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Yvonne Kutzer
Edith Cowan University

Lisa Whitehead
Edith Cowan University

Eimear Quigley
Edith Cowan University

Shih Ching Fu
Edith Cowan University

Mandy Stanley
Edith Cowan University

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ORIGINAL ARTICLE

Subjective versus objective sleep outcomes in older adults with and without uncoupled sleep following online cognitive behavioural therapy for insomnia

Yvonne KUTZER ¹, Lisa WHITEHEAD,¹ Eimear QUIGLEY,^{1†} Shih Ching FU^{1,2} and Mandy STANLEY¹

¹Edith Cowan University and ²Curtin University, Perth, Australia

Correspondence: Ms Yvonne Kutzer, MSc, Edith Cowan University, School of Medical & Health Sciences, 270 Joondalup Drive, Joondalup, WA, 6027, Australia. Email: y.kutzer@ecu.edu.au

† ORS Group, Level 1, 1 Puccini Court, Stirling WA 6021

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Key words: aged, cognitive Behavioural therapy, digital technology, sleep initiation and maintenance disorders.

Abstract

Background: Uncoupled sleep is a phenomenon characterised by a disconnect between sleep pattern and sleep complaint. This study examined the impact of uncoupled sleep on dysfunctional sleep beliefs and objective and subjective sleep outcomes in community-dwelling older adults following digitally delivered Cognitive Behavioural Therapy for Insomnia (CBT-I) to assess how these groups respond to CBT-I.

Methods: Objective sleep was measured using wrist actigraphy, subjective sleep quality via sleep diaries and the Pittsburgh Sleep Quality Index (PSQI). Dysfunctional sleep beliefs were assessed by the Dysfunctional Beliefs and Attitudes about Sleep scale (DBAS-16). All measurements were taken prior to and following a 4-week online CBT-I program. Linear mixed model and generalised linear mixed model analyses were conducted to examine objective and subjective sleep onset latency, total sleep time, wake after sleep onset and number of awakenings as well as PSQI and DBAS-16 scores, respectively.

Results: Out of 80 enrolled participants, 62 participants (55 females, 89%; 16 complaining good sleepers, 26 complaining poor sleepers, 11 non-complaining good sleepers, and nine non-complaining poor sleepers) completed the study. CBT-I reduced dysfunctional sleep beliefs across all sleeper classifications. Objective and self-reported changes in sleep parameters were demonstrated in complaining poor sleepers without uncoupled sleep. Complaining good sleepers with uncoupled sleep only reported a decrease in the number of subjective sleep awakenings. There were no changes in sleep outcomes in non-complaining good and non-complaining poor sleepers.

Conclusions: Online CBT-I was effective in improving the sleep outcomes of individuals who had both subjective and objective poor sleep. However, as the online CBT-I reduced dysfunctional sleep beliefs in all sleep groups, further examination of dysfunctional sleep beliefs and whether they mediate the outcomes of digital CBT-I in older adults will need to be conducted.

INTRODUCTION

Older adults report a high rate of sleep problems, with about 60% complaining of insomnia.¹ Insomnia has a negative impact on quality of life, with the associated daytime impairment leading to increased stress and social isolation. In addition, insomnia in older individuals is often falsely attributed to the

ageing process and therefore remains under-diagnosed and undertreated.² A diagnosis of insomnia by a healthcare professional is generally based on self-reported symptoms,³ and often a comprehensive sleep assessment is not possible due to the demands of provision of care for insomnia within the current funding and time constraints, and the lack of

comprehensive practice guidelines.⁴ Without such assessment it is difficult to identify individuals with sleep state misperception: those who complain of insomnia but who do not have poor sleep, so-called uncoupled sleepers. It has been estimated that nearly 70% of older adults with sleep problems present with uncoupled sleep characterised by the presence of a sleep complaint and the absence of a sleep problem: they are complaining good sleepers (Fig. 3).^{5, 6} Conversely, individuals who have poor sleep but who do not complain about having insomnia are non-complaining poor sleepers. These individuals are unlikely to seek help from their healthcare practitioner as they do not consider themselves as affected by poor sleep, and the health outcomes or treatment requirements of this group are unknown.⁵

Several studies have suggested that cognitive processes are important factors in the development and maintenance of insomnia regardless of whether uncoupled sleep is present or not,^{7,8} and that this is especially true in older adults.⁹ Cognitive Behavioural Therapy for Insomnia (CBT-I) is the gold-standard treatment approach for insomnia as recommended by the Australasian Sleep Association.¹⁰ However, the availability of therapists trained in CBT-I is limited, and <10% of individuals with insomnia symptoms have access to CBT-I provided by a healthcare professional.¹ Newer treatment modalities, such as online-delivered CBT-I, have been developed to help address these issues. Digitally delivered CBT-I has demonstrated efficacy,¹¹ and in a recent systematic review and meta-analysis has been shown to significantly increase sleep efficiency, total sleep time, and to reduce sleep onset latency as well as wake after sleep onset and insomnia severity.¹² In addition, online CBT-I has been shown to be efficacious in treating older adults with insomnia.¹³

While it is known that CBT-I is effective, what is less clear is for whom it works as 20%–30% of individuals with self-reported insomnia do not respond to CBT-I treatment.⁷ Since the characteristics of those non-responders are not well-understood, this study assessed how digitally delivered CBT-I affected the sleep outcomes of older adults, namely: sleep onset latency, the time taken to fall asleep; total sleep time, the time spent asleep in bed following sleep onset; wake after sleep onset, the sum of all periods of wakefulness that occur after sleep onset; the number of awakenings, the total number of nocturnal

awakenings following sleep onset; and self-reported sleep quality, depending on whether they were classified as complaining good sleepers, complaining poor sleepers, non-complaining good sleepers, and non-complaining poor sleepers. Complaining good sleepers and non-complaining poor sleepers are the groups presenting with uncoupled sleep. We anticipated that complaining good sleepers and complaining poor sleepers would show improved sleep outcomes following CBT-I, whereas non-complaining good and non-complaining poor sleepers would not.^{5,14} In addition, dysfunctional sleep beliefs, maladaptive perceptions around sleep and wake, have been implicated in the aetiology of insomnia in older adults,¹⁵ and we examined these as a secondary outcome, as well as self-reported sleep quality. We hypothesised that complaining good sleepers and complaining poor sleepers would exhibit greater changes in dysfunctional sleep beliefs and self-reported sleep quality than non-complaining good and non-complaining poor sleepers.

METHODS

Recruitment

Ethics approval for this study was granted by the university's Human Research Ethics Committee and informed written consent was obtained from all participants prior to their inclusion in the study. This study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki.

Older adults with and without self-reported poor sleep were recruited from the Western Australian community from March 2020 to March 2021 using a targeted Facebook advertisement. Facebook was used because older adults are the social media platform's fastest growing user group.¹⁶ Participants were eligible to take part if they were aged 60–80 years, had not been diagnosed with a sleep disorder other than insomnia (e.g., obstructive sleep apnoea), did not currently have a psychiatric or cognitive disorder, were not employed as a shift worker in the past year, had not been diagnosed with epilepsy or chronic fatigue syndrome and did not have a high fall risk. Sleep restriction therapy, which formed part of the CBT-I program, can result in daytime sleepiness and should not be used for individuals with conditions that are exacerbated by sleepiness, including epilepsy, sleep disordered breathing, or

mental health disorders such as bipolar disorder or schizophrenia.¹⁷ In addition, poorer cognitive performance, which can be a side effect of sleep restriction, has been shown to lead to an increased fall risk in older adults.¹⁸ We therefore excluded older adults with epilepsy, an existing diagnosis or increased risk of developing obstructive sleep apnoea, as well as bipolar disorder and schizophrenia and high fall risk. Screening for obstructive sleep apnoea was conducted using the STOP-Bang questionnaire, a brief self-report instrument which has demonstrated high sensitivity in detecting sleep apnoea.¹⁹ High fall risk was assessed using a simplified version of the STEADI algorithm, by asking the following three questions: 'Do you feel unsteady when standing or walking?', 'Do you worry about falling?', and 'Have you had a fall in the past year?'.²⁰

A total of 175 initial expressions of interest were received, and of those 142 participants were assessed for eligibility. The remainder did not respond when they were contacted about the study (33 individuals). Out of the 142 participants who were screened for eligibility, 34 individuals were not eligible to participate: 15 were excluded due to high risk of developing or having an existing diagnosis of obstructive sleep apnoea, five due to self-reported restless legs syndrome, four on account of high fall risk, three as a result of poorly managed anxiety and/or depression, two on account of the age criterion, and one participant each was excluded as they had bipolar disorder, post-traumatic stress disorder, or had been a shift worker in the past year. Two additional participants were excluded due to other medical conditions that were not part of the exclusion criteria per se, but were deemed potential contraindications for sleep restriction therapy (polycythemia vera and chronic fatigue syndrome). Twenty-eight respondents withdrew following the screening process citing lack of time. This left 80 participants who completed the baseline data collection. An additional 15 participants were lost to follow-up: five participants withdrew due to health reasons, including pain, one due to a lack of time, one had no access to a computer, and the remaining eight did not give a reason for discontinuing. Three participants were excluded due to missing actigraphy data, leaving a total of 62 participants who completed both measurements (Fig. 1).

Design

This study comprises a non-randomised trial, consisting of a single arm, pre-test and post-test design. Study participants completed online questionnaires using Qualtrics software (Qualtrics XM Platform™ software, Qualtrics, Provo, UT, USA), to evaluate sleep outcomes and dysfunctional sleep beliefs. In addition, participants wore an Actigraph model wGT3X-BT activity monitor (ActiGraph, Pensacola, FL, USA) and completed a sleep diary over 96 h (72 h plus an additional 24 h to account for non-wear time). The activity monitor has demonstrated accuracy, allowing for sleep-wake estimation comparable with polysomnographic sleep assessment.²¹ The actigraphy recording time was in keeping with guidelines governing actigraphy use which recommend a minimum period of data collection of 72 h.²² Participants with sleep recordings of <36 h were excluded from the analysis.

Participants were considered poor sleepers if their actigraphy-measured sleep onset latency or wake after sleep onset was ≥ 31 min, three times or more during the recording period (i.e., on a minimum of 3 days out of 4 days of actigraphy recordings), and a complaining sleeper if they reported having had a sleep problem for a minimum of 6 months at baseline data collection. This categorisation was based on quantitative criteria stipulated in previous research.^{14,23} The sleep complaint criterion was evaluated in the baseline questionnaire by assessing two separate self-report items: (1) 'Do you have a sleep problem? (Yes/No)', 'If yes, please describe your sleep problem (e.g., trouble falling asleep, long or frequent awakenings, waking up too early)' (2) 'How long have you had this sleep problem? (e.g., weeks or months)'.

Primary outcome measures

Actigraphic sleep assessment and sleep diary data were used to assess objective and subjective sleep onset latency, wake after sleep onset, total sleep time, and number of night-time awakenings. Sleep efficiency was excluded as it is calculated with time in bed as the denominator, which can create a methodological problem in sleep intervention research where sleep restriction therapy is employed. This can result in the improvement of sleep efficiency due to a

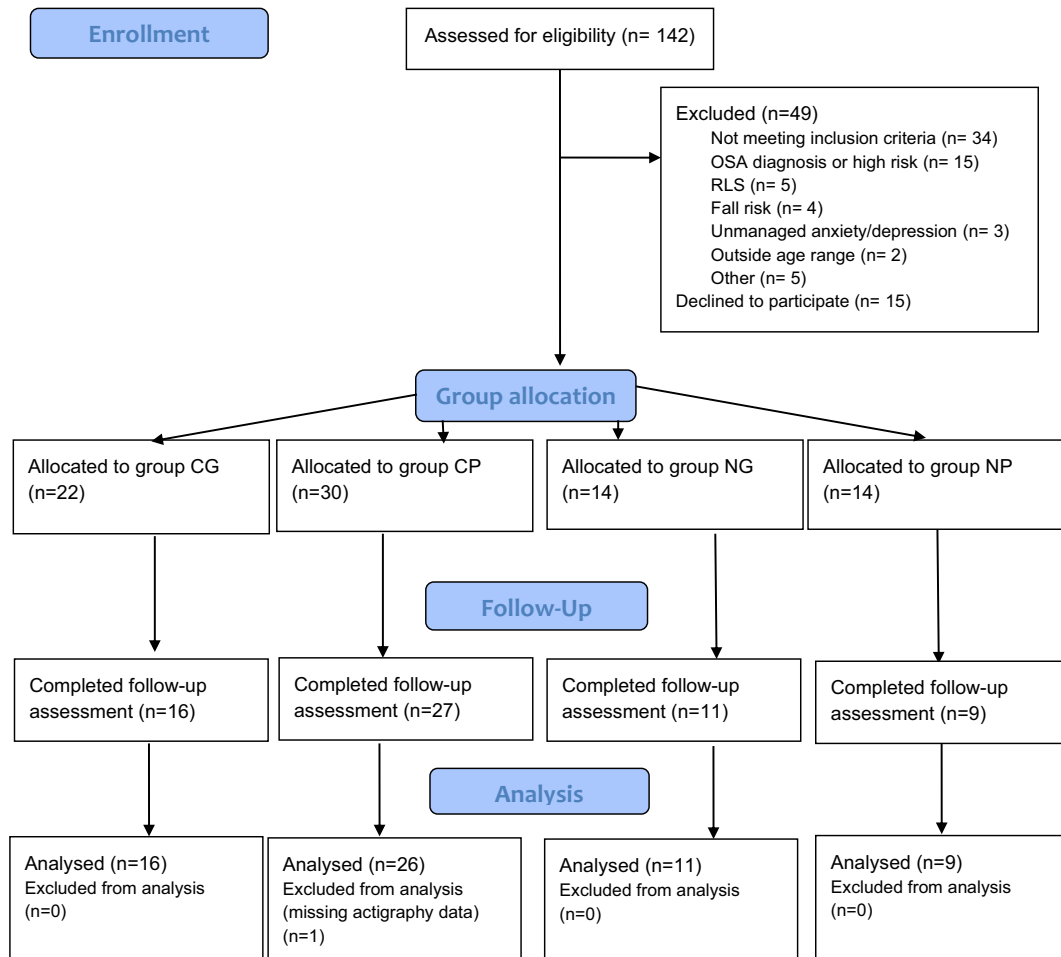


Figure 1 Study process flow chart.

participant's adherence to instructions to reduce time spent in bed, not because of treatment effects of the intervention.²⁴

The sleep diary followed the format of the Consensus Sleep Diary – Core,²⁵ with the addition of questions about nap times and use of sleep medication. The diary recorded information such as time of getting into bed, time attempting to fall asleep, sleep onset latency, number of awakenings, duration of awakenings, time of final awakening, final rise time, perceived sleep quality, and a section allowing open-ended comments.

Secondary outcome measures

Sleep-related dysfunctional beliefs were assessed with the Dysfunctional Beliefs and Attitudes about Sleep scale (DBAS-16).²⁶ The DBAS-16 is comprised of 16 statements about individuals' beliefs and

attitudes about their sleep. Questions such as 'I am worried that I may lose control over my abilities to sleep' are scored on a 10-point Likert scale. The DBAS-16 has been found to reliably discriminate between self-reported good and poor sleepers in older adult populations and has been proven to have adequate internal consistency (Cronbach $\alpha = 0.79$ for research samples).^{26,27} Scores ≥ 4 are indicative of unrealistic expectations about sleep.²⁷

The Pittsburgh Sleep Quality Index (PSQI)²⁸ was used to examine sleep quality. The PSQI consists of 19 items and examines sleep quality and disturbances over the past month. The first four questions are open, whereas items 5–19 are rated on a four-point Likert scale. Individual item scores from the seven sections are calculated first, and those seven component scores are subsequently added up to calculate the global score, ranging from 0 to 21. A sleep

score of >5 is indicative of poor sleep quality. The PSQI measures sleep quality in a broader sense than just insomnia severity. The PSQI has good internal consistency (Cronbach $\alpha = 0.83$).²⁸

Covariates

In addition to the outcome variables outlined above, we recorded gender, age, alcohol consumption (consumption of alcohol yes or no, if yes, did the participant consume >4 standard drinks on a regular basis), smoking status (yes or no), employment status and caffeine consumption (in mg; consumption above 500 mg/day exceeds daily guidelines).

Procedure

Once participants expressed their interest in taking part, the lead researcher arranged an appointment for a 15–30 min screening call. During the screening call, participants were assessed for an existing diagnosis of a sleep disorder other than insomnia, psychiatric or cognitive disorders, current employment as a shift worker, a diagnosis of epilepsy, and fall risk. Once individuals were confirmed eligible and had provided written confirmed consent, they were emailed the link to the baseline questionnaire. Following completion, participants were contacted again to arrange for the actigraph to be sent out to them. Based on their sleep complaint status, as recorded in the questionnaire, and their actigraphy results, participants were then grouped into four sleep categories: non-complaining good sleepers, complaining good sleepers, non-complaining poor sleepers and complaining poor sleepers.

The return of the actigraph triggered the next phase of the study protocol, which was the completion of the online CBT-I intervention. All participants regardless of insomnia status were asked to complete the intervention and all received the same instructions. Once participants confirmed they had completed the CBT-I program, participants were emailed the follow-up questionnaire. As before, sleep was then recorded via actigraphy over four consecutive nights.

Description of intervention

The CBT-I intervention is a self-guided online CBT-I program, consisting of four modules, which was developed by Clinical Research Unit for Anxiety & Depression at the University of New South Wales.²⁹

The first module involves the delivery of background information about sleep hygiene. Modules two and three examine maladaptive cognitive processes and behaviours and focus on sleep restriction, stimulus control and cognitive therapy. Module four covers relaxation techniques. Participants are unable to customise the program content to reflect their particular sleep problem, but the intervention covers all facets of insomnia, for example difficulties falling asleep or waking too early. Program users are prompted to complete one module a week including associated reading material and to keep a sleep diary. Access to the intervention is freely available to individuals residing in Australia. Research examining the efficacy of the program indicated that 65% individuals with self-reported insomnia experienced insomnia remission following treatment.³⁰ Prior to this trial, we conducted a feasibility study to examine the suitability of this digital intervention in a sample of older adults (unpublished manuscript).

Completion of the online program was assessed by self-report. Participants were required to complete the entire CBT-I program. The lead researcher contacted the participants on a weekly basis for an update on progress, and to confirm the participant had completed the module. Participants were required to finish the program within 8 weeks of registration. Study participants who failed to respond to the lead researcher's request for an update after two reminders were excluded from the study. Sixty-two participants confirmed that they had completed all four modules of the program.

Data scoring and analysis

An *a priori* power analysis was conducted using G*Power version 3.1.9.7 for sample size estimation,³¹ based on data from a published study ($N = 103$ participants (mean = 72.81 years; SD = 7.12)),²³ which compared subjective and objective sleep patterns in older adults. The effect size in the published study was 0.68, and this was considered a medium effect using Cohen's criteria.³² With a significance criterion of $\alpha = 0.05$ and power = 0.80, the minimum sample size needed with this effect size is $N = 40$. Thus, the obtained sample size of $N = 62$ should be sufficient to test the study hypothesis.

Actigraphy measures were scored using the Cole-Kripke algorithm, which is suitable for use with older populations,³³ and ActiLife software (ActiLife

6 software, Version 6.13.1, ActiGraph). The actigraph was set to record activity in tri-axial mode and light over 60-s epochs. Statistical analysis using linear mixed modelling was conducted using JASP (Version 0.14.1). A random intercept linear mixed effect model was fitted to the objective and subjective outcomes of total sleep time, wake after sleep onset, as well as PSQI and DBAS-16 scores. A random intercept generalised linear mixed effect model was fitted to the objective and subjective sleep onset latency and the number of awakenings outcomes. For each model, time point, sleep group, gender, age, alcohol consumption, smoking status, employment status, and caffeine consumption were included as fixed effects, and participant as the random effect. The interaction between time point and sleep group was also included as a term in the models. The linear model assumptions of zero mean, homoskedasticity, and normality of residuals were confirmed by examining residuals plots. A violation of the homoskedasticity assumption for sleep onset latency and number of awakenings outcomes was addressed by fitting a generalised linear effect model using the Poisson log-arithmic link function. An interaction between time point and group was included to estimate treatment outcomes separately prior to and following the intervention. Restricted maximum likelihood was used to fit the model, and a Holm adjustment was employed to adjust for multiple comparisons. Model terms were tested using the Satterthwaite approximation.³⁴ The effect sizes (partial eta squared, η_p^2 and Cramer's ϕ) were manually calculated. An effect size of $\eta_p^2 \leq 0.01$ was indicative of a small effect size, ≤ 0.06 was considered a medium and ≥ 0.14 a large effect size. For Cramer's ϕ an effect size of ≤ 0.10 was considered a small effect size, ≤ 0.30 a medium and ≥ 0.50 a large effect size.³⁵

RESULTS

A total of 80 participants completed the questionnaires and actigraphy assessment at baseline, with 78 out of 80 participants completing data collection for all four actigraphy measurement days. The baseline sleep outcomes are reported elsewhere (manuscript submitted for publication, see Appendix S1).

Post-intervention questionnaires and actigraphy recordings were completed by 62 participants

(55 females; 89%), with 58 providing actigraphy data for all four measurement days, with the remainder providing between 3 and 2 days of actigraph data. The mean age was 66 years (SD = 3.82). Forty-one participants were retired (65%), six participants were in full-time employment (10%), five participants were part-time employed (8%), five participants were self-employed (8%), two participants were not employed and not looking for work (3%), and one participant respectively was a student, full-time carer or looking for employment (2%).

Based on questionnaire responses and actigraphy outcomes at baseline, participants were categorised as complaining good sleepers (16), complaining poor sleepers (26), non-complaining good sleepers (11) and non-complaining poor sleepers (9). An overview of the number of participants in each group can be found in Table 1.

Actigraphy-defined sleep continuity

The sleep outcomes for each of the sleep groups can be found in Table 2. A graphic representation of the changes can be seen in Fig. 2. There were no significant changes in objective sleep onset latency following the CBT-I intervention. For objective total sleep time, linear mixed modelling indicated that there was a significant main effect for time ($F(1,511.48) = 4.923, P = 0.03$), a small effect size ($\eta_p^2 = 0.01$). An interaction effect of time and group was observed ($F(3,517.61) = 2.741, P = 0.04$); this

Table 1 Number of participants in each sleep group at pre- and post-intervention

Gender	Sleep group	Pre-intervention	Post-intervention
Female	CG	20	14 (70%)
	CP	28	24 (86%)
	NG	11	9 (82%)
	NP	12	8 (67%)
Male	CG	2	2 (100%)
	CP	2	2 (100%)
	NG	3	2 (67%)
Total	NP	2	1 (50%)
	CG	22	16 (73%)
	CP	30	26 (87%)
	NG	14	11 (79%)
Total	NP	14	9 (64%)
		80	62

Abbreviation: CP, complaining poor sleepers; NG, non-complaining good sleepers; CG, complaining good sleepers; NP, non-complaining poor sleepers. Changes in group allocation pre- to post-intervention are due to loss to follow-up.

Table 2 Mean differences for sleep outcomes pre/post-intervention

Group M_{Diff}	CG	CP	NG	NP	Good vs. poor sleepers	Complaining vs. non-complaining sleepers
Objective SOL (SE)	0.14 (0.4)	-0.08 (0.3)	0.12 (0.6)	2.83 (1.6)	-3.2 (2.6)	0.83 (2)
Objective TST (SE)	1.71 (10.1)	34.1 (8.7)*	8.45 (12.1)	6.66 (12.6)	-2.54 (11.2)	-12.66 (12.1)
Objective WASO (SE)	-1.16 (3.4)	11.74 (3)*	0.4 (4.13)	-8.75 (4.3)	-30.94 (3.74)*	0.81 (4.05)
Objective number Awakenings (SE)	-0.03 (0.5)	1.3 (0.6)	-0.57 (0.6)	0.18 (0.9)	2.65 (1.6)	-11.86 (2.3)*
Subjective SOL (SE)	-0.57 (0.7)	7.47 (3.3)	3.66 (1.9)	-1.93 (1.1)	6.43 (5.1)	1.91 (4.4)
Subjective TST (SE)	-19.26 (13.3)	-2.51 (11.5)	-13.34 (15.97)	-5.88 (16.7)	-19.02 (13.7)	-44.2 (14.9)**
Subjective WASO (SE)	13.76 (7.5)	26.37 (6.5)*	16.82 (9)	5.61 (9.4)	11.31 (7.1)	26.21 (7.7)***
Subjective number Awakenings (SE)	0.82 (0.3)*	0.47 (0.2)	0.32 (0.3)	0.11 (0.2)	0.72 (0.4)	-0.4 (0.4)*
DBAS-16	0.78 (0.1)*	0.45 (0.1)*	-0.05 (0.1)	0.66 (0.14)*	0.18 (0.3)	0.81 (0.3)#
PSQI	2.49 (0.3)*	1.11 (0.2)*	1.46 (0.3)*	1.34 (0.3)*	0.17 (0.5)	2.59 (0.6)*

Notes: Higher scores indicate improved outcome. Pairwise comparisons from the mixed effects models pairwise comparisons based on time. Abbreviation: CG, complaining good sleepers; CP, complaining poor sleepers; DBAS-16, Dysfunctional Beliefs and Attitudes about Sleep scale (16 items); NG, non-complaining good sleepers; NP, non-complaining poor sleepers; No. Awakenings, number of nocturnal awakenings; PSQI, Pittsburgh Sleep Quality Index; SOL, sleep onset latency; TST, total sleep time; WASO, wake after sleep onset. * $P < 0.001$. ** $P = 0.018$. *** $P = 0.003$. # $P = 0.045$.

was again a small effect ($\eta_p^2 = 0.02$). Objective total sleep time decreased slightly in all groups following CBT-I, but was only significant in complaining poor sleepers, with a decrease of over half an hour. For objective wake after sleep onset, linear mixed modelling revealed there was a significant main effect for group ($F(3,73.82) = 24.962$, $P < 0.001$), and this was a large effect size ($\eta_p^2 = 0.50$). There was also an interaction effect of time and group ($F(3,518.51) = 6.449$, $P < 0.001$): a small effect size ($\eta_p^2 = 0.04$). Objective wake after sleep onset in the complaining poor sleeper group significantly decreased following the intervention, almost 12 min lower post-intervention. There were no significant differences in any of the other groups; however, the objective wake after sleep onset across the two poor sleep quality groups (complaining poor sleepers and non-complaining poor sleepers) was 31 min lower following the CBT-I intervention compared to the good sleep quality groups (complaining good and non-complaining good sleepers). For objective number of awakenings, generalised linear mixed modelling revealed there were no significant changes following the intervention in any of the groups. However, the poor sleeper groups (non-complaining poor and complaining poor sleepers) had a significantly lower number of awakenings following the CBT-I intervention compared with the good sleeper groups.

Self-reported sleep continuity

For the self-reported measurements of sleep no significant main effect for subjective sleep onset latency was found. For subjective total sleep time, linear

mixed modelling showed there was a significant main effect for group ($F(3,74.44) = 3.56$, $P = 0.02$), a medium effect size ($\eta_p^2 = 0.13$), but no effect for time. The non-complaining sleeper groups (non-complaining good sleepers and non-complaining poor sleepers) reported a subjective total sleep time close to 45 min lower than that of the complaining sleeper groups (complaining good sleepers and complaining poor sleepers). For subjective wake after sleep onset, a significant main effect for time was found ($F(1,513.89) = 13.318$, $P < 0.001$), a small effect size ($\eta_p^2 = 0.03$). There was a significant main effect for group also ($F(3,74.01) = 6.108$, $P < 0.001$), a large effect size ($\eta_p^2 = 0.20$). Subjective wake after sleep onset decreased in all four groups; however, statistically significant changes were only found in the complaining poor sleeper group (between group mean difference = 26.37, $P < 0.001$) following the CBT-I intervention. When we combined complaining good and complaining poor sleepers, the complaining sleeper groups reported wake after sleep onset that was 26 min lower than that of the non-complaining groups. For subjective number of awakenings, generalised linear mixed modelling revealed there was a significant main effect for time ($\chi^2(1, N = 556) = 14.53$, $P < 0.001$), a small effect size (Cramer's $\phi = 0.16$), and group ($\chi^2(3, N = 556) = 8.29$, $P = 0.04$), also a small effect size (Cramer's $\phi = 0.07$). The complaining good sleeper group reported a significantly lower number of awakenings following the CBT-I intervention (between group mean difference = 0.821, $P < 0.001$), but there were no significant differences in any of the other groups.

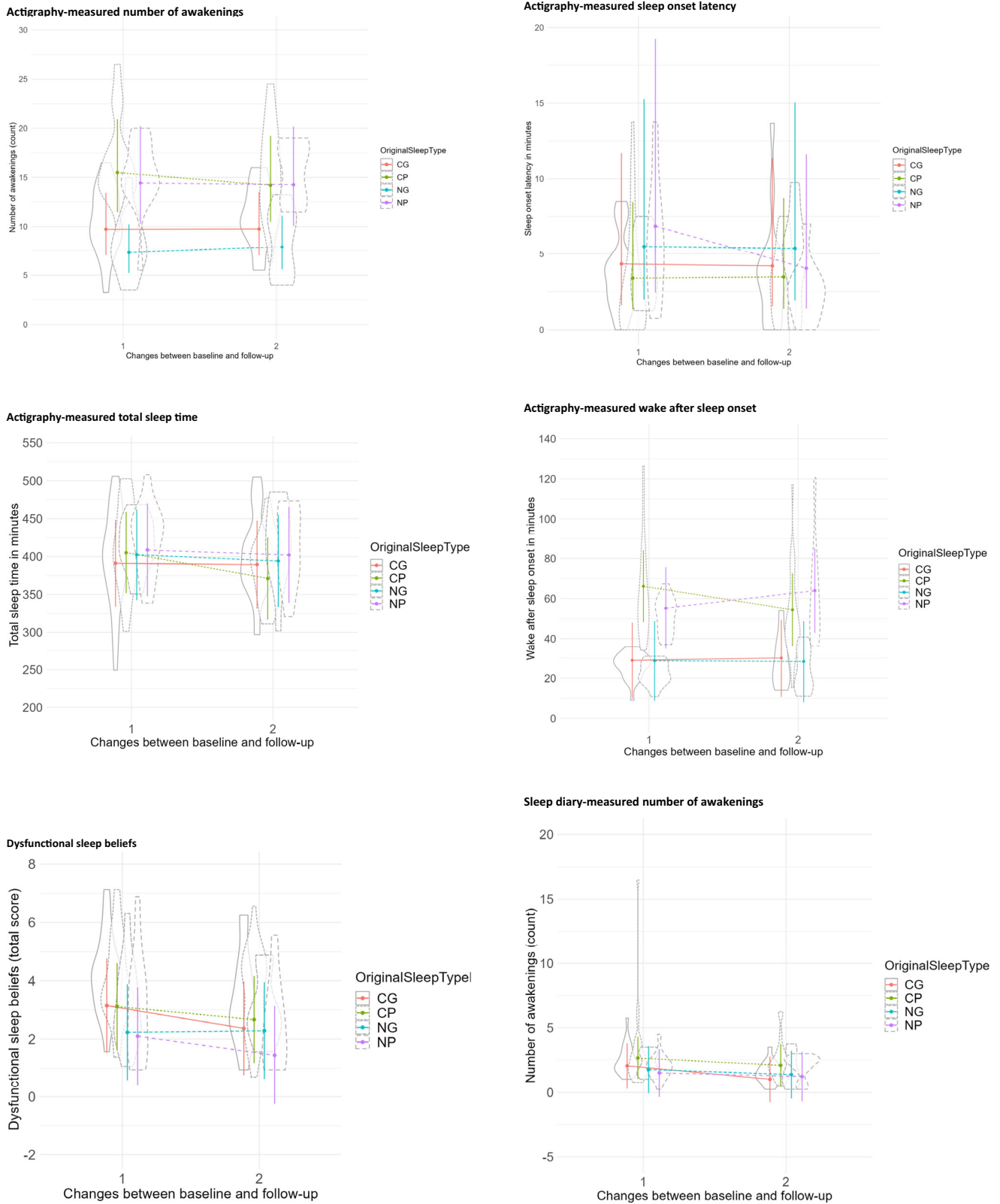


Figure 2 Changes in objective and subjective sleep measures following the online Cognitive Behavioural Therapy for Insomnia (CBT-I) intervention. CG, complaining good sleepers, CP, complaining poor sleepers, NG, non-complaining good sleepers, NP, non-complaining poor sleepers.

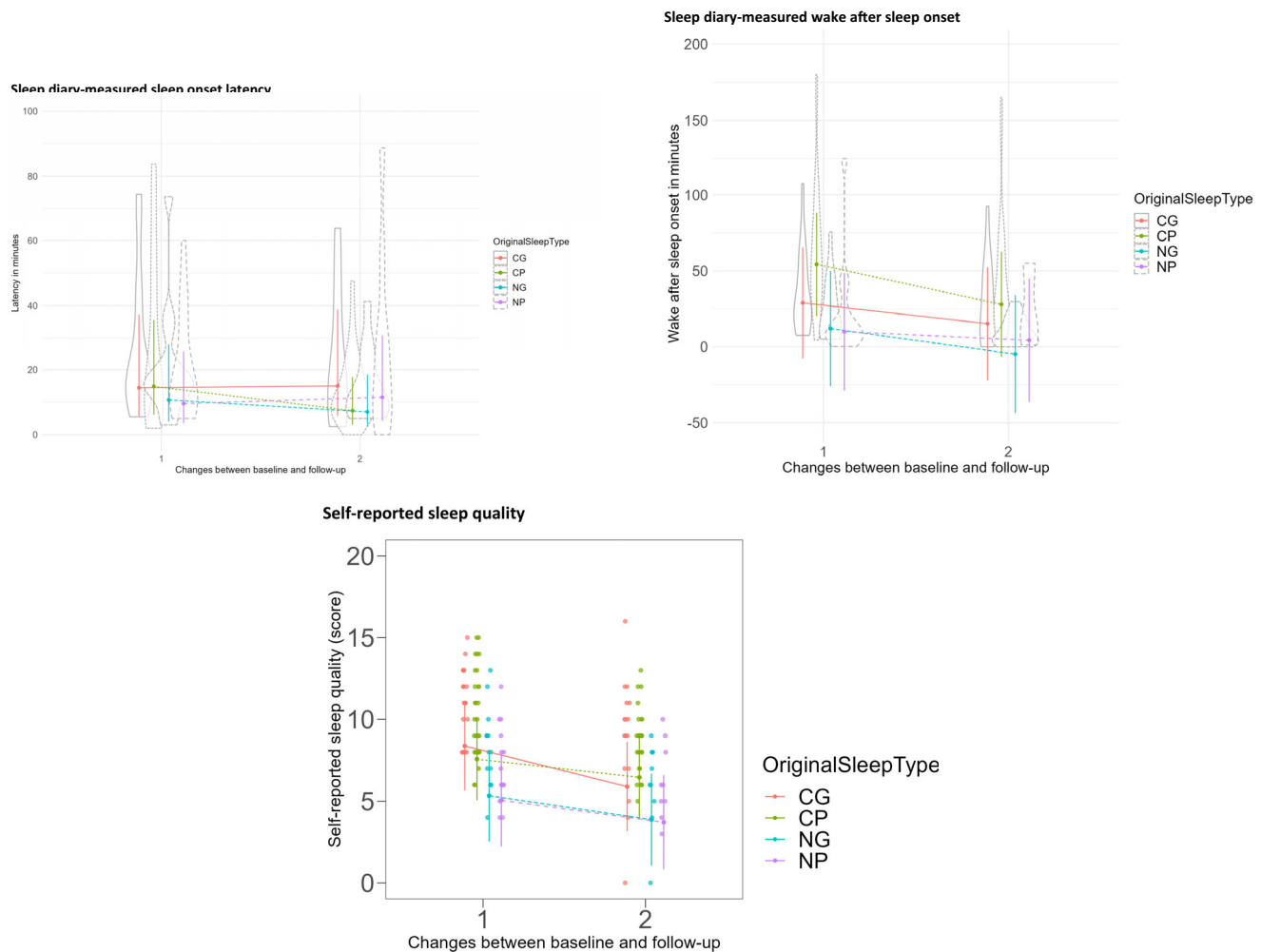


Figure 2 Continued

Dysfunctional sleep beliefs

For dysfunctional beliefs, linear mixed modelling revealed there was a significant main effect for time ($F(1,472.53) = 53.979, P < 0.001$), a medium effect size ($\eta_p^2 = 0.10$). There was also an effect of alcohol consumption (>4 standard drinks) ($F(1,521.05) = 17.317, P < 0.001$), a medium effect size ($\eta_p^2 = 0.09$) and employment status ($F(9,393.30) = 7.013, P < 0.001$), a large effect size ($\eta_p^2 = 0.14$). In addition, we found an interaction effect of time and group ($F(3,481.54) = 8.608, P < 0.001$), a small effect ($\eta_p^2 = 0.05$). Complaining good sleepers showed significantly lower dysfunctional beliefs following the CBT-I intervention, as did complaining poor sleepers, and non-complaining poor sleepers, but not non-complaining good sleepers. Overall, DBAS-16 scores of the

complaining sleeper groups were lower following the intervention than those of the non-complaining sleeper groups.

Self-reported sleep quality

Linear mixed modelling showed a significant main effect for time ($F(1,476.52) = 129.287, P < 0.001$, $\eta_p^2 = 0.21$) with a large effect size, group ($F(3,65.98) = 7.007, P < 0.001$, $\eta_p^2 = 0.24$), gender ($F(1,63.40) = 4.040, P = 0.049, \eta_p^2 = 0.06$), caffeine consumption ($F(1,329.54) = 31.152, P < 0.001$, $\eta_p^2 = 0.09$), and employment status ($F(9,325.43) = 6.886, P < 0.001$, $\eta_p^2 = 0.16$). There was also an interaction effect between time and group ($F(3,488.15) = 6.998, P < 0.001$), with a small effect size

		Insomnia complaint	
		Present	Absent
Poor sleep	Present	Complaining poor sleeper (CP)	Non-complaining poor sleeper (NP)
	Absent	Complaining good sleeper (CG)	Non-complaining good sleeper (NG)

Figure 3 Representation of sleep pattern and sleep complaint categories.

(partial $\eta^2 = 0.04$). Those that were in full-time employment had PSQI scores that were on average five points higher than the reference group (full-time carers). All groups showed significantly lower PSQI scores following the CBT-I intervention. When we combined complaining good and complaining poor sleepers, the complaining sleeper groups had lower PSQI scores than the non-complaining sleeper groups.

DISCUSSION

This study compared the outcomes of CBT-I in older adults with and without uncoupled sleep. We detected a statistically significant decrease in objective and subjective wake after sleep onset in the complaining poor sleeper group. In complaining good sleepers with uncoupled sleep we only noted a significant reduction in the number of subjective nocturnal awakenings. We did not find any changes in sleep onset latency, the time taken to fall asleep, in any of the groups. Earlier research has reported that sleep problems differ across age groups, with younger adults describing difficulties relating to sleep onset latency, whereas older adults mainly exhibited problems with wake after sleep onset.¹ This could explain why changes were reported in the time individuals spent awake during the night but not with sleep onset.³⁶

Our findings suggest that the self-guided, online CBT-I program might be effective in improving both subjective and objective sleep in individuals without uncoupled sleep who fit traditional insomnia criteria

but also older adults with uncoupled sleep. We did not find any differences in objective or subjective sleep in non-complaining poor sleepers following CBT-I, even though these individuals have poor objective sleep. However, self-rated sleep quality, measured using the PSQI, significantly increased in all four groups, and dysfunctional sleep beliefs were significantly reduced in complaining good and poor sleepers as well as in non-complaining poor sleepers. These findings are in line with recent systematic reviews suggesting that CBT-I reduces dysfunctional sleep beliefs, thus contributing to the easing of insomnia symptoms.^{37,38} We previously examined levels of dysfunctional beliefs in older adults in a cross-sectional study (manuscript submitted for publication) and found that non-complaining poor sleepers had the same low levels of dysfunctional beliefs as normal sleepers. It is possible that CBT-I outcomes are influenced by the level of dysfunctional sleep beliefs, and in their recent paper Sella *et al.*⁹ stressed that during the COVID-19 pandemic changes in self-reported sleep quality in older adults were predominantly associated with changes in dysfunctional sleep beliefs. Since non-complaining poor sleepers appear to have lower levels of maladaptive sleep beliefs, sleep improvements following CBT-I might not be easily quantifiable. More research is required to investigate whether dysfunctional sleep beliefs mediate the treatment outcomes of CBT-I in older adults, which components of CBT-I are most effective, and if CBT-I could be better tailored to meet individual needs. Differences in subjective and objective sleep outcomes in the sleep groups further indicate that a patient's sleep complaint requires more extensive assessment in primary care. As dysfunctional sleep beliefs were reduced in all sleep groups apart from normal sleepers, this could indicate that sleep problems in these older adults might have a substantial cognitive component, that might not be solved by the provision of sleep medication alone. Indeed, in this study individuals with a sleep complaint frequently reported taking sleep medication as a precaution when they anticipated poor sleep. Additional research is required examining whether the use of sleep medication is associated with a worsening of dysfunctional beliefs and subsequent sleep deterioration in older adults complaining of poor sleep.

Our study had several limitations. We observed an unexpected decrease in objective total sleep time in all groups following the intervention. This could have been due to the fact that we conducted the follow-up measurements immediately after the invention, and it is possible that participants still followed the prescribed sleep restriction protocol, which is part of the CBT-I program. In addition, we used actigraphy to measure objective sleep, which has lower accuracy for sleep onset latency compared to polysomnography.^{39,40} However, actigraphy has the advantage to allow for the measurement of objective sleep in a naturalistic setting. We further used a convenience sample, and while the recruitment advertisement clearly stated that the aim of the study was to investigate sleep in older adults in general, the sample may have been biased toward those who were concerned about having insomnia. Another possible limitation is the fact that the data collection coincided with the onset of the COVID-19 pandemic, which was not controlled for in this study, and which could have impacted outcome measures. However, due to the absence of community transmission and only minimal lockdowns in Western Australia at the time, we anticipated that the impact would be low. The small sample size could suggest a reduction in statistical power and affect generalisability, which may have been further impacted by the relatively high attrition rates in our sample.

In addition, the use of a convenience sample of individuals who self-selected as being interested in learning more about their sleep presents a possible limitation of this study. However, we anticipated the risk of bias to be low, as we included respondents who reported not having sleep problems and whose participation was not motivated by a desire to improve their sleep. Furthermore, our study utilised a pre- and post-test design, an approach associated with several limitations.⁴¹ Non-randomisation of participants limits the generalisability of the findings. The repeated use of the assessment questionnaires in itself may have introduced bias, since administration of the same tests could have resulted in familiarity with the assessment questions, resulting in higher scores. Furthermore, due to time and financial constraints, we were unable to administer a later post-test in addition to the one administered immediately following the intervention. We recommend that future

research studies should employ randomisation and an additional post-test 6 months after study completion to help address the limitations identified.

A strength of our study was that we used both subjective and objective sleep measures.⁸ In addition, we studied CBT-I outcomes in varying classifications of poor sleepers with differing subjective assessments of their sleep. This could provide direction for future research into treatment mechanisms of CBT-I in complaining good sleepers compared with complaining poor sleepers, and whether they are distinct from each other.

CONCLUSIONS

The self-guided, online CBT-I program appears to be most effective in improving sleep outcomes in older adults who do not have uncoupled sleep compared with older adults with uncoupled sleep. However, since dysfunctional sleep beliefs decreased in all groups, and subjective sleep quality increased in all except normal sleepers, it could be argued that CBT-I could hold some benefits even for those uncoupled sleepers who have poor sleep but lack a sleep complaint who do not typically seek help for sleep disturbances. Future research should employ mediation analysis to examine whether dysfunctional beliefs mediate CBT-I outcomes in coupled and uncoupled good and poor sleepers.

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DISCLOSURE

Authors declare no conflict of interests for this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

- 1 Reynolds AC, Appleton SL, Gill TK, Adams RJ. *Chronic Insomnia Disorder in Australia*. East Melbourne: A Report to the Sleep Health Foundation, 2019.
- 2 Berkley AS, Carter PA, Yoder LH, Acton G, Holahan CK. The effects of insomnia on older adults' quality of life and daily functioning: a mixed-methods study. *Geriatr Nurs* 2020; **41**: 832–838.
- 3 American Academy of Sleep M. *International Classification of Sleep Disorders*. Darien, IL: American Academy of Sleep Medicine; 2014.
- 4 Haycock J, Grivell N, Redman A *et al*. Primary care management of chronic insomnia: a qualitative analysis of the attitudes and experiences of Australian general practitioners. *BMC Fam Pract* 2021; **22**: 158.
- 5 Lichstein KL. Insomnia identity. *Behav Res Ther* 2017; **97**: 230–241.
- 6 Castelnovo A, Ferri R, Punjabi NM *et al*. The paradox of paradoxical insomnia: a theoretical review towards a unifying evidence-based definition. *Sleep Med Rev* 2019; **44**: 70–82.
- 7 Lancee J, Eftting M, van der Zweerde T, van Daal L, van Straten A, Kamphuis JH. Cognitive processes mediate the effects of insomnia treatment: evidence from a randomized wait-list controlled trial. *Sleep Med* 2019; **54**: 86–93.
- 8 Tutek J, Mulla MM, Emert SE *et al*. Health and demographic discriminators of an insomnia identity and self-reported poor quantitative sleep. *Sleep Health* 2019; **5**: 221–226.
- 9 Sella E, Cellini N, Miola L, Sarlo M, Borella E. The influence of metacognitive beliefs on sleeping difficulties in older adults. *Appl Psychol Health Well Being* 2019; **11**: 20–41.
- 10 Ree M, Junge M, Cunningham D. Australasian Sleep Association position statement regarding the use of psychological/behavioral treatments in the management of insomnia in adults. *Sleep Med* 2017; **36**: S43–S47.
- 11 Song Y, Kelly MR, Fung CH *et al*. Change in dysfunctional sleep-related beliefs is associated with changes in sleep and other health outcomes among older veterans with insomnia: findings from a randomized controlled trial. *Ann Behav Med* 2022; **56**: 35–49.
- 12 Gao Y, Ge L, Liu M *et al*. Comparative efficacy and acceptability of cognitive behavioral therapy delivery formats for insomnia in adults: a systematic review and network meta-analysis. *Sleep Med Rev* 2022; **64**: 101648.
- 13 Scogin F, Lichstein K, DiNapoli EA *et al*. Effects of integrated telehealth-delivered cognitive-behavioral therapy for depression and insomnia in rural older adults. *J Psychother Integr* 2018; **28**: 292–309.
- 14 Lichstein KL, Durrence HH, Taylor DJ, Bush AJ, Riedel BW. Quantitative criteria for insomnia. *Behav Res Ther* 2003; **41**: 427–445.
- 15 Ellis JG, Perlis ML, Espie CA *et al*. The natural history of insomnia: predisposing, precipitating, coping, and perpetuating factors over the early developmental course of insomnia. *Sleep* 2021; **44**: 1–10.
- 16 Care Connect. *The Connectivity Report: Sagacity Research*. Abbotsford: Care Connect; 2018. Available from: <https://www.careconnect.org.au/wp-content/uploads/2018/04/Care-Connect-Connectivity-Report-April-2018-Full-report.pdf>.
- 17 Perlis ML, Aloia M, Kuhn B. *Behavioral Treatments for Sleep Disorders: A Comprehensive Primer of Behavioral Sleep Medicine Interventions*. New York: Elsevier Science; 2010.
- 18 Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. *Age Ageing* 2012; **41**: 299–308.
- 19 Chung F, Abdullah HR, Liao P. STOP-bang questionnaire: a practical approach to screen for obstructive sleep apnea. *Chest* 2016; **149**: 631–638.
- 20 Stevens JA, Phelan EA. Development of STEADI: a fall prevention resource for health care providers. *Health Promot Pract* 2013; **14**: 706–714.
- 21 Quante M, Kaplan ER, Cailler M *et al*. Actigraphy-based sleep estimation in adolescents and adults: a comparison with polysomnography using two scoring algorithms. *Nat Sci Sleep* 2018; **10**: 13–20.
- 22 Smith MT, McCrae CS, Cheung J *et al*. Use of actigraphy for the evaluation of sleep disorders and circadian rhythm sleep-wake disorders: an American Academy of sleep medicine clinical practice guideline. *J Clin Sleep Med* 2018; **14**: 1231–1237.
- 23 McCrae CS, Rowe MA, Tierney CG, Dautovich ND, DeFinis AL, McNamara JPH. Sleep complaints, subjective and objective sleep patterns, health, psychological adjustment, and daytime functioning in community-dwelling older adults. *J Gerontol B Psychol Sci Soc Sci* 2005; **60**: P182–P189.
- 24 Reed DL, Sacco WP. Measuring sleep efficiency: what should the denominator be? *J Clin Sleep Med* 2016; **12**: 263–266.
- 25 Carney CE, Buysse DJ, Ancoli-Israel S *et al*. The consensus sleep diary: standardizing prospective sleep self-monitoring. *Sleep* 2012; **35**: 287–302.
- 26 Morin CM, Vallières A, Ivers H. Dysfunctional beliefs and attitudes about sleep (DBAS): validation of a brief version (DBAS-16). *Sleep* 2007; **30**: 1547–1554.
- 27 Carney CE, Edinger JD, Morin CM *et al*. Examining maladaptive beliefs about sleep across insomnia patient groups. *J Psychosom Res* 2010; **68**: 57–65.
- 28 Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. Pittsburgh sleep quality index. *Psychiatry Res* 1989; **28**: 193–213.
- 29 This Way Up. This Way Up - Managing Insomnia® Available from: <https://thiswayup.org.au/courses/managing-insomnia-course/>.
- 30 Grierson AB, Hobbs MJ, Mason EC. Self-guided online cognitive behavioural therapy for insomnia: a naturalistic evaluation in patients with potential psychiatric comorbidities. *J Affect Disord* 2020; **266**: 305–310.
- 31 Faul F, Erdfelder E, Lang A-G, Buchner A. G*power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods* 2007; **39**: 175–191.
- 32 Cohen J. *The Effect Size. Statistical Power Analysis for the Behavioral Sciences*. Abingdon: Routledge, 1988.
- 33 Cole RJ, Kripke DF, Gruen W, Mullaney DJ, Gillin JC. Automatic sleep/wake identification from wrist activity. *Sleep* 1992; **15**: 461–469.
- 34 Satterthwaite FE. An approximate distribution of estimates of variance components. *Biometrics* 1946; **2**: 110–114.
- 35 Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Front Psychol* 2013; **4**: 863.
- 36 Li J, Vitiello MV, Gooneratne NS. Sleep in normal aging. *Sleep Med Clin* 2018; **13**: 1–11.
- 37 Parsons CE, Zachariae R, Landberger C, Young KS. How does cognitive behavioural therapy for insomnia work? A systematic review and meta-analysis of mediators of change. *Clin Psychol Rev* 2021; **86**: 102027.
- 38 Thakral M, Von Korff M, McCurry SM, Morin CM, Vitiello MV. Changes in dysfunctional beliefs about sleep after cognitive behavioral therapy for insomnia: a systematic literature review and meta-analysis. *Sleep Med Rev* 2020; **46**: 101230.

- 39 Chae KY, Kripke DF, Poceta JS *et al.* Evaluation of immobility time for sleep latency in actigraphy. *Sleep Med* 2009; **10**: 621–625.
- 40 Lichstein KL, Stone KC, Donaldson J *et al.* Actigraphy validation with insomnia. *Sleep* 2006; **29**: 232–239.
- 41 Stratton SJ. Quasi-experimental design (pre-test and post-test studies) in prehospital and disaster research. *Prehosp Disaster Med* 2019; **34**: 573–574.

SUPPORTING INFORMATION

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Appendix S1. Supporting Information