effort required to print, organise and transcribe data from paper materials (JL)
  - Allowing facilitators to collaborate from a distance from various locations in Scotland
- Using one facilitator to respond to messages on chat function helped with time-keeping as it allowed the simultaneous delivery of material and the answering of questions (NT)

Do the facilitators believe the delivery method was acceptable?

- The delivery method was acceptable overall
- No challenges were large enough to not consider using an online delivery method again
- Development in several areas would improve the delivery method acceptability:
  - More time to develop materials (e.g. add information about calculating sleep efficiency from the sleep diary)
  - Use of more sophisticated technology (e.g. Zoom poll function, linktree) to a) make session more engaging and b) streamline research processes
  - Clearer processes with teams external to the research team to reduce miscommunication and/or human error (NT)

Do the facilitators believe the content of the session was suitable and appropriate for online delivery?

- Yes
- Content was comprehensive, but clear and understandable
- The lack of highly sensitive material or risky participants means online delivery was appropriate
- Could have improved the screening process in study to make completely sure no inappropriate participants attending (MG)

4.4. Acceptability

The percentage agreement ratings were calculated for acceptability questions presented to participants at different stages (sign-up, acceptability questionnaire and follow up questionnaire) of the study. Summary tables of the key themes from participant responses to questionnaire open questions can be found in Appendix B.5.3., while a summary of the numbers and proportions of participants responding to each question is linked in Appendix B.5.2.

4.4.1. Sign-up

Figure 2.2. shows the percentage agreement ratings for acceptability questions administered at the "Sign-up" stage. Questions relating to the "self-efficacy" TFA domain elicited lower agreement ratings (i.e. either "strongly agree" or "somewhat agree") when regarding participants' view of their ability to use technology (26%) compared to their ability to change their habits (88%). Conversely, questions relating to the "perceived effectiveness" TFA domain elicited higher agreement ratings when regarding the online delivery method's ability to improve participants' sleep (74%) compared to that of the sleep session itself (56%). Questions relating to the "burden" TFA domain showed mixed results; most participants expected the online delivery method to increase their understanding and engagement (76% selecting either "strongly agree" or "somewhat agree") despite a lower percentage of participants expecting the technology to work well (52% selecting either "strongly agree" or "somewhat agree"). A large majority (90%) of participants reported positive feelings about the sleep session and a similarly high percentage (82%) viewed the online delivery method as a fair way to offer access to the session ("affective attitude" and "ethicality" TFA domains respectively). A large portion of participants were not aware of the main CBT-I principles (50% selecting either "somewhat disagree" or "completely disagree").

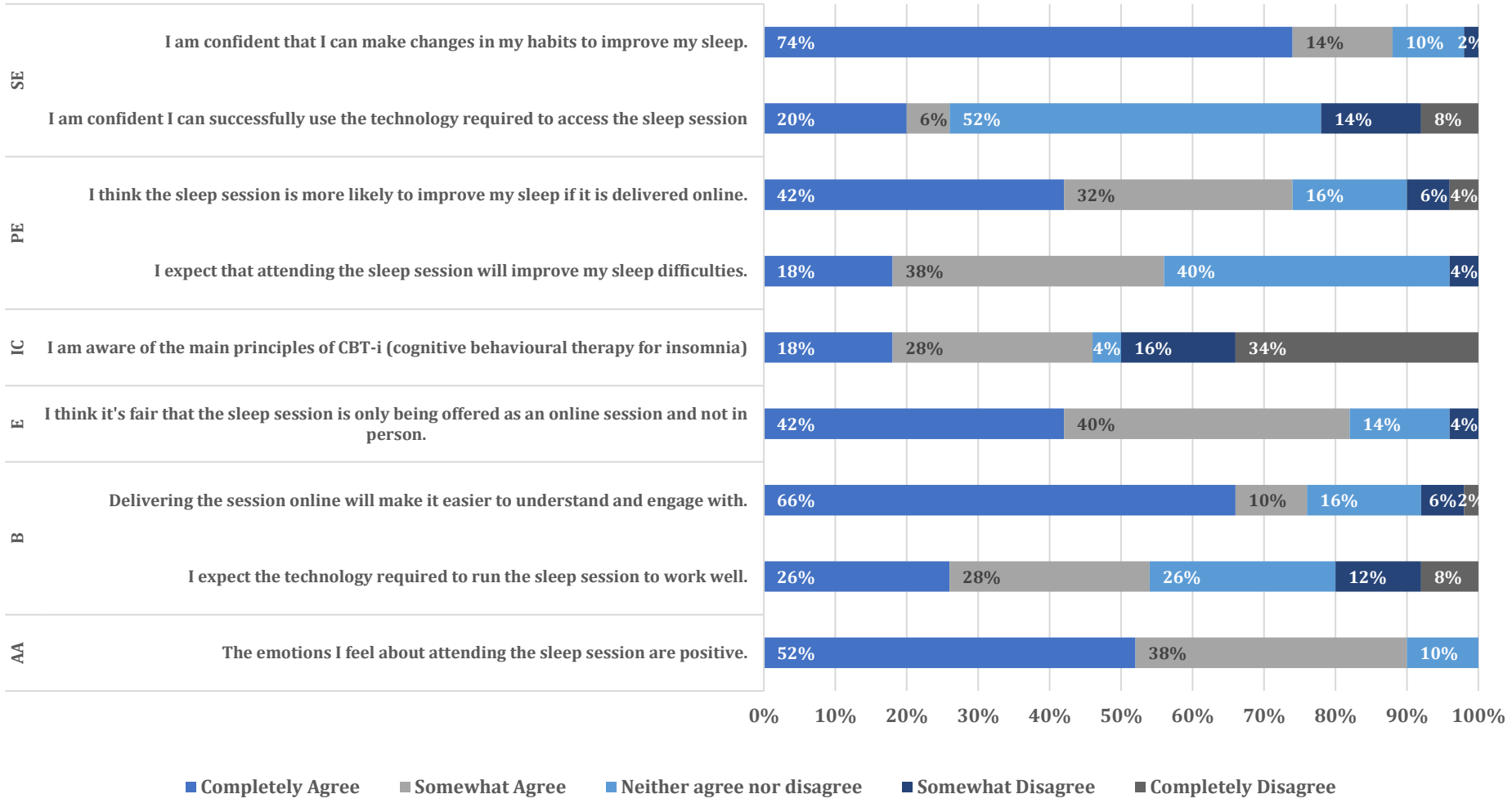

Figure 2.2. Stacked bar chart showing percentage agreement ratings for acceptability questions administered at the "Sign-up" stage.
Abbreviations are TFA domains: SE = "Self-efficacy", PE = "Perceived effectiveness", "OC = Opportunity Costs", IC = "Intervention Coherence", E = "Ethicality", B = "Burden", AA = "Affective Attitude". Please refer to Appendix B.5.2. for the full dataset, where the number of participants providing each response can be found.

4.4.2. Acceptability Questionnaire

Figure 2.3. shows the percentage agreement ratings for acceptability questions administered at the "Acceptability Questionnaire" stage. Questions relating to the "self-efficacy TFA domain elicited higher agreement ratings when regarding participants' intention to incorporate recommendations from the sleep session into their daily lives (95.4% rating either "strongly agree" or "somewhat agree") compared to their confidence that they would do so (63.6% rating "somewhat agree" only). Interestingly, in questions relating to the "perceived effectiveness" TFA domain, more participants agreed (i.e. gave either "strongly agree" or "somewhat agree" responses) that the sleep session would positively impact on the quality of their life (50%) than the quantity or quality of their sleep (36.4% and 27.2% respectively). Although the question relating to the "opportunity costs" TFA domain overall produced mixed responses, a small majority (54.5%) disagreed (i.e. gave either "somewhat disagree" or "completely disagree responses) that attending the sleep session required them to sacrifice other opportunities. In regard to questions relating to the "intervention coherence" TFA domain, participants provided very high agreement ratings (i.e. either "strongly agree" or "somewhat agree") that the sleep session concepts were clearly explained (95.5%), that the recommendations made were understandable (95.5%) and that there was enough time in the session (81.8%); however, a majority of participants also agreed that none of the concepts were new to them (54.6%). Regarding the "ethicality" TFA domain, 77.3% of participants agreed that the sleep session aligned with their values. Participants gave similarly high agreement ratings (77% or more of participants responding with "strongly agree" or "somewhat agree" ratings) across all questions relating to the "affective attitude" TFA domain. Questions relating to the "burden" TFA domain largely received high agreement ratings. All participants (100%) agreed (i.e. selected either "strongly agree" or "agree" ratings) that the study was well advertised and easy to sign up to take part in. Similarly, high percentages of participants agreed that the technology ran well (81.8%), that the facilitators used the technology well (95.5%), that the sleep diaries were easy to fill out (86.4%) and that the calendar reminders were useful (68.2%). The majority (86.3%) of participants also agreed that the sleep session being run online made it easier for them to attend; however, participants' views were more mixed regarding whether the online delivery method made it more likely they would ask questions or engage in discussion, with most (36.4%) participants selecting the neutral "neither agree nor disagree" response. Participants' views were equally divided regarding how easy the sleep session recommendations are to follow, with 50% selecting the "somewhat agree" response and 45% selecting the "somewhat disagree" responses.

The key themes from participant responses to open questions regarding the *online delivery* of the study and sleep session at the "Acceptability Questionnaire" stage were summarised (see

Appendix B.5.3. for summary tables). Sixteen participants provided responses about what they liked about the online delivery method. Factors related to convenience or ease of access (e.g. a lower time commitment, eliminating the need for travel, ability to access from anywhere in the world) were the most commonly referenced reason and were mentioned fourteen times. Thirteen participants provided responses about what they did not like about the online delivery method. Poorer quality or absent interaction between participants or between facilitators and participants was the most commonly referenced factor (four references). Technology failures (two references), difficulty concentrating (two references) and a lowered desire to ask questions (two references) were other cited factors.

The key themes from participant responses to open questions regarding the *content* of the sleep session at the "Acceptability Questionnaire stage" were summarised (see Appendix B.5.3. for summary tables). Seventeen participants provided responses about the most helpful content from the session. Being provided with tips generally (five references), the opportunity for discussion (four references) and information about the science of sleep (four references) were the top three most commonly referenced helpful content elements. Sixteen participants provided responses about the least helpful content from the session. Recommendations which had been heard already (four references) and not having enough of the session devoted to discussion (three references) were the two most commonly cited unhelpful content elements. When asked for other comments regarding the content of the session, eight participants provided responses. Responses referencing a sense of satisfaction (three references) were the most common, while a desire for more information on sleep quality (two references) and more information on the impact of food on sleep (two references) were also mentioned.

The key themes from participant responses to open questions regarding the *recommendations* from the sleep session at the "Acceptability Questionnaire" stage were summarised (see Appendix B.5.3. for summary tables). Eighteen participants provided responses about what factors would influence whether they use the recommendations from the session. A lack of control over situational factors (seven references), the availability of energy or motivation (five references) and work factors (three references) were the top three most commonly referenced factors. Seventeen participants provided responses about what recommendations from the session they would find easiest to implement. Limiting alcohol and caffeine (four references), limiting screens before bed (three references), limiting bed use to sleep and sex (three references) and sticking to a sleep schedule (three references) were the top four most commonly referenced recommendations. Sixteen participants provided responses about what recommendations from the session they would find the hardest to implement. Sticking to a sleep schedule (seven

references) and limiting screens before bed (four references) were the top two most commonly referenced recommendations.

The key themes from participant responses to open questions regarding the *facilitators* at the "Acceptability Questionnaire" stage were summarised (see Appendix B.5.3. for summary tables). Six participants provided responses about the facilitators. That they presented well (three references) and that they made asking questions easy (two references) were the most commonly referenced themes.

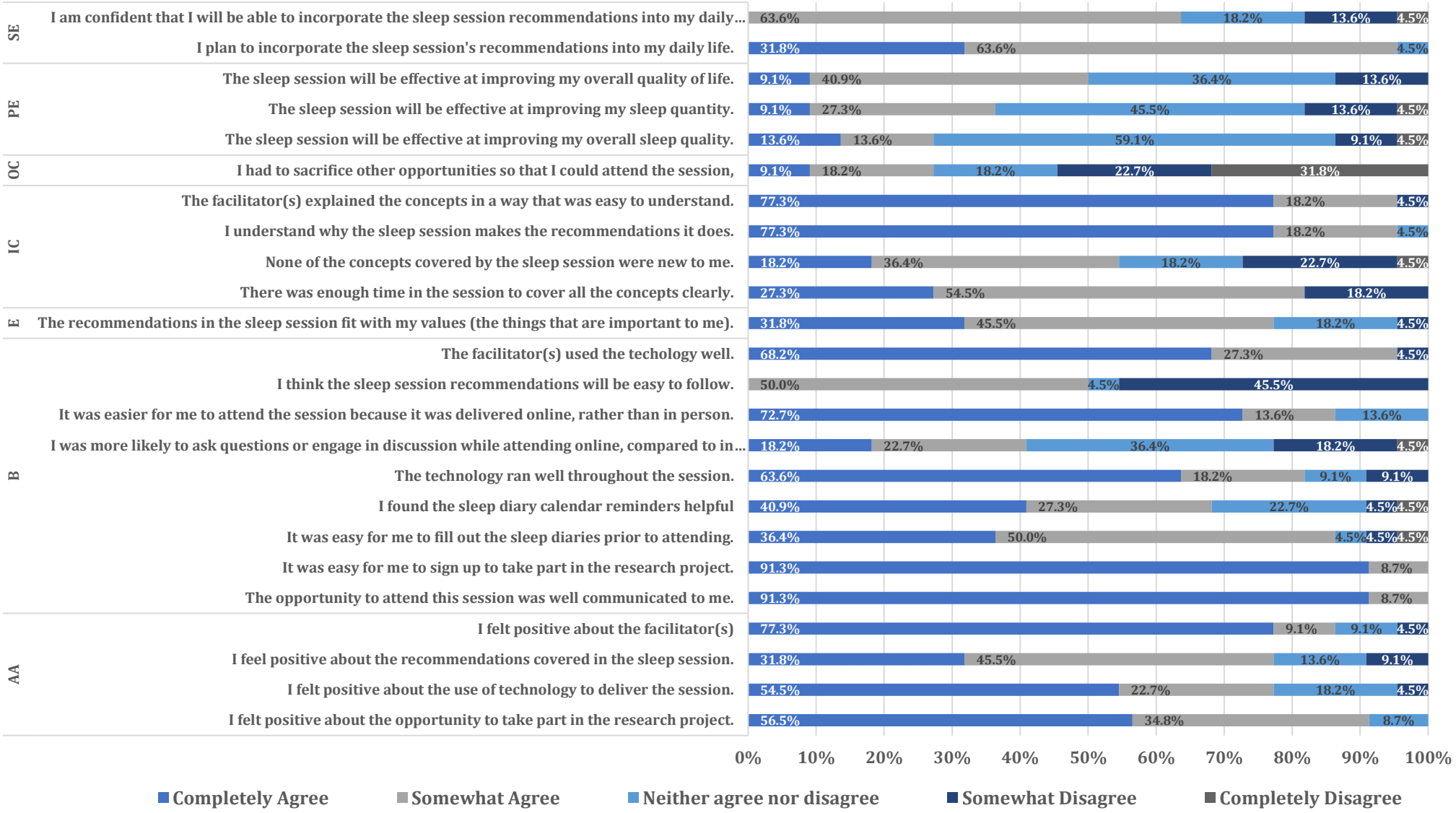

Figure 2.3. Stacked bar chart showing the percentage agreement ratings for acceptability questions administered at the "Acceptability Questionnaire" stage.
Abbreviations are TFA domains: SE = "Self-efficacy", PE = "Perceived effectiveness", "OC = Opportunity Costs", IC = "Intervention Coherence", E = "Ethicality", B = "Burden", AA = "Affective Attitude". Please refer to Appendix B.5.2. for the full dataset, where the number of participants providing each response can be found.

4.4.3. Follow-up

Figure 2.4. shows the percentage agreement ratings for acceptability questions administered at the "Follow-up" stage. Agreement ratings relating to the "self-efficacy" TFA domain remained high, with 70% of participants selecting either a "strongly agree" or "somewhat agree" response. In relation to the "perceived effectiveness" TFA domain, participants perceived the sleep session to be most effective at improving the quality of their sleep (60% selecting either "strongly agree" or "somewhat agree") and least effective at improving the quantity of their sleep (30% selecting either "strongly agree" or "somewhat agree"), while they perceived the sleep session to be moderately effective at improving their overall quality of life (50% selecting either "strongly agree" or "somewhat agree"). 40% of participants agreed (i.e. selected either "strongly agree" or "somewhat agree") that they would have to give up other important or beneficial things in their life to keep implementing the recommendations from the sleep session ("opportunity costs" TFA domain). In relation to the "intervention coherence" TFA domain, slightly more participants agreed (50% selecting either "strongly agree" or "somewhat agree") that they were aware of the main principles of CBT-I, than at the sign-up stage (46% selecting either "strongly agree" or "somewhat agree"). When asked if it was fair for the sleep session to continue to be offered online ("ethicality" TFA domain) much higher proportion of participants selected completely agree (80%) than at the sign- up stage (42%). Questions relating to the "burden" TFA domain showed mixed results; an equal proportion (40%) of participants selected "somewhat agree" and "somewhat disagree" when asked if they found the recommendations from the sleep session easy to put into practice, but 60% of participants agreed (i.e. selected either "strongly agree" or "somewhat agree") that they had managed to stick closely to the recommendations. A large majority (80% selecting either "strongly agree" or "somewhat agree") of participants reported positive feelings about the sleep session recommendations and an even larger majority (90% "strongly agree" or "somewhat agree") were glad to have attended the sleep session ("affective attitude" TFA domain).

The key themes from participant responses to open questions regarding the *recommendations* from the sleep session at the "Follow-up" stage were summarised (see Appendix B.5.3. for full summary tables). Eight participants provided responses about what recommendations from the session they found easiest to implement. Limiting screens before bed (two references) and limiting bed use to sleep and sex (three references) were the top two most commonly referenced recommendations. Limiting coffee, limiting eating directly before bed and sticking to a sleep schedule were also cited. Eight participants provided responses about what recommendations from the session they found hardest to implement. Using devices in or before bed (three references) was the most commonly referenced recommendation. Limiting bed use to sleep and

sex, the 20-minute rule (a stimulus control strategy), leaving enough time for sleep and sticking to a sleep schedule were also cited.

The key themes from participant responses to open questions regarding the *study measures* at the "Follow-up" stage were summarised (see Appendix B.5.3. for full summary tables). One participant responded to the question asking if there had been any study measures they had not filled out, commenting they had not filled out the sleep diaries. Two participants provided responses regarding why they had not filled out study measures and cited seeing no change in their sleep and filling out the measures having a negative impact on their sleep as factors.

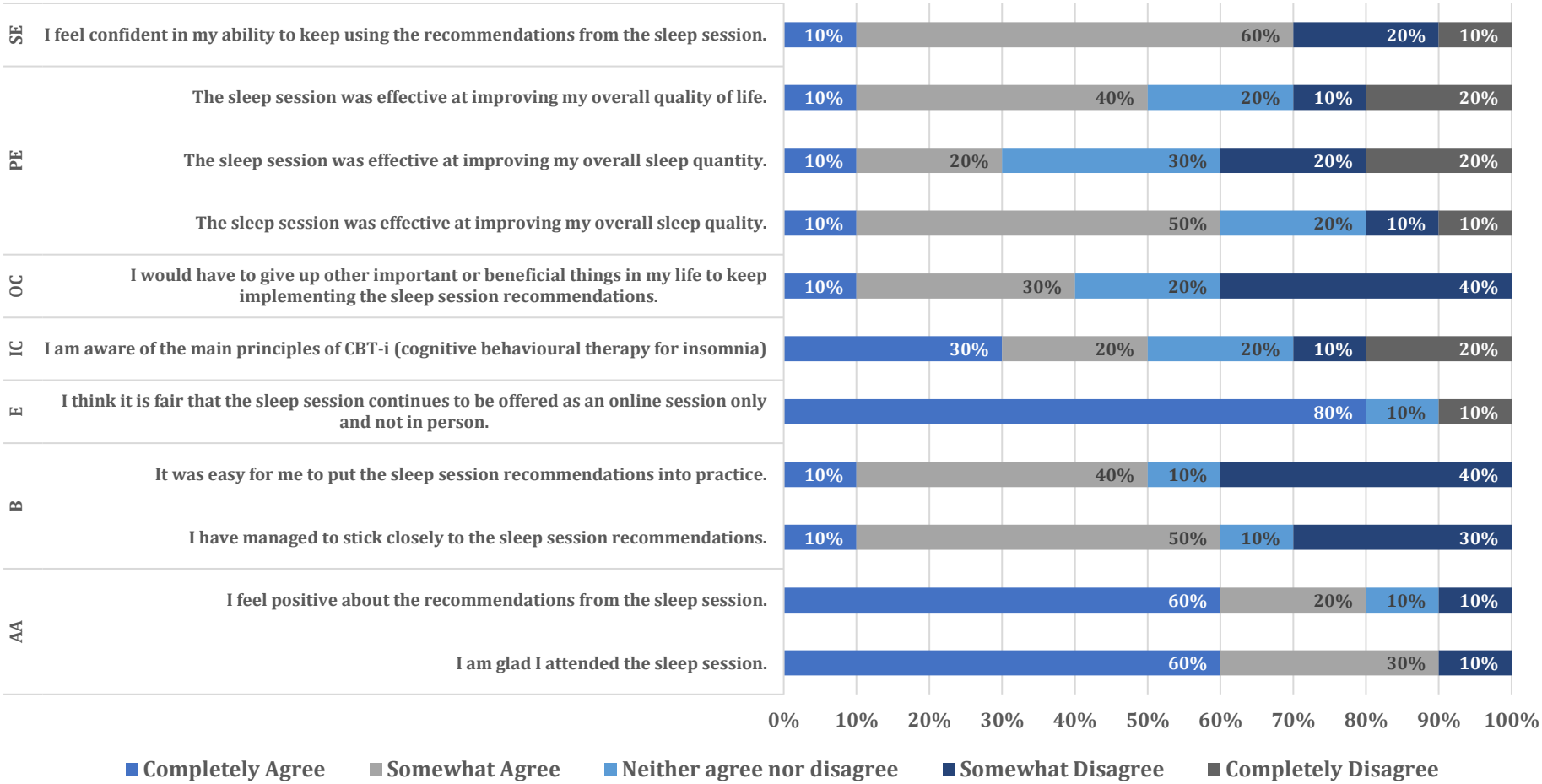

Figure 2.4. Stacked bar chart showing percentage agreement for acceptability rating questions included at the "Follow-up" stage.
Abbreviations are TFA domains: SE = "Self-efficacy", PE = "Perceived effectiveness", "OC = Opportunity Costs", IC = "Intervention Coherence", E = "Ethicality", B = "Burden", AA = "Affective Attitude". Please refer to Appendix B.5.2. for the full dataset, where the number of participants providing each response can be found.

5. Discussion

Our findings suggest that both the intervention and delivery method, assessed via questionnaires both prospectively and retrospectively, were generally acceptable to recipients. Furthermore, facilitator feedback indicated that running the sleep session online via videoconferencing was a feasible method of delivery. However, several factors such as collaboration issues with teams external to the research team and the most optimal use of available software appear to have negatively impacted on areas of feasibility such as recruitment and outcome completion rates. Data gathered after the adaptation of research processes halfway through the study suggest that it is possible to mitigate the negative impact of these factors.

5.1. Feasibility

We were interested in exploring the feasibility of both running a study involving a single session sleep intervention and of running the intervention digitally via videoconferencing.

5.1.1. Recruitment:

Using the available recruitment method (emails sent via an external distribution list), we were able to recruit 55 participants across the course of the study (approximately four months). While this allowed us to reach the sample size set out in Section 3.4, it represents only 1.4% of the estimated postgraduate researchers (approximately 4,000) currently matriculated at the University of Glasgow and included on the email distribution list. As research suggests that at least 18% of students suffer from sleep difficulties (Jiang et al., 2015b; Chowdhury et al., 2020; Jahrami et al., 2020), it seems reasonable to have predicted a higher recruitment rate. Similarly, the data from Session 1 (open session) shows that only 12% of attendees at the session were participants in the study, substantially lower than the 30% found in the Smilie and Gardani (2019) study conducted with the same population but utilising a face-to-face study design. As the running of Session 2 was severely impacted by collaboration issues, we cannot know if this low recruitment rate in the "open" research groups is an anomaly or not. One possible explanation for a low recruitment rate is that the burden of participating in our research was perceived as high by potential participants. However, although we did not gather data on the acceptability of the study processes prospectively, retrospective data gathered at the Acceptability Questionnaire and Follow-Up stages suggests that the study processes were generally acceptable to participants (see Section 5.2.1.), leaving the source of our poor recruitment rate unclear.. The limited data available from the open compared to closed study groups suggest that recruitment to the study was improved by the amendment to "closed" sleep sessions.

5.1.2. Response

In addition to poor recruitment, the "open" sleep sessions yielded a much poorer response on study measures, particularly the sleep diaries. Perhaps unsurprisingly, given that the usability issues have been identified as a barrier to engaging with an intervention (Borghouts et al., 2021), this appears to have been resolved by the adaptation of processes to utilise Forms, a more user-friendly platform for our purposes which lowered the probability of user-error.

Overall participant attendance at the sleep session (64%; n=35) was slightly below one systematic review which reported intervention completion in 74.5% of participants (Seyffert et al., 2016), but was within the range reported in the broader literature on digital interventions for insomnia with various recent studies reporting intervention completion in between 40-70% of their sample (e.g. Kallestad et al., 2021; Jernelov et al., 2021; van der Zweerde et al., 2019). However, these interventions differed from the current study in that they spanned multiple sessions so they may not be directly comparable. Broadly, though, this suggests that a similar response, in terms of attendance, can be expected from the postgraduate population compared to the general adult population. Any research team utilising this design for a full-scale trial would need to take this into account when calculating their required sample size.

5.1.3. Facilitator Perceptions:

Clinician attitude has been recognised as a vital facet of implementing interventions in "real world" settings (Krahn, 2013; Simon et al., 2021; Koffel et al., 2018). Although the facilitators in this study perceived the intervention content and delivery method as acceptable, they identified several challenges. Firstly, that the digital delivery method requires researchers to give more time and consideration to resource development and best use of technology to make the session more engaging for participants (although this was counter-balanced somewhat by the time saved on other research processes). Secondly, that collaboration with external teams needs to be well thought out and research process requirements clearly and frequently communicated to minimise the potential for these issues to impact on recruitment and response variables. However, facilitators did feel that the challenges associated with the digital delivery method were surmountable, suggesting that no issues were identified which suggest that a full-scale trial with this research design would not be feasible.

5.2. Acceptability

5.2.1. Study processes

Although not specifically part of our original research questions, several questions at the acceptability questionnaire and follow-up stages addressed participants' perception of the acceptability of our study processes. A comfortable majority of participants indicated that they felt positive about the opportunity to take part in the research, they found the calendar reminders helpful, the sleep diaries were easy to fill out and that the facilitators used the technology well. These results appear to suggest that the study processes were acceptable to participants. However, only 40% of the sample provided responses at the acceptability questionnaire stage and these may be biased towards a self-selecting group whose attitudes towards completing measures and taking part in research is generally more positive. Including further questions on the prospective acceptability of study processes could have mitigated this concern by a) potentially generating higher response return rate and b) allowing for comparison of acceptability ratings over time.

5.2.2. Online Delivery Method

This study aimed to assess the acceptability of an online videoconferencing delivery method specifically. Questions regarding the delivery method at the sign-up stage (i.e. assessing *prospective* acceptability) revealed that participants were not highly confident in their own ability to use technology and only held moderate expectations for the technology to work well; a result which is surprising given the age of the study sample (90% under the age of 35) which is considered to be on the technology proficient side of the "digital divide" compared to those who are older (Francis et al., 2019). Higher educational attainment, as found in postgraduates, is also generally associated with lower digital poverty/inequality (Cruz-Jesus et al., 2016) although there is some evidence that this is not always the case. For example, one study surveyed students beginning their attendance at a higher education institution in the USA which was predominantly attended by students from ethnic minority communities and found that, on average, students felt they could have been better prepared for the technological demands of higher education (Buzzetto-Hollywood et al., 2016). Similarly, those with mental health issues are more likely to experience "digital exclusion" (i.e. not being able to access services due to digital poverty; Tobitt et al., 2019) and may face a number of barriers to accessing remote treatment such as lack of access to digital devices (particularly those with a larger screen), a fast enough internet connection and a private space (Watson et al., 2021). These factors have implications for how digital interventions should be developed and implemented within services, especially within the

context of the various organisational and governmental strategies or reports which encourage the adoption of digital approaches (e.g. NHS England, 2016; European Commission, 2013). Further research is required into ways to overcome barriers to access of digital interventions. Wykes et al. (2016) proposed a number of areas which, if addressed, may aid the successful and equitable implementation of digital interventions such as skills and access to the internet, digital empowerment and choice, adherence, reciprocity and user involvement.

A large majority of participants, however, regarded the delivery method as a fair way to deliver the intervention, expected it to increase their understanding of and engagement with the materials and considered it more likely to improve their sleep, which suggests that the intervention is prospectively acceptable to participants despite their lack of confidence in their abilities to use technology. Interestingly, there was evidence in a shift of opinion about engaging with the session by the acceptability questionnaire stage, when a much lower number of participants regarded the delivery method as improving the likelihood they would ask questions or engage in discussion during the session. A lack of interaction was also the highest referenced factor that participants didn't like about the delivery method. Participants did, however, regard the delivery method as making it easier for them to attend and ease of access was the most referenced factor that participants liked about the delivery method. Another shift in attitude regarding the delivery method over the study period was participants' perception of how fair (ethical) it was to only offer the intervention via an online platform; although the majority of participants indicated high levels of overall agreement to this statement, the *strength* of their agreement (i.e. those selecting the "completely agree" response) doubled between the sign-up and follow-up stages. Few other studies have attempted to assess participant's views on the ethicality of interventions (a point echoed by Ortblad et al., 2022) and so it isn't possible to say whether this is a common response pattern.

These results are consistent with other literature which suggests that some interaction with an expert is often highly valued by the recipients of dCBT-I interventions (e.g. Hasan et al., 2022; Koffel et al., 2018; Hermes et al., 2019) and may improve the efficacy of the interventions (Zachariea et al., 2016; Ho et al., 2014). Similarly, this was also perceived as a challenge reported by the facilitators, although they believed it could be overcome with more creative use of technology. For example, one study reported participants being able to successfully establish a working alliance and affective bond with an avatar during a fully-automated dCBT-I intervention, and that the strength of this alliance predicted treatment outcomes (Heim et al., 2018).

The shift in ratings from sign-up (pre-sleep session) to acceptability questionnaire (post-sleep session) also reinforces the importance of assessing acceptability over time, as highlighted by Sekhon et al. (2017), a practice which is not commonplace in current research design. There are

potential implications for multi-session interventions, where a pronounced decrease in concurrent or retrospective acceptability compared to prospective acceptability could plausibly influence how likely participants are to go on and complete all elements of an intervention.

5.2.3. Content

This study also aimed to assess the acceptability of the intervention, both overall and regarding the content covered and recommendations provided. We found high agreement ratings across several TFA domains such as self-efficacy, ethicality and affective attitude, and these were stable over time. Moderate agreement ratings were found for the opportunity costs, burden and intervention coherence domains, suggesting that acceptability was not as high in these domains.

Within the perceived effectiveness domain which covered participant's views about how helpful the sleep session would be for their quality of life, quantity of sleep and quality of sleep, a shift in participants ratings occurred over time. At the acceptability questionnaire stage, participants viewed the sleep session as most likely to help with the quality of their life and unlikely to help with the quality of their sleep. At the follow-up stage, however, while participants agreement ratings remained relatively stable regarding the impact of the sleep session on their quality of life and the quantity of their sleep, the proportion of participants who agreed that the sleep session had a positive impact on the quality of their sleep doubled compared to the acceptability questionnaire stage. As already discussed, this is one of the first studies attempting to use an acceptability measure based on the TFA and administered over several timepoints, meaning it is not possible to say whether this pattern is typical for those receiving dCBT-I interventions.

5.3. Limitations

One limitation to the research presented here is the absence of an explicitly referenced framework throughout the study design and outcome reporting. For example, the Consolidated Standards of Reporting Trials (CONSORT; Schulz et al., 2010) is a guideline originally created to increase the standards of randomised controlled trial reporting, but has more recently been extended to be suitable for randomised pilot and feasibility trials (Eldritch et al., 2016). Although not intended for non-randomised feasibility studies such as the current study, it has been suggested that it is possible for CONSORT to be appropriately adapted for such studies (Lancaster, et al., 2019). Similarly, the recently updated Medical Research Council framework for developing complex interventions (Skivington et al., 2021) describes the phases and core elements required in developing an intervention, thereby assisting researchers to frame research questions and

subsequently design and complete research projects appropriately. The consistent use of such frameworks aims to add to the quality of the literature by setting standards for "best practice" within research design and reporting, and thereby increasing quality, consistency and comparability across different studies. The absence of such a framework limits the confidence we can have in the quality and generalisability of the current study. Furthermore, frameworks such as those mentioned encourage the *a priori* consideration of what criteria or indicators would allow researchers to judge the study as feasible or intervention as acceptable. The current study, although not designed as a formal pilot study where such criteria are deemed essential, could have benefited from the inclusion of such "benchmarks for success". Their absence limits the clarity of conclusions we can draw about whether the study design and intervention were feasible or acceptable.

Similarly, the lack of an explicit framework could arguably be responsible for the somewhat higher focus given to acceptability than feasibility throughout this study. However, this imbalance in focus is perhaps unsurprising given the attempt to create a novel measure linked to a formal model of acceptability, something which has been identified as lacking in the acceptability literature (e.g. Sekhon et al., 2017; Ortblad et al., 2022). Indeed, in the framework for the implementation of healthcare interventions proposed by Klaic et al. (2022), the authors suggest that acceptability factors be considered prior (but in relation) to feasibility factors. Therefore, the larger consideration of acceptability data may be appropriate in this study which looks at a novel delivery method for an intervention to a novel population. Arguably more concerning is the the small numbers of participants engaging with the acceptability measure at follow-up, meaning we must be cautious about the strength of conclusions drawn about acceptability changes over time.

This study utilised a questionnaire which was designed by the research team to correspond to the domains proposed in the TFA, something which we are not aware of having been previously attempted in the literature at the time of running. However, when the questionnaires were separated into the different components of the study and intervention (such as content, delivery method, research processes) for analysis, it became clear that not all TFA domains were present for each study component at each timepoint. This meant it was not possible to assess changes over time for each TFA domain and each study component, which represents a loss of potentially valuable data and may limit the reliability of our findings. Any future attempt to replicate this type of model-based questionnaire should take this into consideration.

The current lack of such a measure or the broader lack of consensus on how to define and assess acceptability also means that the ease with which this study can be compared to other similar studies is limited. Ongoing development of validated measures corresponding to models of acceptability such as the TFA should be considered a future priority for researchers in the field.

Initial work on developing such a measure has recently been published by the research team who developed the TFA (Sekhon et al., 2022) but this is in its infancy and requires further research. Such work would have the potential to, with adoption more broadly into routine research practice, improve consistency and quality of acceptability assessment within the broader literature.

5.5. Implications & Recommendations

A single session of a CBT-I-based intervention delivered via videoconferencing appears to have the potential to be acceptable to postgraduate students and feasible to deliver for providers. This implies that digitally delivered interventions could offer an alternative option for insomnia treatment to postgraduates while maintaining flexibility and efficiency for providers. There are a number of ways in which future researchers could consider building on this research, for example:

- Conducting a formal pilot study using explicit criteria to more clearly determine the success of the study
- Full scale trials assessing the efficacy of digitally delivered single session CBT-I interventions, both in the postgraduate and other populations
- Developing different methods of delivery, possibly including alternative digital delivery methods, and assessing the relative acceptability and feasibility of these.

In addition to implications for research into single session CBT-I and its delivery methods, this study also has implications for future research into acceptability. For example, it further reinforces the need for standardised, theory-driven measures to assess acceptability and for further consideration for how these are used across different timepoints of a study. Future research directions include:

- Studies validating newly proposed standardised acceptability measures (e.g. Sekhon et al., 2022) for the postgraduate population.
- Studies which examine independently both the prospective acceptability of different sleep interventions and how acceptability changes over time.

5.6. Conclusions

We aimed to assess the feasibility and acceptability of delivering a single, CBT-I based sleep session digitally via videoconferencing technology and found that it is both feasible for researchers and acceptable to recipients. The findings from this study were limited by a small sample at follow-up and a lack of generalisability due to wider issues in the literature regarding how acceptability is defined and measured. Factors which appear to impact on recruitment and outcome completion rates include the software used and reliance on other professionals for recruitment. Future researchers wishing to complete large-scale research utilising this study design may wish to take all these factors, along with feedback from facilitators, into account.

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Appendices

A. Systematic Review

A.1. Database search strategies

A.1.1. Embase & Medline (via OVID)

1	exp insomnia/
2	(insomnia* or sleep diff* or sleep disturb*).ab,kw,ti.
3	1 or 2
4	Mobile Applications/
5	exp internet/
6	telephone/ or exp cell phone/ or videoconferencing/
7	computers/ or exp computers, handheld/
8	Medical Informatics Applications/
9	Therapy, Computer-Assisted/
10	(app or apps).ab,ti.
11	(online or web or internet or digital*).ab,ti.
12	((online or web or internet or digital*) adj3 (based or application* or intervention* or program* or therap*)).ab.
13	(phone* or telephone* or smartphone* or cell phone* or smartwatch*).ab,ti.
14	((phone* or telephone* or smartphone* or cell phone* or smartwatch*) adj3 (based or application* or intervention* or program* or therap*)).ab.
15	(mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental).ab,ti.
16	((mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental) adj3 (based or application* or intervention* or program* or therap*)).ab.
17	(mobile* adj3 (based or application* or intervention* or device* or technolog*)).ab,ti.
18	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 1744956
19	Cognitive Behavioral Therapy/
20	"cognitive behavio* therap*".ab,kw,ti.
21	(cognitive behavio* therap* adj2 insomnia).ab,kw,ti.
22	19 or 20 or 21
23	3 and 18 and 22
24	remove duplicates from 23

A1.2. PsycINFO & CINAHL (via EBSCOhost)

S21	S20 AND S15 AND S4
S20	S16 OR S17 OR S18 OR S19
S19	intervention* OR therap* OR treatment OR strateg* [TI/AB]
S18	"cognitive behavio* therapy for insomnia" OR *cbt-i OR *cbti [TI/AB]
S17	"cognitive behavio* therapy" [TI/AB]
S16	Cognitive Behavior Therapy [DE/ MeSH]
S15	S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14
S14	(TI (mobile* N2 (based or application* or intervention* or device* or technolog*)) OR (AB (mobile* N2 (based or application* or intervention* or device* or technolog*))
S13	AB (("mobile health" OR mhealth OR ehealth OR e-health OR emental OR e-mental) N2 (based or application* OR intervention* OR program* or therap*))
S12	TI ("mobile health" OR mhealth OR ehealth OR e-health OR emental OR e-mental)
S11	AB ((phone* OR telephone* OR cellphone* OR "cell phone*" OR "mobile phone*" OR smartphone*) N2 (based or application* OR intervention* OR program* or therap*))
S10	(TI (phone* OR telephone* OR cellphone* OR "cell phone*" OR "mobile phone*" OR smartphone*)) OR (AB (phone* OR telephone* OR cellphone* OR "cell phone*" OR "mobile phone*" OR smartphone*))
S9	AB ((online OR internet OR web* OR browser OR digital*) N2 (based or application* OR intervention* OR program* or therap*))
S8	(TI (online OR internet OR web* OR browser OR digital*)) OR (AB (online OR internet OR web* OR browser OR digital*))
S7	(TI (app OR apps OR application)) OR (AB (app OR apps OR application))
S6	((DE "Computer Assisted Therapy") OR (DE "Telemedicine" OR DE "Online Therapy" OR DE "Teleconferencing" OR DE "Teleconsultation" OR DE "Telepsychiatry" OR DE "Telepsychology" OR DE "Telerehabilitation")
S5	DE "Internet" OR "Mobile Applications" OR "Mobile Phones" OR "Smartphones" OR "Digital Interventions" OR "Digital Technology" OR "Electronic Health Services" OR "Health Information Technology"
S4	S1 OR S2 OR S3
S3	TI sleep dis* OR AB sleep dis*
S2	TI insomnia* OR AB insomnia*
S1	DE "Insomnia"

A1.3. The Cochrane Library

#1	MeSH descriptor: [Sleep Initiation and Maintenance Disorders] explode all trees
#2	(insomnia* OR "sleep diff*" OR "sleep disturb*"):ti,ab,kw

#3	#1 OR #2
#4	MeSH descriptor: [Mobile Applications] this term only
#5	MeSH descriptor: [Telephone] explode all trees
#6	MeSH descriptor: [Internet] explode all trees
#7	MeSH descriptor: [Computers, Handheld] explode all trees
#8	MeSH descriptor: [Medical Informatics Applications] this term only
#9	MeSH descriptor: [Therapy, Computer-Assisted] this term only
#10	(app OR apps):ti,ab,kw
#11	(online OR web OR internet OR digital*):ti
#12	((online or web or internet or digital*) n2 (based or application* or intervention* or program* or therap*)):ab
#13	(phone* or telephone* or smartphone* or cellphone* or smartwatch*):ti
#14	((phone* or telephone* or smartphone* or cellphone* or smartwatch*) n2 (based or application* or intervention* or program* or therap*)):ab
#15	(mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental):ti
#16	((mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental) n2 (based or application* or intervention* or program* or therap*)):ab
#17	(mobile* n2 (based or application* or intervention* or device* or technolog*)):ti,ab,kw
#18	#4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17
#19	MeSH descriptor: [Cognitive Behavioral Therapy] this term only
#20	(cognitive behavio* therap*):ti,ab,kw
#21	(“cognitive behavio* therap* for insomnia” OR *cbt-i OR *cbti):ti,ab,kw
#22	#19 OR #20 OR #21
#23	#3 AND #18 AND #22

A.2. Tool used for screening purposes

Criteria	Y	N	Notes
Publishing Characteristics			
Is the study published in English?		E	
Is the study published in a peer-reviewed journal?		E	
Is the study one of the following? *Editorials, literature reviews, systematic reviews, meta-analyses, protocols, conference abstracts, posters, theses and dissertations, methodological and epidemiological studies and letters.*	E		
Participant Characteristics			
Does it involve humans?		E	
Does it involve children (under 16 years of age) or elderly people (over 65)?	E		*If studies have mixed-age samples, these will be included only if the relevant acceptability data have been reported for the adult (16-65) sub-group separately.*
Does it involve adults with a learning disability?	E		
Are the participants recruited based on a specific neurological or medical condition or have insomnia related to sleep breathing difficulties (e.g. sleep apnea)?	E		*Examples include: cancer, asthma, traumatic brain injury, pain, osteoarthritis, pregnancy, menopause*
Are the insomnia symptoms captured by: a) Validated psychometric measures for insomnia OR b) Standard questions which EXPLICITLY state they are based on DSM or ICD diagnostic criteria		E	*Examples include:* *The Pittsburgh Insomnia Rating Scale (PIRS)* *The Insomnia Symptom Questionnaire (ISQ)* *The Insomnia Severity Index (ISI)* *The Sleep Condition Indicator (SCI)*
Intervention Characteristics			

Criteria	Y	N	Notes
Is cognitive behavioural therapy for insomnia (CBT-I) the intervention used?		E	
Does the CBT-I intervention include two of the following key components? *Sleep hygiene psychoeducation, stimulus control, sleep restriction, relaxation techniques and cognitive reappraisal.*		E	
If the intervention incorporates components related to other topics (e.g. anxiety management or smoking cessation), do these make up more than 25% of the intervention?	E		
Does the intervention deliver therapeutic content using digital approaches (including telephone)?		E	*(please add a "telephone" label to any telephone studies you find)*
Does the digital component make up 50% or more of the intervention?		E	
Outcome Characteristics			
Does it report either quantitative or qualitative acceptability data? (or could these be easily calculated from the data provided)		E	*Examples include:* *Qualitative: focus groups, surveys* *Quantitative: attrition, adherence, module completion, homework completion, rating scales*
Is the only reported acceptability data: a) drop-out at follow up or b) relating explicitly to only the intervention content?	E		*For b) e.g. whether participants found sleep restriction techniques helpful*

A.3. Principles for quantitative data transformation

1) The results and discussion were searched, and the author's own qualitative descriptors used.

2) Where no qualitative descriptors from the authors were present, literature was sought regarding the appropriate qualitative categories for the measures used.

   Example: It has been suggested that Client Satisfaction Questionnaire (CSQ-8) scores, which range from 8 to 32, can be subdivided into the following: scores of 8–13 indicate "poor" satisfaction, 14–19 "fair" satisfaction, 20–25 "good" satisfaction, and 26–32 "excellent" satisfaction. (Smith et al., 2014)

3) Where neither of the above steps were possible, the reviewers produced their own qualitative descriptions based on the value range and any other information (e.g. whether high or low scores were desirable) provided in the article. Values which, as a proportion of the scale total, fell in the bottom fifth of the range were considered "extremely low", the second fifth were "low" and so on (see Table A.1. below).

Table A.1. Qualitative descriptors by value range

Range	Qualitative Descriptor
Highest fifth	Extremely High
Second highest fifth	High
Middle fifth	Moderate
Second lowest fifth	Low
Lowest fifth	Extremely Low

Example: "Average modules completed: 5.73/6 modules" became "module completion was extremely high"

References

Smith, D., Roche, E., O'Loughlin, K., Brennan, D., Madigan, K., Lyne, J., Feeney, L. and O'Donoghue, B. (2014) Satisfaction with services following voluntary and involuntary admission. *Journal of Mental Health*, *23*(1), pp.38-45.

A.4. Characteristics of studies reporting only proxy measures of acceptability

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**		**Intervention Characteristics**
Mahoney et al. (2022) Australia	Uncontrolled, two-group, pre-post	**Sample size:** *experimental group (total)*	811/1883	**Delivery Method:** Internet **Intervention Period:** 90 days **Number of Modules:** 4 **Module length:** n.r. **Clinician involvement:** None (fully automated)
		Average Age: *M (SD)*	44.46 (14.97)	
		Gender: *% Female*	69.5%	
		Comorbidity*:	n/a	
Baka et al. (2022) Netherlands	RCT	**Sample size:** *experimental group (total)*	69 (134)	**Delivery Method:** Internet **Intervention Period:** 8 weeks **Number of Modules:** 5 **Module length:** n.r. **Clinician involvement:** online feedback from mental health nurse practitioners (15-20 mins per session)
		Average Age: *M (SD)*	51.74 (n.r.)	
		Gender: *% Female*	62%	
		Comorbidity*:	n/a	
Kallestad et al. (2021) Norway	RCT	**Sample size:** *experimental group (total)*	49 (101)	**Delivery Method:** Internet **Intervention Period:** 6 months **Number of Modules:** 6 **Module length:** 45-60min **Clinician involvement:** None (fully automated)
		Average Age: *M (SD)*	41.5 (10.5)	
		Gender: *% Female*	71%	
		Comorbidity*:	n/a	
Wogan et al. (2021) UK	Uncontrolled, pre-post	**Sample size:** *experimental group (total)*	56	**Delivery Method:** Internet **Intervention Period:** n.r. **Number of Modules:** 5 **Module length:** 40-60min **Clinician involvement:** online feedback from psychological wellbeing practitioners (15-20 mins per session)
		Average Age: *M (SD)*	median 47 (IQR 23)	
		Gender: *% Female*	66.1%	
		Comorbidity*:	n/a	

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**	**Intervention Characteristics**
Reilly et al. (2021) USA	Pilot RCT	**Sample size:** *experimental group (total)* 17 (33) **Average Age:** *M (SD)* 37.61 **Gender:** *% Female* 24% **Comorbidity*:** sleep apnea (56% sample)	**Delivery Method:** Mobile Application **Intervention Period:** 6 weeks **Number of Modules:** unstructured **Module length:** n/a **Clinician involvement:** None (fully automated)
Jernelov et al. (2021) Sweden	Uncontrolled pre-post	**Sample size:** *experimental group (total)* 552 **Average Age:** *M (SD)* 44 (13) **Gender:** *% Female* 66% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 11 **Module length:** n.r. **Clinician involvement:** online feedback from therapist
Nam et al. (2021) Multisite (Hong Kong/ Korea)	RCT (Secondary Data Analysis)	**Sample size:** *experimental group (total)* 158 **Average Age:** *M (SD)* 22.3 **Gender:** *% Female* 69.6& **Comorbidity*:** n/a	**Delivery Method:** Email **Intervention Period:** 8 weeks **Number of Modules:** 8 **Module length:** n.r. **Clinician involvement:** None (fully automated)
Okajima et al. (2020) Japan	RCT	**Sample size:** *experimental group (total)* 47 (92) **Average Age:** *M (SD)* 42.7 (11.5) **Gender:** *% Female* 35% **Comorbidity*:** n/a	**Delivery Method:** Mobile Application **Intervention Period:** 2 weeks **Number of Modules:** non-structured **Module length:** n/a **Clinician involvement:** None (fully automated)

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**	**Intervention Characteristics**
van der Zweerde et al. (2020) Netherlands	RCT	**Sample size:** *experimental group (total)* 69 (134) **Average Age:** *M (SD)* 51.7 (15.77) **Gender:** *% Female* 62% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 5 weeks **Number of Modules:** 5 **Module length:** n.r. **Clinician involvement:** online feedback from mental health nurse practitioners (5-20 mins per session)
Chinyere et al. (2020) USA	Uncontrolled pre-post	**Sample size:** *experimental group (total)* 17 **Average Age:** *M (SD)* 52 (n.r.) **Gender:** *% Female* 100% **Comorbidity*:** n/a	**Delivery Method:** Mobile Application **Intervention Period:** 6 weeks **Number of Modules:** unstructured **Module length:** n/a **Clinician involvement:** None (fully automated)
Glozier et al. (2019) Australia	RCT	**Sample size:** *experimental group (total)* 45 (87) **Average Age:** *M (SD)* 58.1 (6.1) **Gender:** *% Female* 0% **Comorbidity*:** Depression	**Delivery Method:** Internet **Intervention Period:** 12 weeks **Number of Modules:** 6 **Module length:** 30-40min **Clinician involvement:** None (fully automated)
Kyle et al. (2019) UK	RCT	**Sample size:** *experimental group (total)* 853 (1711) **Average Age:** *M (SD)* 48 (13.8) **Gender:** *% Female* 77.7% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 12 weeks **Number of Modules:** 6 **Module length:** 20-30min **Clinician involvement:** None (fully automated)

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**	**Intervention Characteristics**
Lorenz et al. (2019) Multisite (Switzerland, Austria, Germany)	RCT	**Sample size:** *experimental group (total)* 29 (56) **Average Age:** *M (SD)* 41.72 (17.31) **Gender:** *% Female* 72% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 6 **Module length:** 10-20min **Clinician involvement:** None (fully automated)
Sato et al. (2019) Japan	RCT	**Sample size:** *experimental group (total)* 11 (23) **Average Age:** *M (SD)* 49.4 (13.8) **Gender:** *% Female* 81.8% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 5 **Module length:** n.r. **Clinician involvement:** 1 email per week from CBT therapist
Lopez et al. (2019) France	RCT	**Sample size:** *experimental group (total)* 23 (46) **Average Age:** *M (SD)* Median 46 (IQR 11) **Gender:** *% Female* 82.61% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 12 weeks **Number of Modules:** 7 **Module length:** n.r. **Clinician involvement:** None (fully automated)
Taylor et al. (2017) USA	RCT	**Sample size:** *experimental group (total)* 33 (100) **Average Age:** *M (SD)* 32.73 (7.73) **Gender:** *% Female* 17% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 6 weeks **Number of Modules:** 6 **Module length:** 60min **Clinician involvement:** None (fully automated)

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**		**Intervention Characteristics**
Ritterband (2017) USA	RCT	**Sample size:** *experimental group (total)*	151 (303)	**Delivery Method:** Internet **Intervention Period:** 9 weeks **Number of Modules:** 6 **Module length:** 30-40min **Clinician involvement:** None (fully automated)
		Average Age: *M (SD)*	43.75 (n.r.)	
		Gender: *% Female*	68.2%	
		Comorbidity*:	n/a	
Freeman et al. (2017) UK	RCT	**Sample size:** *experimental group (total)*	1891 (3755)	**Delivery Method:** Internet **Intervention Period:** 10 weeks **Number of Modules:** 6 **Module length:** 20min **Clinician involvement:** None (fully automated)
		Average Age: *M (SD)*	24.8 (7.7)	
		Gender: *% Female*	72%	
		Comorbidity*:	n/a	
Luik et al. (2017) UK	Uncontrolled pre-post	**Sample size:** *experimental group (total)*	98	**Delivery Method:** Internet **Intervention Period:** n.r. **Number of Modules:** 6 **Module length:** 20min **Clinician involvement:** 6 x 20-30min phone calls
		Average Age: *M (SD)*	44.4 (14.7)	
		Gender: *% Female*	66%	
		Comorbidity*:	n/a	
Feuerstein et al. (2017) USA	RCT	**Sample size:** *experimental group (total)*	18 (34)	**Delivery Method:** Internet **Intervention Period:** n.r. **Number of Modules:** 6 **Module length:** 20-40min **Clinician involvement:** None (fully automated)
		Average Age: *M (SD)*	48 (10)	
		Gender: *% Female*	56.3%	
		Comorbidity*:	n/a	

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**	**Intervention Characteristics**
Bostock et al. (2016) USA	RCT	**Sample size:** *experimental group (total)* 135 (270) **Average Age:** *M (SD)* 33.9 (6.41) **Gender:** *% Female* 34.8% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 8 weeks **Number of Modules:** 6 **Module length:** 20min **Clinician involvement:** None (fully automated)
Christensen et al. (2016) Australia	RCT	**Sample size:** *experimental group (total)* 1149 **Average Age:** *M (SD)* 42.95 (14.37) **Gender:** *% Female* 74% **Comorbidity*:** Depression	**Delivery Method:** Internet **Intervention Period:** 6 week **Number of Modules:** 6 **Module length:** n.r. **Clinician involvement:** None (fully automated)
Lancee et al. (2015) Netherlands	RCT	**Sample size:** *experimental group (total)* 36 (63) **Average Age:** *M (SD)* 47.5 (14.37) **Gender:** *% Female* 83.3% **Comorbidity*:** n/a	**Delivery Method:** Internet **Intervention Period:** 8 weeks **Number of Modules:** 6 **Module length:** n.r. **Clinician involvement:** up to 1h feedback over 6 week course
Arnedt et al. (2013) Canada	RCT	**Sample size:** *experimental group (total)* 15 (30) **Average Age:** *M (SD)* 38.1 (14.6) **Gender:** *% Female* 100% **Comorbidity*:** n/a	**Delivery Method:** Telephone **Intervention Period:** 4-8 weeks **Number of Modules:** 4-8 **Module length:** 15-60min **Clinician involvement:** 100% involvement in delivering intervention (with accompanying paper resources mailed to participants.

Publishing Details *(author, year, location)*	**Design**	**Sample Characteristics**		**Intervention Characteristics**
Vincent et al. (2009) Canada	RCT	**Sample size:** *experimental group (total)*	59 (118)	**Delivery Method:** Internet **Intervention Period:** 5 weeks **Number of Modules:** 5 **Module length:** n.r. **Clinician involvement:** None (fully automated)
		Average Age: *M (SD)*	n.r.	
		Gender: *% Female*	67.8%	
		Comorbidity*:	n/a	

B. Major Research Project

All links below are hosted on the Open Science Framework site. The overall project link is: https://osf.io/wh829/?view_only=c550ecbffb804d20a8749074213c49b8

B.1. Approved MRP Proposal

https://osf.io/k42e7

B.3. Participant Information Sheet, Consent Form & Study Emails

Information Sheet: https://osf.io/adn9r

Consent Form: https://osf.io/kehn4

Study Advertisement & Reminder Emails: https://osf.io/rsma9

B.4. Relevant Research Materials

B.4.1. Lifestyle & Acceptability Questionnaires

- Demographic & Lifestyle: https://osf.io/erd9h
- Sign-Up Acceptability: https://osf.io/8yqc5
- Acceptability Questionnaire: https://osf.io/rguw3
- Follow-up Acceptability: https://osf.io/qxswb

B.5. Supplementary Results

B.5.1. Wellbeing & Sleep Diary Data Summary

https://osf.io/av935

B.5.2. Acceptability Questionnaire Quantitative Dataset Summary

https://osf.io/7jfhb

B.5.2. Key themes of participant responses to acceptability questionnaires at pre, post and follow-up

Table summarising key themes from participant responses to questions regarding the online delivery of the study and sleep session at the "Acceptability Questionnaire" stage.

What did you like about the sleep session being delivered online? (*n*) (*n* = 16)	**What did you not like about the sleep session being delivered online? (*n*)** (*n* = 13)	**Do you have any other comments about the sleep diaries or calendar reminders? (*n*)** (*n* = 8)	**Do you have any other comments about online delivery of the session? (*n*)** (*n* = 3)
• Convenience/ ease of access (14) • Responses related to COVID-19 (3) • The chat function (2) • Comfort of home (2)	• Poorer quality/ lack of interaction between participants and/or facilitators (4) • Technology failures (2) • Created barrier to asking questions (2) • Difficulty concentrating (2) • Timing (2) • Nothing (2) • Sleep diaries harder to complete (1)	• Useful/ easy to use (3) • Sleep diary questions unclear/ hard to answer (3) • Wasn't aware of this part of the study (1) • Suggested an alternative distribution method (1)	• More resources (1) • More focus on anxiety (1) • Welcoming atmosphere (1)

Table summarising key themes from participant responses to questions regarding the content of the sleep session at the "Acceptability Questionnaire" stage.

What did you find most helpful about the content of the session? (*n*) (*n* = 17)	**What did you find least helpful about the content of the session? (*n*)** (*n* = 16)	**Do you have any other comments about the content of the sleep session? (*n*)** (*n* = 8)
• Tips generally (5) • Q&A/ Discussion (4) • Science of sleep (4) • Sleep hygiene recommendations (3) • Timing of exercise (2) • Understanding the difference between fatigued and sleepy tired (1) • Encouraging flexible/open mindset (1)	• Heard recommendations already (4) • Too short/ more time for Q&A (3) • More emphasis on getting to sleep than frequent awakenings (2) • Introduction/context (2) • Nothing (2) • Lack of handouts (1) • Anxiety tips (1) • Recommendations which are not possible for students (1)	• Satisfaction (3) • More about sleep quality (2) • More on food & sleep (2) • More discussion (1) • Learnt nothing new (1) • Summary of main points at end (1) • More on reducing stress/anxiety (1)

Table summarising key themes from participant responses to questions regarding the recommendations from the sleep session at the "Acceptability Questionnaire" stage.

What factors do you think will influence whether you use the recommendations from the sleep session? (*n*) (*n* = 18)	**What do you predict will be the easiest recommendation to stick to? (*n*)** (*n* = 17)	**What do you predict will be the hardest recommendation to stick to? (*n*)** (*n* = 16)
• Lack of control over situational factors (7) • Energy/ motivation (5) • Work (3) • Time (2) • Other people (2) • Compatibility with existing lifestyle (2) • Remembering session content (1)	• Limiting alcohol/ caffeine (4) • Limiting screens/ blue light before bed (3) • Sticking to a sleep schedule (3) • Limiting bed use to sleep and sex (3) • Scheduling exercise early in the day (1) • Different clothing for bed (1) • Moving desk to near window (1) • Following eating recommendations (1) • Tracking sleep (1)	• Sticking to a sleep schedule (7) • Limiting screens/ blue light before bed (4) • 20 min rule (2) • Exercising early (2) • Reducing stress/anxiety (1) • Limiting caffeine (1) • Using bedroom only for relaxation and rest (1)

Table summarising key themes from participant responses to questions regarding the facilitators at the "Acceptability Questionnaire" stage.

Do you have any other comments about the facilitator(s)? (*n*) (*n* = 6)
• Presented well (3) • Open to questions/ Made asking questions easy (2) • Difficulty understanding (1) • Comfortable environment (1)

Table summarising key themes from participant responses to questions regarding the recommendations from the sleep session at the "Follow-up" stage.

What has been the easiest recommendation to stick to and why? (*n*) (*n* = 8)	**What has been the hardest recommendation to stick to and why? (*n*)** (*n* = 7)	**Do you have any final comments regarding any aspect of the study? (*n*)** (*n* = 1)
• Only using bed for sleeping and sex (2) • Limiting device/ blue light before bed (2) • Sticking to sleep schedule (1) • Limiting coffee (1) • Limiting eating before bed (1)	• Using devices in/ before bed (3) • Keeping bedroom for sleep and sex (1) • Sticking to sleep schedule (1) • Leaving enough time for sleep (1) • 20-minute rule (1)	• Interesting (1)

Table summarising key themes from participant responses to questions regarding study measures at the "Follow-up" stage.

If you haven't completed any components of the research, can you let us know which ones? (*n*) (*n* = 1)	**If you did not fill out some of the measures, what factors contributed to you not filling these out? (*n*)** (*n* = 2)
• Sleep Diaries (1)	• Not noticing an improvement in sleep (1) • Completing sleep measures impacted negatively on quality of sleep (1)