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RESEARCH ARTICLE

Treating narcolepsy-related nightmares with cognitive behavioural therapy and targeted lucidity reactivation: A pilot study

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Summary

Nightmares are a common symptom in narcolepsy that has not been targeted in prior clinical trials. This study investigated the efficacy of Cognitive Behavioural Therapy for Nightmares (CBT-N), adapted for narcolepsy, in a small group of adults. Given the high prevalence of lucid dreaming in narcolepsy, we added a promising adjuvant component, targeted lucidity reactivation (TLR), a procedure designed to enhance lucid dreaming and dream control. Using a multiple baseline single-case experimental design, adults with narcolepsy and frequent nightmares (≥3/week, $N = 6$) were randomised to a 2 or 4 week baseline and received seven treatment sessions (CBT-N or CBT-N + TLR). Across the groups, there was a large effect size (between-case standardised mean difference [BC-SMD] = −0.97, 95% CI −1.79 to −0.14, $p < 0.05$) for reduced nightmare frequency from baseline (M = 8.38/week, SD = 7.08) to post-treatment (M = 2.25/week, SD = 1.78). Nightmare severity improved significantly with large effect sizes on sleep diaries (BC-SMD = −1.14, 95% CI −2.03 to −0.25, $p < 0.05$) and the Disturbing Dream and Nightmare Severity Index ($z = -2.20$, $p = 0.03$, $r = -0.64$). Treatment was associated with a reduction for some

participants in sleep paralysis, sleep-related hallucinations, and dream enactment. NREM parasomnia symptoms ($z = -2.20$, $p = 0.03$, $r = -0.64$) and self-efficacy for managing symptoms ($z = -2.02$, $p = 0.04$, $r = -0.58$) improved significantly with large effect sizes. Participants who underwent TLR ($n = 3$) all recalled dreams pertaining to their rescripted nightmare. In interviews, participants noted reduced shame and anxiety about sleep/nightmares. This study provides a proof of concept for the application of TLR as a therapeutic strategy with clinical populations, as well as preliminary evidence for the efficacy of CBT-N in treating narcolepsy-related nightmares.

KEYWORDS
hypnagogic hallucinations, hypnopompic hallucinations, imagery rehearsal therapy, lucid dreaming, parasomnias, sleep paralysis

1 | INTRODUCTION

Individuals with narcolepsy experience a constellation of symptoms that negatively affect daytime functioning and quality of life. To date, clinical trials have focussed primarily on pharmacotherapy to alleviate excessive daytime sleepiness (EDS), cataplexy, and disrupted nighttime sleep (Maski et al., 2021). However, individuals with narcolepsy experience a variety of other distressing symptoms, particularly symptoms of rapid eye movement (REM) disturbance such as vivid dreams, sleep paralysis, sleep-related hallucinations, dream delusions, dream enactment, and nightmares (American Academy of Sleep Medicine, 2014; Leu-Semenescu et al., 2022; Wamsley et al., 2014). Among people with narcolepsy, 29% to 41.5% have frequent nightmares or nightmare disorder (Leu-Semenescu et al., 2022; Mayer et al., 2002; Pisko et al., 2014), compared with a prevalence of 4–5% in the general adult population (Arnulf, 2022; Li et al., 2010). Despite a higher prevalence of nightmares in narcolepsy, they remain an understudied symptom (Pisko et al., 2014; Schredl, 2014). In a study which included 419 individuals with narcolepsy, nightmares were the most frequently experienced parasomnia in the preceding year, with rates of 85.8% for narcolepsy type 1 and 80.4% for narcolepsy type 2 (Leu-Semenescu et al., 2022). Although nightmares have typically been classified as either trauma-related or idiopathic (Gieselmann et al., 2019), it seems likely that narcolepsy-related nightmares represent an additional type of nightmare with their own aetiology rooted in the REM dysregulation of narcolepsy (Pisko et al., 2014; Schredl, 2009). Additionally, the stress of having narcolepsy may further contribute to nightmares (Rak et al., 2015; Schredl, 2014). For individuals with narcolepsy, sleep disruption caused by nightmares may exacerbate EDS (Maski et al., 2022; Scarpelli et al., 2021), making nightmares an important treatment target for improving sleep quality and daytime functioning. Furthermore, nightmares have been associated with increased depressive symptoms in individuals with and without narcolepsy, and in the latter nightmares have also been associated with increased suicide and anxiety (Garriques et al., 2024; Gieselmann et al., 2019; Köthe & Pietrowsky, 2001; Leu-Semenescu et al., 2022; Nadorff et al., 2011). Notably, research has confirmed higher rates of depression, suicide, and anxiety in people with narcolepsy, although it is unclear to what extent this may be causally linked to nightmares (Cohen et al., 2018; Flores et al., 2016; Kjær Høier et al., 2022).

Despite the pervasiveness of nightmares in narcolepsy and their association with negative daytime sequelae, nightmares have not been targeted in any prior narcolepsy clinical trials. Some researchers (Marín Agudelo et al., 2014; Pisko et al., 2014; Schredl, 2009; Schredl, 2014) have called for research on potential interventions including Imagery Rehearsal Therapy (IRT), which is the standard of care for idiopathic and posttraumatic nightmares (Morgenthaler et al., 2018). (Hereafter, we will refer to this treatment as Cognitive Behavioural Therapy for Nightmares [CBT-N] to align with emerging nomenclature from an expert consensus panel which has produced a standardised protocol for a multicomponent treatment involving imagery rehearsal strategies as well as additional cognitive and behavioural techniques (Pruiksma et al., 2023).) For individuals with narcolepsy, CBT-N has the potential to reduce not only nightmares but also—as suggested by Marín Agudelo et al. (Marín Agudelo et al., 2014) – associated symptoms of sleep paralysis and sleep-related hallucinations. However, there remains a need to investigate the use of CBT-N with this population, including potential ways to adapt this treatment to better suit the needs and characteristics of individuals with narcolepsy. For example, typical methods of rehearsing dreams via eyes-closed visualisation shortly before bedtime might not be feasible for a population with difficulty maintaining wakefulness. Additionally, because individuals with narcolepsy are much more likely to have lucid dreams (Dodet et al., 2015; Rak et al., 2015) and have reported an increased capacity to use lucid dreaming for relief from nightmares (Dodet et al., 2015), it may be beneficial to incorporate strategies to promote lucid dream control. There is evidence that lucid dreaming therapy can reduce nightmares in adults, though no studies have included individuals with narcolepsy (Ouchene et al., 2023). Lucid dreams have been reliably induced in the laboratory by presenting stimuli during REM sleep that were previously paired with a lucid

mental state, a technique called targeted lucidity reactivation (TLR) (Carr et al., 2020; Konkoly et al., 2021). However, this technique has not yet been applied for therapeutic purposes. Prior TLR research has sought to induce and verify lucid dreams via two-way communication with dreamers, and the present study aimed to test whether these procedures could induce lucid dream control for the therapeutic purpose of modifying nightmares in real-time.

Given the high frequency of nightmares in narcolepsy and the absence of research on treatment, this study's primary aim was to adapt CBT-N and TLR for the treatment of narcolepsy-related nightmares and to obtain preliminary data on their efficacy for improving nightmare frequency and severity. Second, we aimed to obtain preliminary data on the efficacy of these treatments for improving daytime sequelae of nightmares (anxiety, depression). As an exploratory aim, we planned to examine changes in other narcolepsy-related symptoms, including several symptoms of the narcolepsy pentad (EDS, sleep paralysis, sleep-related hallucinations) as well as lucid dreaming, dream enactment, dream delusions, and daytime functioning.

2 | METHODS

Study procedures were approved by the Northwestern University Institutional Review Board and participants provided informed consent prior to beginning the study. The study was registered with ClinicalTrials.gov (NCT05709873) prior to beginning recruitment. The trial was conducted using a multiple baseline single-case experimental design (SCED). For early phase behavioural treatment research, this methodology is preferred to small pilot studies because the latter are typically underpowered to detect a treatment effect and do not produce reliable effect sizes to power future larger trials (Czajkowski & Hunter, 2021; Epstein et al., 2021; National Center for Complementary and Integrative Health, 2020). Furthermore, in SCEDs the baseline period serves as the control, providing strong internal validity and allowing for a determination that the intervention resulted in the observed changes (Epstein et al., 2021). Replication of effects across patients provides preliminary external validity.

Study assessments were completed using REDCap electronic data capture tools hosted at Northwestern University (Harris et al., 2009; Harris et al., 2019). Participants were randomised to a baseline period of 2 or 4 weeks. Since symptoms were assessed via daily diaries, there were 14 or 28 data points during the baseline period. Varying the length of the baseline facilitates an assessment as to whether changes in symptoms occur when, and only when, treatment is introduced. After the baseline period, all participants received treatment followed by a 2 week posttreatment period. Treatment was assigned based on the location of the participant, since CBT-N sessions were conducted via telehealth, but TLR required an in-person visit (those outside of the Chicago area received CBT-N, those in the Chicago area received CBT-N + TLR).

2.1 | Eligibility, recruitment, and screening

Individuals were eligible to participate if they met the following criteria: (a) diagnosis of narcolepsy (confirmed via clinical documentation provided by participant), (b) age 18 or older, (c) living in the United States, (d) receiving standard care for narcolepsy, (e) sleep and psychiatric medications stable for at least 3 months and willing to keep medications stable throughout the study (so that changes in symptoms could be attributed to the study intervention rather than changes in medications), (f) nightmare frequency of ≥3 times per week, and (g) Disturbing Dream and Nightmare Severity Index indicating probable nightmare disorder (score > 10). Individuals were excluded for the following: (a) currently engaged in sleep- or trauma-focussed psychotherapy; (b) previous behavioural treatment for nightmares; (c) medical, psychiatric, or cognitive condition which would interfere with the ability to engage in the treatment; and (d) untreated sleep apnea, given evidence that this can cause or exacerbate nightmares (BaHammam & Almeneessier, 2019; McCall & Watson, 2022). For participants residing in the Chicago area who would be assigned to the CBT-N + TLR condition, the following additional criteria were applied: (a) able to attend an in-person study appointment; (b) able and willing to not take any stimulants or wake-promoting medications prior to arrival on day of laboratory visit, and (c) no history of epilepsy.

Participants were recruited through hypersomnia advocacy organisations, social media, and local sleep clinics. Potential participants completed a screening survey to determine preliminary eligibility and then completed an interview to collect additional information on medical and psychiatric history, including the Quick Structured Clinical Interview for DSM-5 Disorders (QuickSCID-5) (First & Williams, 2021). The posttraumatic stress disorder (PTSD) module was administered in order to characterise the presence of PTSD in the sample, and the following additional QuicSCID-5 modules were administered to screen for comorbidities that might affect nightmares or interfere with the ability to engage in the study: bipolar disorder, psychotic symptoms, alcohol use disorder, nonalcohol substance use, and obsessive-compulsive disorder.

2.2 | Treatment

2.2.1 | Cognitive behavioural therapy for nightmares (CBT-N)

All participants received CBT-N (Pruiksma et al., 2023) which was modified for narcolepsy and delivered by a board-certified sleep psychologist (JMM) via videoconference during weekly 1 h sessions. Participants in the CBT-N group completed seven therapy sessions, while those in the CBT-N + TLR group completed six therapy sessions and one session of TLR. In addition to the core techniques of nightmare rescripting and imagery rehearsal which are included in various iterations of IRT, CBT-N includes other cognitive and behavioural components to address factors that perpetuate nightmares. Modifications for narcolepsy were created in consultation with a narcolepsy patient

advocate who is a licensed therapist with experience treating nightmares. Table 1 contains a list of standard CBT-N components alongside the modifications used in the study.

2.2.2 | Targeted lucidity reactivation (TLR)

For session six of the treatment, participants who received TLR completed a 4 h daytime session at the research laboratory. Procedures were based on prior studies (Carr et al., 2020; Konkoly et al., 2021) and involved a training period prior to sleeping while being monitored via polysomnography (electroencephalography, electrooculography, chin electromyography, nasal cannula). This procedure took place during a daytime nap given that participants with narcolepsy were expected to be able to nap easily. They were instructed not to take any stimulants or wake promoting medications on the day of the visit.

The week prior – during the fifth treatment session – the procedures and purpose of TLR were explained to participants and several aspects of the procedures were practised, including the lucidity training procedure in which participants were taught to associate a sound (the TLR cue; three pure-tone beeps increasing in pitch [400, 600, and 800 Hz] lasting approximately 650 ms) with a lucid state of mind. Participants also practised performing signals to indicate if they were lucid (moving eyes left–right–left–right) or rescripting a dream (sniffing in-out-in-out). Because of the therapeutic aim of this study, participants were also trained to associate an additional sound cue with their rescripted dream, thus for the week prior to TLR they were instructed to listen to a sound recording (1 s C69 piano chord repeating every 10 s) while practising imagery rehearsal (Schwartz et al., 2022). Finally, another sound cue associated with the rescripted dream was recorded by the therapist, and this consisted of 2–3 words chosen by the participant which represented the positive themes of their rescripted dream.

Upon arrival at the laboratory for the TLR session, participants were prepared for polysomnography and then underwent a pre-nap training period in which they were trained to associate the TLR cue with a lucid state. To prevent the participant from falling asleep prematurely, they initially practised while sitting up with the lights on and the instructions were given while maintaining eye contact. Then, while lying down and with lights off, the lucidity sound cue was repeated at increasing intervals as the participant fell asleep and played again when the participant entered REM sleep. Once in REM sleep, C69 and verbal cues associated with dream rescripting were also played. When participants woke during the nap, a verbal dream report was collected and then they were allowed to resume sleeping if there was still time remaining in the session. One week following the laboratory visit, participants completed the final treatment session with the study therapist. In addition to covering standard content for the final session of CBT-N, this session included discussion of the participant's experience with TLR and how they could apply it to future nightmares.

TABLE 1 CBT-N components and potential adjustments for narcolepsy.

CBT-N component	Additions, modifications, and considerations for narcolepsy
Sleep and nightmare education	• Narcolepsy education • Narcolepsy as another cause of nightmares • Other symptoms of REM disturbance in narcolepsy
Sleep habits	• Planned or strategic use of naps (rather than prohibition against naps) • Strategic use of caffeine/stimulants in the afternoon/evening (rather than prohibition against use) • Strategies for managing sleep inertia
Stimulus control	• If taking oxybate medication, go to bed when taking medication and remain in bed during awakenings • Allowance for napping outside of the bed if a nap is urgently needed
Grounding	• Strategies for reality checking after waking (for dream delusions)
Relaxation training	• Adjustments to make practice feasible with excessive sleepiness (e.g., shorter duration, practice during a time of higher alertness, keep eyes open, incorporate standing or movement) • Relaxing the muscles (in progressive muscle relaxation) may have a negative association with loss of muscle control experienced in cataplexy • Relaxing (reducing vigilance) may have a negative association with loss of control over alertness experienced in sleep attacks • Daytime relaxation practice may impair subsequent alertness and functioning
Nightmare exposure	• Intense emotions experienced during exposure may trigger cataplexy
Nightmare rescripting	• Rather than focussing only on dream mentation, rescript the entire nightmare episode, including any other accompanying symptoms such as sleep paralysis or hallucinations
Imagery rehearsal	• Practice before naps as well as nighttime sleep • Adjustments to make practice feasible with excessive sleepiness (e.g., shorter duration; practice during a time of higher alertness; keep eyes open; incorporate standing or movement; active method of rehearsal such as drawing, writing, verbalising aloud)

Abbreviation: CBT-N, Cognitive Behavioural Therapy for Nightmares.

2.3 | Measures

2.3.1 | Sleep diary

Participants completed a daily sleep diary (see Appendix A) at baseline, during treatment, and at posttreatment. The sleep diary captured the frequency and severity of nightmares as well as the frequency of

other REM-related disturbances often seen in narcolepsy: sleep paralysis, sleep-related hallucinations, dream enactment, sleep talking, lucid dreams without control, and lucid dreams with control. Participants also estimated the duration of awakenings (wake time after sleep onset; WASO) that were caused by nightmares. For nightmare severity, participants were asked to indicate how severe their nightmares were overall each day (1 = not at all, 2 = slightly, 3 = moderately, 4 = very much, 5 = extremely). For nightmare frequency, participants were asked to note the number they had which did and did not wake them, and both were counted toward the frequency of nightmares used in analyses. By definition nightmares often (but not always) cause an awakening (Garriques et al., 2024), and we deemed it important to include both in the context of narcolepsy because features of narcolepsy make it less likely that awakenings will always be clearly discernable and recollected. Namely, (a) the boundaries of sleep/wake states are more permeable in narcolepsy and (b) brief awakenings are less likely to be recalled, and narcolepsy may make resuming sleep quickly after a nightmare easy (or unavoidable) despite emotional distress.

2.3.2 | Questionnaires

During the baseline and posttreatment periods, participants completed an assessment which included the following measures: Disturbing Dream and Nightmare Severity Index (DDNSI) (Krakow, 2006), Nightmare Disorder Index (NDI) (Dietch et al., 2021), Epworth Sleepiness Scale (ESS) (Johns, 1991), Hypersomnia Severity Index (HSI) (Kaplan et al., 2019), Functional Outcomes of Sleep Questionnaire-10 (FOSQ-10) (Chasens et al., 2009), Paris Arousal Disorders Severity Scale (1-month version; PADSS) (Arnulf et al., 2014; van Mierlo et al., 2022), Lucid Dreaming Skills Questionnaire (LUSK; modified to reflect a 1 month time period) (Schredl et al., 2018), Patient-Reported Outcomes Measurement Information System (PROMIS) Depression (Pilkonis et al., 2011), PROMIS Anxiety (Pilkonis et al., 2011), PROMIS General Self-Efficacy (Salsman et al., 2019), and PROMIS Self-Efficacy for Managing Symptoms (Gruber-Baldini et al., 2017). A new scale was created for this study (with input from two individuals with narcolepsy) to assess the frequency of dream delusions and resulting distress (see Appendix B –Dream Delusions Scale). In order to gauge whether the length of the assessments was acceptable or burdensome to participants with narcolepsy (to inform future trials), we asked a single item at each assessment regarding its length (see Appendix C). At posttreatment, participants also completed the Client Satisfaction Questionnaire (CSQ) (Larsen et al., 1979) and an exit interview with a study coordinator to obtain feedback on the treatment.

2.4 | Data analysis

Seven participants began treatment, and six completed the study (contact was lost with one participant who stopped attending treatment sessions). The six participants who completed the study were included in data analyses. Nightmare frequency and severity (from sleep diaries and the DDNSI) were the primary outcomes. Examination of nightmare frequency and three narcolepsy-related symptoms from sleep diaries (sleep paralysis, sleep-related hallucinations, and dream enactment) was conducted in accordance with established guidelines for analysing SCED data using both visual inspection and statistical methods (Barlow et al., 2009). Visual inspection is considered a conservative approach to data analysis in SCED. To conduct between- and within- subject visual inspection analyses data were plotted graphically and visually assessed for changes across study phases. Changes in level (i.e., mean of outcomes measures) across phases indicate the magnitude of treatment effects. Changes in slope indicate the rate of change. For ease of viewing, the data points in figures for visual inspection (Figure 1) represent weekly means for the daily sleep diary data. In addition to visual inspection, effect sizes were calculated to estimate the magnitude of change using the between-case standardised mean difference (BC-SMD), which accounts for small sample sizes and is interpreted in the same manner as Cohen's *d* (0.2 = small, 0.5 = medium, 0.8 = large) (Cohen, 1988; Valentine et al., 2016). Using the web-based program scdhlm (Pustejovsky et al., 2023; Valentine et al., 2016), effect sizes were calculated for all sleep diary outcomes from baseline to treatment and from baseline to posttreatment. Given the small sample size, effect sizes were calculated for the total sample rather than each treatment group separately. An effect size was considered statistically significant at $p < 0.05$ if the 95% confidence interval (CI) did not include zero. Changes from baseline to posttreatment on the DDNSI and other questionnaires were examined using the Wilcoxon signed-rank test. For this test, an effect size *r* of 0.1 is considered a small effect, 0.3 is medium, and 0.5 is large (Cohen, 1988).

3 | RESULTS

3.1 | Participant characteristics

Participants were six women (five White, one White and Hispanic) with a mean age of 35.8 years (SD = 4.3). Five were diagnosed with narcolepsy type 1 and one was diagnosed with narcolepsy type 2, with an average of 14.3 years since diagnosis (SD = 7.8). Their average duration of nightmares was 27.0 years (SD = 7.0). Participants were asked to estimate the proportion of their nightmares which were related to a traumatic event, and two participants reported this was 0%, while the others estimated it to be 10%, 22%, 40%, and 50%, respectively. On the QuickSCID-5, one participant met criteria for PTSD, and no participants met criteria for any other psychiatric disorders. The only sleep disorder comorbidity participants reported having been diagnosed with was obstructive sleep apnea (two participants in the CBT-N group, both treated with positive airway pressure). Between the end of treatment and the exit interview, one participant

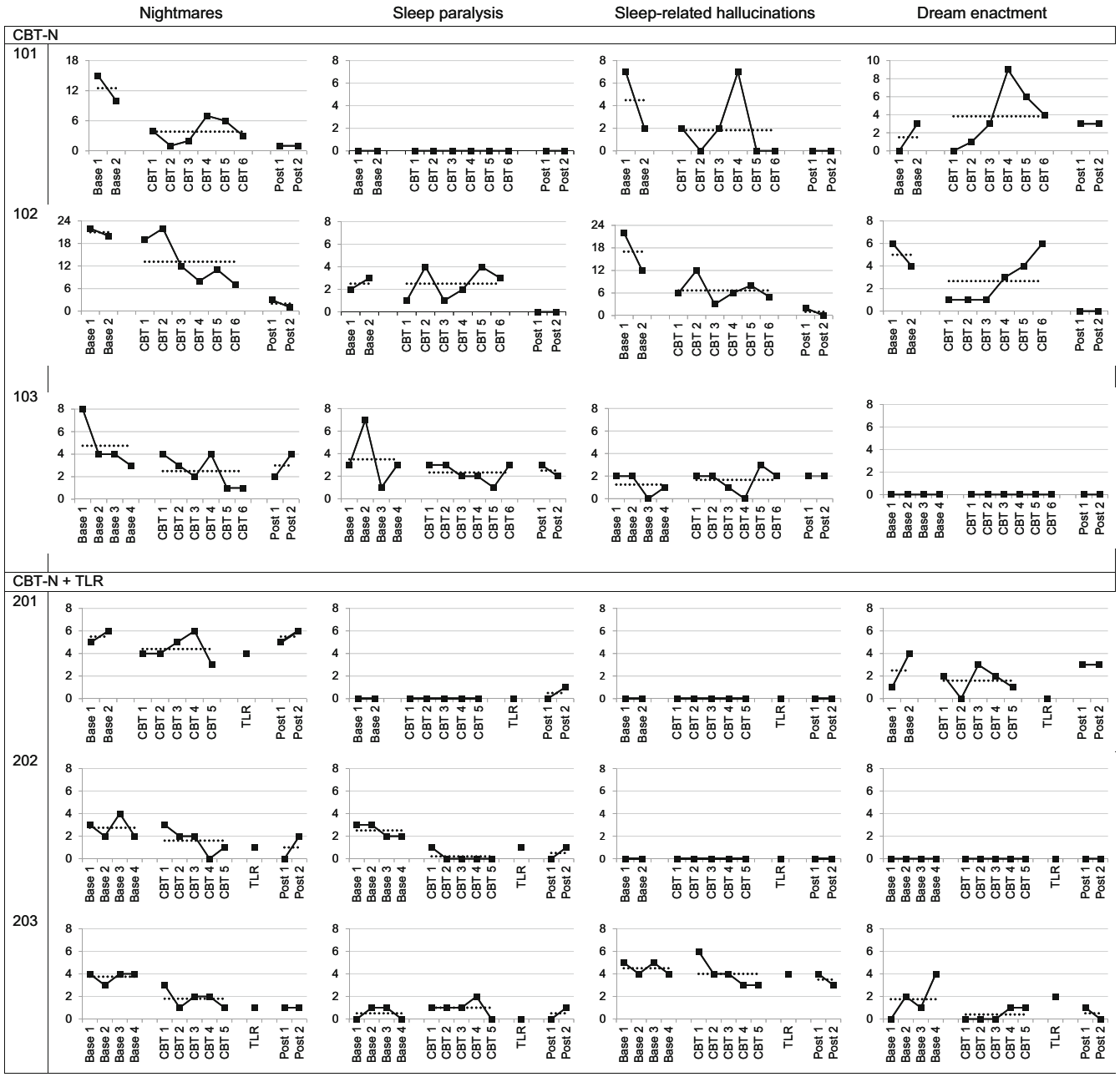

FIGURE 1 Frequency of nightmares, sleep paralysis, sleep-related hallucinations, and dream enactment. Lines represent the weekly frequency of symptoms as reported in daily sleep diaries, and dotted lines represent the mean for each period. Base, baseline. CBT, Cognitive Behavioural Therapy. TLR, targeted lucidity reactivation. Post, posttreatment.

(CBT-N + TLR group) underwent repeat polysomnography and was diagnosed with severe obstructive sleep apnea.

Regarding sleep and psychiatric medications, one participant was taking only modafinil. For the remaining five participants, each was taking three medications from the following, with no overlap among participants: alprazolam, amphetamine mixed salts, armodafinil, buspirone, dextroamphetamine, fluoxetine, gabapentin, lisdexamfetamine, mirtazapine, modafinil, pitolisant, solriamfetol, trazodone, venlafaxine, and zolpidem. No participants were taking medications for the purpose of reducing nightmares.

3.2 | Primary outcomes: Nightmare frequency and severity

Table 2 shows group means for nightmare frequency at baseline, treatment, and posttreatment. Visual inspection (Figure 1) revealed that in the CBT-N group, nightmare frequency began decreasing during the baseline period, although the potential reasons for this reduction were not identified. CBT-N was associated with reductions in nightmares for all six participants. For the CBT-N group, nightmares continued to decrease during the posttreatment period for two

TABLE 2 Sleep diary outcomes at baseline, treatment, and posttreatment.

	CBT-N ($n = 3$)			CBT-N + TLR ($n = 3$)			Total ($N = 6$)		
Sleep diary outcome	Baseline M (SD)	Treatment M (SD)	Posttreatment M (SD)	Baseline M (SD)	Treatment M (SD)	Posttreatment M (SD)	Baseline M (SD)	Treatment M (SD)	Posttreatment M (SD)
Nightmares	12.75 (8.13)	6.50 (5.84)	2.00 (1.00)	4.00 (1.39)	2.49 (1.57)	2.50 (2.60)	8.38 (7.08)	4.50 (4.41)	2.25 (1.78)*
Nightmare severity[a]	2.99 (0.21)	3.05 (0.36)	2.06 (0.94)	2.86 (1.06)	2.28 (0.20)	1.97 (0.50)	2.93 (0.69)	2.67 (0.49)	2.01 (0.68)*
WASO due to nightmares (minutes)	296.67 (63.31)	185.54 (99.40)	86.67 (150.11)	43.25 (32.64)	13.13 (8.53)	11.50 (18.21)	169.96 (145.93)	99.34 (113.57)	49.08 (104.12)
Sleep quality[b]	2.52 (0.49)	2.44 (0.64)	2.70 (1.23)	2.63 (0.46)	2.91 (0.61)	2.78 (0.39)	2.57 (0.43)	2.68 (0.62)	2.74 (0.82)
Sleep paralysis	2.00 (1.80)	1.61 (1.40)	0.83 (1.44)	1.00 (1.32)	0.39 (0.42)	0.50 (0.00)	1.50 (1.52)	1.00 (1.14)	0.67 (0.93)
Sleep-related hallucinations	7.58 (8.32)	3.39 (2.87)	1.00 (1.00)	1.50 (2.60)	1.33 (2.31)	1.17 (2.02)	4.54 (6.44)	2.36 (2.59)	1.08 (1.43)
Dream enactment	2.17 (2.57)	2.17 (1.96)	1.00 (1.73)	1.42 (1.28)	0.66 (0.65)	1.17 (1.61)	1.79 (1.86)	1.41 (1.54)	1.08 (1.50)
Sleep talking	12.92 (9.64)	5.13 (7.86)	0.17 (0.29)	1.08 (1.66)	0.93 (0.53)	0.83 (1.44)	7.00 (8.96)	3.03 (5.49)	0.50 (1.00)*
Lucid dreams without control	3.83 (3.51)	3.16 (1.45)	1.83 (1.44)	3.08 (3.84)	3.66 (6.08)	3.67 (5.92)	3.46 (3.32)	3.41 (3.96)	2.75 (3.98)
Lucid dreams with control	2.42 (3.97)	3.20 (5.28)	3.50 (6.06)	2.83 (4.91)	5.78 (10.01)	5.67 (9.81)	2.63 (4.00)	4.49 (7.29)	4.58 (7.39)

Abbreviations: Baseline, Weekly mean for 2 or 4 week baseline period; CBT-N, Cognitive Behavioural Therapy for Nightmares; Posttreatment, Weekly mean for 2 week posttreatment period; TLR, targeted lucidity reactivation; Treatment, Weekly mean for 6 week treatment period; WASO, wake time after sleep onset.

[a]Nightmare severity range = 1 to 5. Higher score indicates worse severity.

[b]Sleep quality range = 1 to 5. Higher score indicates better sleep quality.

*Effect size for change from baseline to posttreatment was significant at $p < 0.05$.

TABLE 3 Effect sizes for sleep diary outcomes at treatment and posttreatment ($N = 6$).

Sleep diary outcome	Baseline M (SD)	Treatment			Posttreatment		
		M (SD)	BC-SMD	95% CI	M (SD)	BC-SMD	95% CI
Nightmares	8.38 (7.08)	4.50 (4.41)	−0.26	[−0.71, 0.20]	2.25 (1.78)	−0.97	[−1.79, −0.14]*
Nightmare severity	2.93 (0.69)	2.67 (0.49)	−0.36	[−0.96, 0.23]	2.01 (0.68)	−1.14	[−2.03, −0.25]*
WASO due to nightmares (minutes)	169.96 (145.93)	99.34 (113.57)	−0.34	[−0.82, 0.14]	49.08 (104.12)	−0.71	[−1.50, 0.08]
Sleep quality	2.57 (0.43)	2.68 (0.62)	0.17	[−0.33, 0.68]	2.74 (0.82)	0.13	[−0.54, 0.80]
Sleep paralysis	1.50 (1.52)	1.00 (1.14)	−0.38	[−0.85, 0.09]	0.67 (0.93)	−0.55	[−1.20, 0.11]
Sleep-related hallucinations	4.54 (6.44)	2.36 (2.59)	−0.34	[−0.85, 0.17]	1.08 (1.43)	−0.36	[−0.96, 0.25]
Dream enactment	1.79 (1.86)	1.41 (1.54)	−0.50	[−1.12, 0.12]	1.08 (1.50)	−0.52	[−1.26, 0.22]
Sleep talking	7.00 (8.96)	3.03 (5.49)	−0.51	[−1.08, 0.06]	0.50 (1.00)	−0.95	[−1.78, −0.11]*
Lucid dreams without control	3.46 (3.32)	3.41 (3.96)	0.02	[−0.47, 0.51]	2.75 (3.98)	0.08	[−0.47, 0.62]
Lucid dreams with control	2.63 (4.00)	4.49 (7.29)	0.25	[−0.17, 0.67]	4.58 (7.39)	0.32	[−0.20, 0.84]

Note: Outcomes are reported as the mean weekly frequency during each period. Posttreatment effect sizes reflect change from baseline to posttreatment. BC-SMD = between-case standardised mean difference (interpreted as 0.2 = small effect size, 0.5 = medium, 0.8 = large). WASO, wake time after sleep onset.

*Significant improvement at $p < 0.05$.

TABLE 4 Sleep, mood, and daytime functioning outcome measures at baseline and posttreatment.

Measure	CBT-N ($n = 3$)		CBT-N + TLR ($n = 3$)		Total ($N = 6$)				
	Baseline M (SD)	Posttreatment M (SD)	Baseline M (SD)	Posttreatment M (SD)	Baseline M (SD)	Posttreatment M (SD)	z[a]	p	r[b]
Disturbing dream and Nightmare severity index	23.67 (8.02)	12.33 (4.16)	18.33 (2.89)	5.33 (1.15)	21.00 (6.13)	8.83 (4.71)	−2.20	0.03*	−0.64
Nightmare disorder index	13.33 (1.53)	8.33 (1.15)	11.00 (1.73)	7.33 (1.15)	12.17 (1.94)	7.83 (1.17)	−2.21	0.03*	−0.64
PROMIS depression	56.33 (3.69)	55.07 (4.47)	50.27 (5.28)	47.37 (9.19)	53.30 (5.25)	51.22 (7.72)	−0.42	0.67	−0.12
PROMIS anxiety	58.80 (10.91)	56.53 (9.42)	50.33 (8.03)	48.70 (4.47)	54.57 (9.74)	52.62 (7.87)	−0.11	0.92	−0.03
Epworth sleepiness scale	14.33 (4.04)	14.00 (3.61)	19.00 (5.00)	18.33 (5.51)	16.67 (4.80)	16.17 (4.79)	−0.74	0.46	−0.21
Hypersomnia severity index	28.67 (5.13)	25.00 (6.08)	23.00 (4.00)	21.33 (6.66)	25.83 (5.15)	23.17 (6.05)	−1.08	0.28	−0.31
Functional outcomes of sleep questionnaire-10	10.78 (3.91)	12.72 (1.58)	10.44 (1.59)	11.17 (2.35)	10.61 (2.67)	11.95 (1.99)	−1.57	0.12	−0.45
Paris arousal disorders severity scale	19.33 (2.31)	10.00 (1.00)	9.67 (4.04)	6.33 (5.51)	14.50 (6.06)	8.17 (4.07)	−2.20	0.03*	−0.64
Lucid dream skills questionnaire	1.30 (1.30)	1.27 (1.36)	1.37 (0.74)	1.53 (0.55)	1.33 (0.95)	1.40 (0.94)	−0.14	0.89	−0.04
Dream delusions scale	5.00 (1.00)	2.67 (1.53)	1.67 (2.89)	1.00 (1.73)	3.33 (2.66)	1.83 (1.72)	−1.89	0.06	−0.55
PROMIS general self-efficacy	51.57 (7.87)	53.97 (5.74)	49.83 (4.74)	50.17 (6.52)	50.70 (5.89)	52.07 (5.88)	−1.48	0.14	−0.43
PROMIS self-efficacy for managing symptoms	35.77 (3.72)	40.60 (2.95)	40.53 (1.44)	43.13 (3.19)	38.15 (3.63)	41.87 (3.08)	−2.02	0.04*	−0.58

Abbreviations: CBT-N, Cognitive Behavioural Therapy for Nightmares; PROMIS, Patient-Reported Outcomes Measurement Information System. TLR, targeted lucidity reactivation.

[a]Wilcoxon signed-rank test.

[b]Effect size r is interpreted as 0.1 = small, 0.3 = medium, 0.5 = large.

*Significant at $p < 0.05$.

participants (101, 102). One participant (103) experienced a small increase during posttreatment (103), which may have been due to increased health-related stress reported by the participant. For participants who also received TLR, nightmares continued to decrease for all three during the TLR phase, and these improvements were maintained during posttreatment for two participants (202, 203), whereas nightmares increased back to baseline for one participant (201). The latter attributed her increased nightmares to having attended a haunted house and watched scary movies. This participant was also coincidentally diagnosed with severe sleep apnea during the posttreatment phase.

For nightmare frequency and severity measured by sleep diaries, effect sizes for changes from baseline to treatment (across the entire sample, $N = 6$) were non-significant (see Table 3). However, changes from baseline to posttreatment were significant with large effect sizes for both nightmare frequency (BC-SMD = −0.97, 95% CI = −1.79 to −0.14) and nightmare severity (BC-SMD = −1.14, 95% CI = −2.03 to −0.25). Baseline and posttreatment means for the DDNSI are shown in Table 4. At posttreatment, the DDNSI score decreased to below the nightmare disorder cutoff score for four of six participants (one who received CBT-N and all three who received CBT-N + TLR; see Figure 2). Overall, the reduction in DDNSI was significant with a large effect size, $z = -2.20$, $p = 0.03$, $r = -0.64$. Similarly, scores on the NDI reduced significantly with a large effect size, $z = -2.21$, $p = 0.03$, $r = -0.64$. Effect sizes from baseline to posttreatment for all sleep diary outcomes and questionnaires are shown in Figure 3.

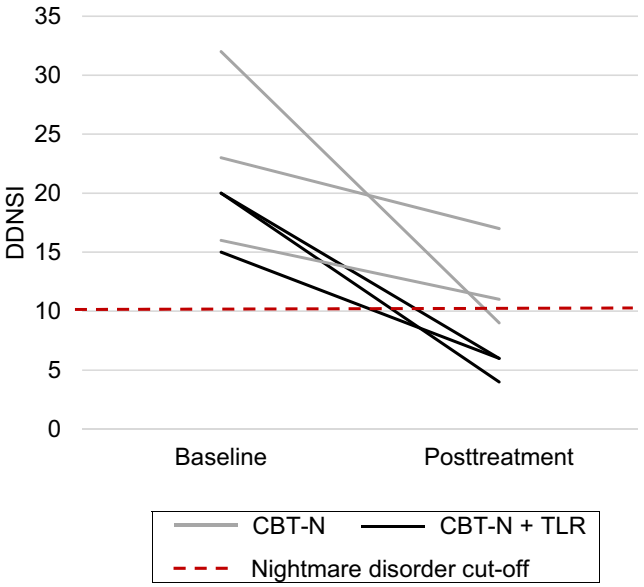

FIGURE 2 Nightmare severity for each participant at baseline and posttreatment. Scores above 10 are indicative of nightmare disorder. CBT-N, Cognitive Behavioural Therapy for Nightmares. DDNSI, Disturbing Dream and Nightmare Severity Index. TLR, targeted lucidity reactivation.

3.3 | Secondary outcomes: Anxiety and depression

At both baseline and posttreatment, group means (across the entire sample, $N = 6$) for anxiety and depression were within the normal range (T-score < 55 (HealthMeasures, n.d.), see means in Table 4). The Wilcoxon signed-rank test showed that anxiety did not significantly change with treatment, $z = -0.11$, $p = 0.92$, $r = -0.03$. Depression also did not change significantly, $z = -0.42$, $p = 0.67$, $r = -0.12$.

3.4 | Exploratory outcomes: Sleep diaries

3.4.1 | Visual inspection

Sleep paralysis

As shown in Figure 1, one participant in the CBT-N group (101) reported no sleep paralysis during the entirety of the study, exhibiting a floor effect. Floor effects were also present for one participant in the CBT-N + TLR group (201) who reported no sleep paralysis during the study except for a single episode during the posttreatment period. Visual inspection results for the remaining four participants are as follows. CBT-N was associated with a reduction in sleep paralysis for two participants (103, 202), an increase in sleep paralysis for one (203), and a maintenance of symptoms for one (102). For the CBT-N group, posttreatment was associated with a further reduction in symptoms for one (102) and a maintenance of symptoms for one (103). For the CBT-N + TLR group, one participant (202) experienced an increase in sleep paralysis during TLR and posttreatment, relative to the CBT-N phase. For the other CBT-N + TLR participant (203), TLR and posttreatment were associated with a small reduction in sleep paralysis compared with the CBT-N phase.

Sleep-related hallucinations

In the CBT-N group, sleep-related hallucinations began decreasing for two participants (101, 102) during the baseline period, although the potential reasons for this reduction were not identified. Those two participants experienced a decrease in hallucinations during treatment, as well as a further reduction during posttreatment. The third CBT-N group participant (103) showed a slight increase in hallucinations from baseline to treatment as well as from treatment to posttreatment. Floor effects were present for two participants in the CBT-N + TLR group (201, 202) who reported no hallucinations during the entirety of the study. For the remaining participant in that group (203), hallucinations decreased with CBT, remained stable through TLR, and decreased during posttreatment.

Dream enactment

Floor effects were present for two participants (one in each treatment group; 103, 202) who reported no dream enactment during the entirety of the study. In the CBT-N group, treatment was associated with an increase in symptoms for one (101) and a decrease for the other (102), and both participants demonstrated a reduction in dream enactment from treatment to posttreatment (though in 101, symptoms

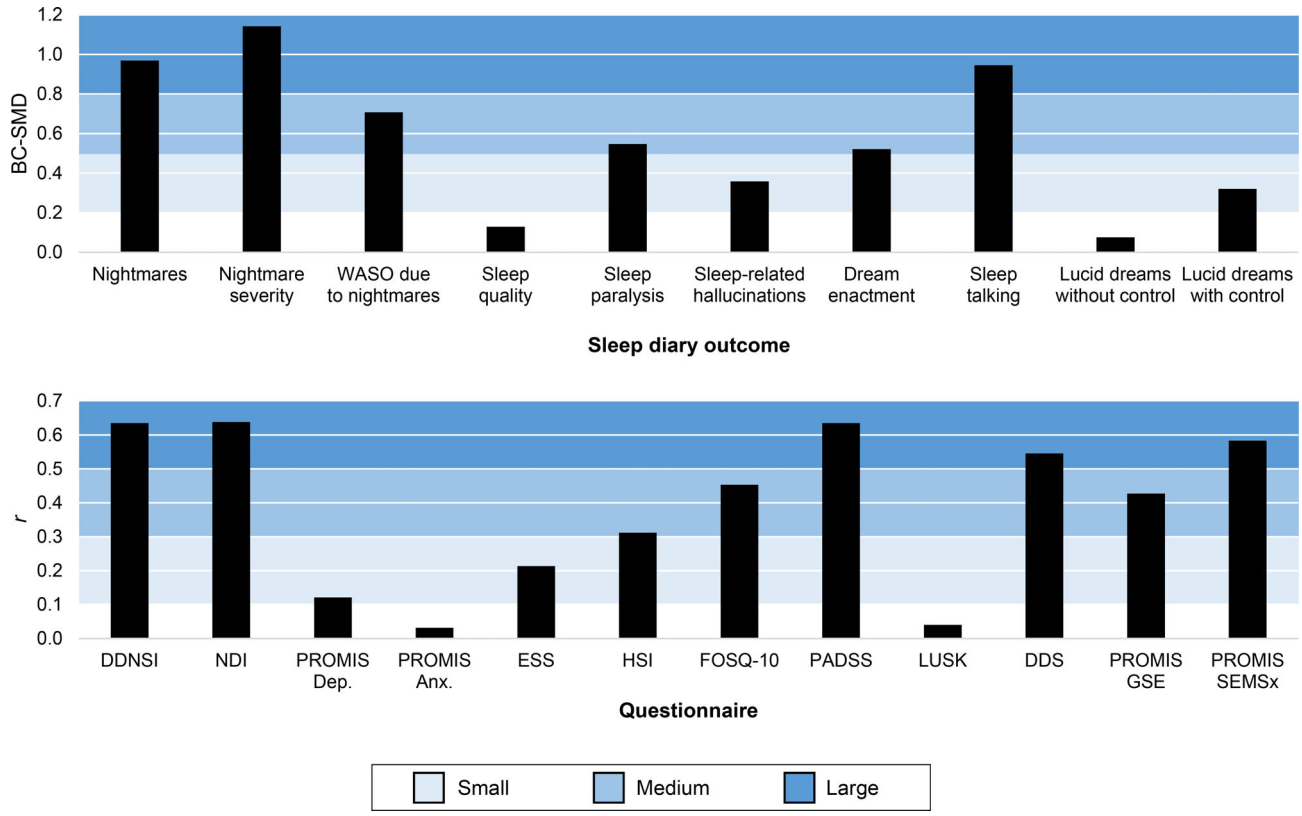

FIGURE 3 Effect sizes for changes in sleep diary outcomes and questionnaires from baseline to posttreatment. Effect sizes shown are for the change across the entire sample ($N = 6$) from baseline to posttreatment. Anx., Anxiety; BC-SMD, between-case standardised mean difference; DDNSI, Disturbing Dream and Nightmare Severity Index. DDS, Dream Delusions Scale; Dep., Depression; ESS, Epworth Sleepiness Scale; FOSQ-10, Functional Outcomes of Sleep Questionnaire-10; HSI, Hypersomnia Severity Index; GSE, General Self-Efficacy; LUSK, Lucid Dreaming Skills Questionnaire; NDI, Nightmare Disorder Index; PADSS, Paris Arousal Disorders Severity Scale; PROMIS, Patient-Reported Outcomes Measurement Information System; SEMSx, Self-Efficacy for Managing Symptoms.

at posttreatment were still higher than at baseline). In the CBT-N + TLR group, CBT-N was associated with a decrease in symptoms for both participants, and TLR led to a further reduction for one (201) and an increase for the other (203). Compared with TLR, symptoms increased during posttreatment for one (201) but decreased for the other (203).

3.4.2 | Effect sizes

Effect sizes for exploratory sleep diary variables – calculated for changes across the entire sample ($N = 6$) – are shown in Table 3. Effect sizes were not significant for sleep paralysis, sleep-related hallucinations, dream enactment, WASO, sleep quality, or lucid dreams. The only significant change found was in the reduction in sleep talking from baseline to posttreatment, which showed a large effect (BC-SMD = −0.95, 95% CI −1.78 to −0.11). WASO reduced from a mean of 169.96 minutes at baseline to 49.08 minutes at posttreatment. Despite this large and clinically significant reduction, the 95% CI for the effect size included zero and was thus considered not significant (BC-SMD = −0.71, 95% CI −1.50 to 0.08).

3.5 | Exploratory outcomes: Questionnaires

Group means for questionnaires are shown in Table 4, along with the results of Wilcoxon signed-rank tests and corresponding effect sizes. Analyses were conducted for changes across the entire sample ($N = 6$). There was a significant reduction on the PADSS from baseline to posttreatment, with a large effect size, $z = -2.20$, $p = 0.03$, $r = -0.64$. At baseline, five of the six participants were above the threshold which is indicative of non-REM (NREM) parasomnia (score >8), and – despite decreasing – all five remained above the threshold at posttreatment. Figure 4 shows the change in each participant's PADSS total score from baseline to posttreatment, and Figure 5 shows baseline and posttreatment scores for individual PADSS items which were endorsed by participants. There was a significant improvement with a large effect size on PROMIS Self-Efficacy for Managing Symptoms, $z = -2.02$, $p = 0.04$, $r = -0.58$. On this measure, the mean score at baseline (38.15) was in the low range, and the mean at posttreatment (41.87) was in the average range (HealthMeasures, n.d.). Figure 6 shows each participant's self-efficacy scores at baseline and posttreatment. Improvement in dream delusions trended toward significance with a large effect size, $z = -1.89$,

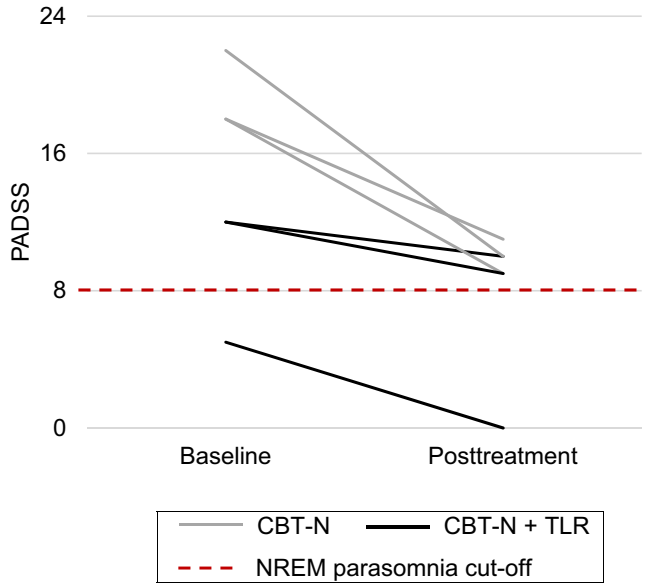

FIGURE 4 NREM parasomnia symptom severity for each participant at baseline and posttreatment. Scores above 8 are indicative of NREM parasomnia. CBT-N, Cognitive Behavioural Therapy for Nightmares. PADSS, Paris Arousal Disorders Severity Scale; TLR, targeted lucidity reactivation.

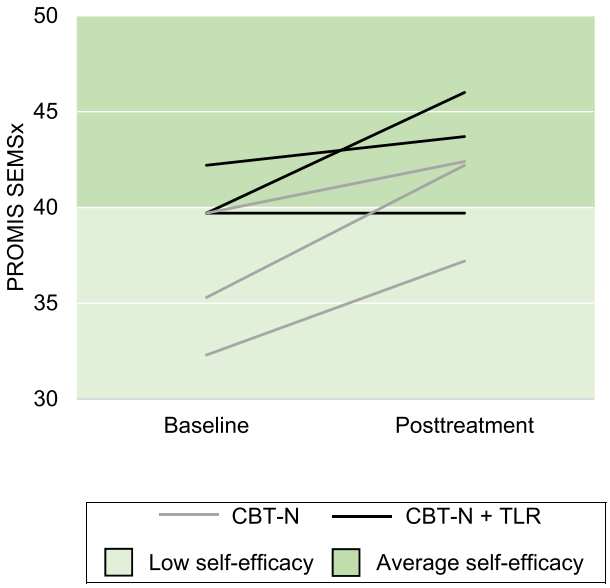

FIGURE 6 Self-efficacy for managing symptoms for each participant at baseline and posttreatment. Scores between 40 and 60 are indicative of average self-efficacy, and scores between 30 and 40 are indicative of low self-efficacy. CBT-N, Cognitive Behavioural Therapy for Nightmares; PROMIS SEMSx, Patient-Reported Outcomes Measurement Information System Self-Efficacy for Managing Symptoms; TLR, targeted lucidity reactivation.

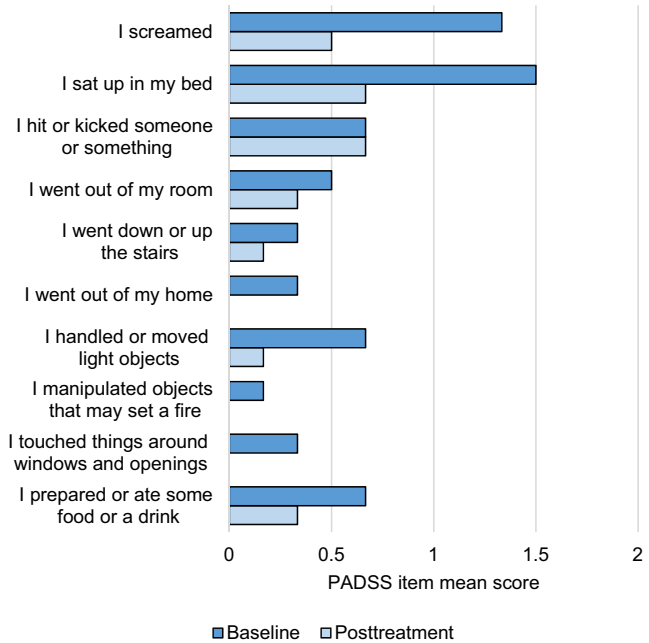

FIGURE 5 PADSS item mean scores for NREM parasomnia symptoms at baseline and posttreatment across the entire sample ($N = 6$). PADSS, Paris Arousal Disorders Severity Scale; Responses on the PADSS are scored as Never = 0, Sometimes = 1, Often = 2. Figure does not include the following items which were not endorsed by any participants: I fell out of bed; I climbed out a window; I handled or moved heavy objects; I broke an object, window, wall; I picked up sharp objects; I unwillingly performed a sexual act.

$p = 0.06$, $r = -0.55$. Changes in other measures (ESS, HSI, FOSQ-10, LUSK, PROMIS General Self-Efficacy) were not significant.

3.6 | Targeted lucidity reactivation (TLR)

All three participants who underwent TLR had dreams during the laboratory session pertaining to their rescription, and for two of these the dreams occurred while being cued in REM sleep. The first participant did not enter REM sleep during the laboratory session, precluding the opportunity for presenting TLR cues in REM sleep. She did perform left–right–left–right eye signals several times during wake and stage 1. At the end of her nap, she reported that she would begin experiencing lucid dreams with control and start playing out her rescripted dream, but as soon as she signalled with her eyes that she was doing so, she would wake up.

The second participant had two REM periods in which we presented lucid and rescripting cues. During her second REM period, the participant performed a left–right–left–right lucid signal following a lucid cue (see Figure 7). Upon awakening she reported a non-lucid dream of waking up after the experiment. She said, "Mostly that it was done, and it was the whole process of taking the cables off. It was taking the car and then going home…getting my kid…and then I ended up at the park". Although she did not recall being lucid, she did recall "at some point I heard the [lucid] cue". Her dream was consistent with the rescription she had been rehearsing, which involved

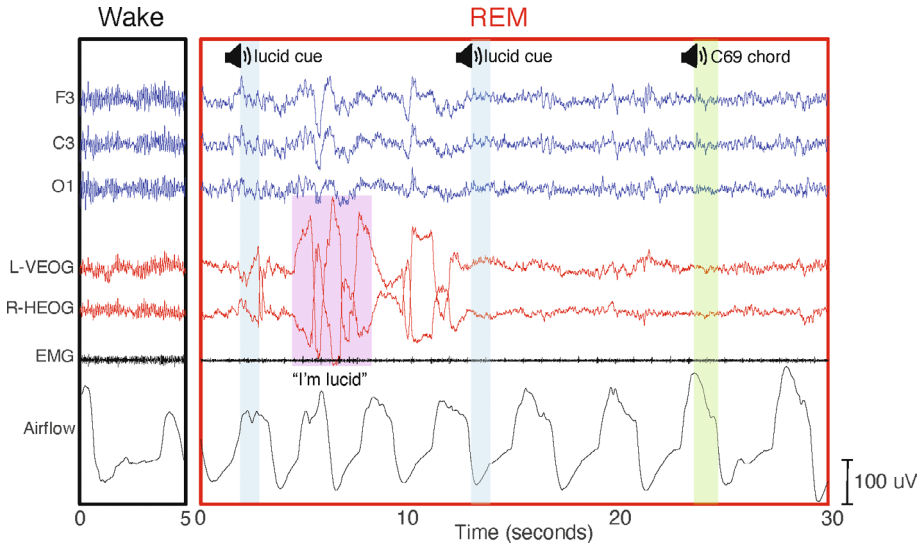

FIGURE 7 Participant performing a left–right–left–right lucid signal in response to a lucid cue. We presented another lucid cue and two C69 cues, which were not responded to, and the participant woke up approximately 30 s later. Upon awakening, the participant recalled hearing the cue, but did not recall responding or being lucid. Nevertheless, she had a dream consistent with the rescripted nightmare she had been rehearsing.

going to a park with her family. Additionally, the participant later noted that she had performance anxiety about the laboratory visit, and her dream thus demonstrated that she had utilised the rescripted dream as a means of resolving a dream about a distressing situation.

The third participant was also cued in REM sleep and reported having a dream similar to her rescription, but she did not recall hearing any sound cues while sleeping and did not signal that she was lucid or rescripting. Her rescription had involved being on a docked cruise ship enjoying eating food with her family. During the laboratory session, the dream involved the same pleasant activities but the water element transformed from being on a cruise ship to being in a shopping mall with many water fountains: "It was somewhat like the rescripting…it had the water".

3.7 | Assessment acceptability

Overall, participants found the length of the assessment acceptable. Out of the 12 total times the assessment was administered (twice for each participant), participants selected "The length seemed about right" 75% of the time (nine times), "It was too short, I think additional questions are needed" twice, and "It was too long but I don't think it needs to be changed" once. No participants selected the option recommending it be shortened.

3.8 | Treatment satisfaction and feedback

Participants reported a high degree of satisfaction with their treatment experience, with a mean CSQ total score of 31.83 out of a possible 32. In exit interviews, participants noted improvement in nightmares and expressed surprise at how helpful the treatment had been (see example comments in Table 5). They described the nightmare rescripting component as the most helpful aspect of the treatment. Some participants noted improvement in other aspects of sleep such as sleep continuity, whereas others commented that their narcolepsy symptoms were unchanged. Participants also highlighted how treatment had validated their experiences and helped to reduce feelings of anxiety and shame about sleep and nightmares.

3.9 | Adverse events

Screening for adverse events was conducted during the third treatment session and at the end of the study. The screening included querying for any changes in medication, physical health, and mental health, as well as any new problems related to sleep or sleepiness (e.g., accidents). One adverse event was reported during the course of the study by a participant in the CBT-N group. The participant reported twisting her ankle while walking shortly after awakening, and she attributed this injury partly to being sleepy and partly to other underlying medical factors. This event was deemed causally unrelated to study procedures.

4 | DISCUSSION

In order to treat narcolepsy-related nightmares, we adapted an established behavioural treatment (CBT-N) and augmented it with TLR, given the increased capacity of individuals with narcolepsy for lucid dreaming. We used a multiple baseline single-case experimental design and treated six adults with narcolepsy and nightmares with either CBT-N or CBT-N + TLR. In analyses combining the two treatment groups, large effect sizes were found for improvements in the primary outcomes, nightmare frequency and severity, as measured by both sleep diaries and questionnaires (DDNSI and NDI). At posttreatment, four out of six participants (including all three who received the combined intervention) were below the cutoff for nightmare disorder on the DDNSI. As a secondary outcome, we examined changes in anxiety and depression, which have previously been associated with

TABLE 5 Exit interview themes related to treatment experience and outcomes.

Theme	Sample quotes from exit interviews
Impact on nightmares and narcolepsy	"I saw a decrease in nightmares and was able to use a lot of the skills and the relaxation throughout my day in general. When I wake up from a nightmare it helps me go back to sleep. It has reduced other narcolepsy symptoms as well since I'm not having as many distressing nightmares" "This has been a part of my life for years and years and years and not having them made me realise how much I disliked having them. Taking that little thing off my plate made me realise how much it was weighing on me. I still feel tired all day and daytime sleepiness isn't any different" "I'm not having as many bad dreams as I was having before starting, because now I know how to change them or think of the positive scripting of how I want the dreams to go. It did not affect any other narcolepsy symptoms" "The effect of the nightmares has been less. I go to bed with a lot of less stress and I am sleeping better because of it. I wake up with a little more sense of control. I am waking up less throughout the night" "I went from having nightmares every day of my life to once or twice a week"
Anxiety and shame related to nightmares/ sleep	"I'm not as afraid now of having nightmares, I have a way of handling it. I'm not anxious about going to sleep" "It was very validating, I've always felt really dumb being affected by a nightmare, and for a week I'll be having flashbacks to the nightmare and I always felt silly, and being told by somebody that it can have a real emotional, psychological impact because it is real to you. Having someone validate that experience felt really good" "Learning about nightmare themes and statistics helped to normalise something that I have been dealing with for a long time. It was isolating when younger because of having such horrific nightmares and this brought some normalcy"
Treatment expectations vs. outcomes	"I was surprised by how impactful it was" "I didn't think it was going to work, but it was amazing. I am so blown away how well rescripting works"

nightmares. No significant change was observed in anxiety or depression, and this null finding is likely due to the fact that participants' symptoms were within normal limits at baseline.

Exploratory outcomes included a variety of parasomnia symptoms which are more common in narcolepsy. At a group level, there was a significant reduction in sleep talking but not in other parasomnia symptoms. However, visual inspection of sleep diary data demonstrated that from baseline to posttreatment there was a reduction for some participants in sleep paralysis ($n = 3$), sleep-related hallucinations ($n = 3$), and dream enactment ($n = 2$). Notably, not all participants experienced these symptoms but for those who did, sleep diaries suggested that the fluctuations and changes in these symptoms over time tended to mirror that of nightmares. A prior study which examined parasomnias in narcolepsy found that nightmares were significantly correlated with only sleep-related hallucinations (in narcolepsy type 1 only) but not other parasomnias (Leu-Semenescu et al., 2022). Further research is needed to determine if treating narcolepsy-related nightmares can reliably reduce other types of REM disturbance. This is particularly important to explore given that some of these symptoms (i.e., sleep paralysis and hallucinations) are core symptoms of the narcolepsy pentad. Future trials focused on narcolepsy-related nightmares should continue to measure other parasomnia symptoms, given the ways in which these symptoms frequently co-exist and combine with nightmares in a manner that is not typically observed in other types of nightmares.

Interestingly, although prior research has shown that NREM parasomnias were not elevated in narcolepsy (with the exception of sleep-related eating disorder) (Leu-Semenescu et al., 2022), five of six participants in this study had PADSS scores indicative of NREM parasomnia. It may be that PADSS scores in the present study reflected REM symptoms as well as (or instead of) NREM symptoms; in screening interviews, none of the participants reported having been previously diagnosed with a NREM parasomnia, and study procedures did not include any systematic evaluation for the presence of undiagnosed NREM parasomnias. On the PADSS, some items endorsed by participants might have reflected vocalisation or dream enactment occurring in REM rather than NREM (e.g., "I screamed" or "I hit or kicked someone or something") or might have been episodes of automatic behaviour (e.g., "I went out of my room"). Thus, while the observed PADSS decrease indicates that CBT-N and TLR might have the potential to improve parasomnia symptoms, this must be interpreted with caution as we cannot definitively say whether this reduction was in behaviours occurring in NREM or REM sleep.

Given the potential contribution of nightmares to disrupted nocturnal sleep and subsequent daytime functioning, we explored whether treatment impacted the measures of narcolepsy symptoms and daytime functioning. Disrupted nocturnal sleep was not captured on any standardised measures, though sleep diary-assessed WASO may be a useful proxy for this dimension. We found a large and clinically meaningful decrease in the weekly WASO resulting from nightmares (an average decrease of 120 minutes), though the effect size for this change was not statistically significant. Treatment was not associated with an improvement in daytime sleepiness (ESS) or overall hypersomnia symptoms (HSI) or functioning (FOSQ-10). However, there was an improvement in self-efficacy for managing symptoms. This improvement in self-efficacy was echoed in participant exit

interviews. In interviews, the participants also reported decreased anxiety and shame related to sleep and nightmares, an important finding which was not captured on any standardised measures.

Our inclusion of TLR to augment CBT-N provides a proof-of-concept for the application of this experimental procedure with a clinical population. We found that all participants ($n = 3$) were able to sleep during the daytime nap opportunity and had dreams related to their nightmare rescription. For two participants, the dreams occurred while being cued in REM sleep, though they did not recall achieving lucidity (however, despite a lack of recall one participant did signal with eye movements in response to the lucid cue). Those two participants reported having zero dreams with lucid control during either the baseline or posttreatment periods, while the third participant experienced an increase in episodes of lucid dream control from 8.5/week at baseline to 17/week at posttreatment. Thus, TLR did not lead to subsequent lucid dream control in individuals who did not already experience this, though TLR may have augmented the pre-existing capability of one individual (however, one individual in the CBT-N group also experienced an increase in lucid dream control from 7/week to 10.5/week). These results raise interesting questions as to whether achieving lucidity is necessary to benefit from TLR, or if simply reactivating memories (targeted memory reactivation; TMR) is sufficient. Schwartz and colleagues demonstrated that TMR (conducted at home with a portable device) enhanced outcomes when added to IRT (Schwartz et al., 2022). Their study included participants with nightmare disorder but did not specify if any had narcolepsy. Further research with TLR is needed to ascertain the efficacy of this compared with TMR, including what dose of TLR or TMR is needed (e.g., a single laboratory session as in the present study, or multiple nights as in Schwartz et al.). Finally, the finding that the participants in our study had dreams during TLR related to their rescription is notable, as individuals undergoing IRT or CBT-N do not typically have dreams which replay their rescripted dreams (Rousseau & Belleville, 2018), even with the addition of TMR (Schwartz et al., 2022).

In addition to the limitations noted above regarding the interpretation of PADSS scores in this sample, this study has several other limitations worthy of mention. Although we found evidence that treatment reduced nightmare frequency, nightmares did begin decreasing during the baseline period for some participants, possibly due to the benefits of positive expectancy and self-monitoring, or it may represent natural fluctuation or regression to the mean. Regarding study methods, while SCED is recognised as a rigorous approach for obtaining preliminary efficacy data, the small sample size nonetheless increases the potential for outliers to impact outcomes. The small sample size also precluded comparing outcomes between the two treatment groups. Furthermore, for logistical reasons participants were not randomly assigned to treatments, only to different baseline lengths. Further, to reduce participant burden, we did not require stable trend lines for either baseline or posttreatment periods. Replication with a larger sample in a randomised controlled trial is needed to confirm the results of the present study. Regarding measurement of nightmares, it should be noted that available standardised measures have not been validated in narcolepsy and may not accurately reflect the severity of nightmares. Most notably, both the DDNSI and NDI include items about the frequency with which nightmares wake the respondent, but in narcolepsy awakenings may not be as clearly discernable. Finally, we created a new scale to capture dream delusions, but the reliability and validity of the Dream Delusions Scale has not been established, and these data must therefore be interpreted with caution. A strength of the Dream Delusions Scale was the inclusion of input from two individuals with narcolepsy in drafting the wording of instructions and items.

5 | CONCLUSION

This study provides a proof of concept for the application of TLR as a therapeutic strategy with clinical populations, as well as preliminary evidence for the efficacy of CBT-N to reduce nightmare frequency and severity in individuals with narcolepsy-related nightmares. Treating narcolepsy-related nightmares may also reduce concomitant parasomnias, which occur frequently in narcolepsy, and the strongest evidence was found for improvement in sleep talking, dream delusions, and NREM parasomnias. However, changes in the latter may have reflected an improvement in REM-related phenomena (vocalisation, dream enactment, automatic behaviour) given that no participants carried a diagnosis of NREM parasomnia. Sleep paralysis and sleep-related hallucinations also improved for some participants. While daytime symptoms of narcolepsy did not improve significantly, participants reported improved self-efficacy for managing symptoms as well as reduced anxiety and shame about sleep and nightmares. These results provide promising preliminary evidence for the efficacy of nonpharmacological treatment of narcolepsy-related nightmares. TLR holds promise for treating or augmenting treatment in other types of nightmares as well. Additional studies are needed to substantiate the benefits of both types of treatment in narcolepsy as well as in other nightmare populations.

AUTHOR CONTRIBUTIONS

Jennifer M. Mundt: Conceptualization; investigation; funding acquisition; writing – original draft; writing – review and editing; visualization; methodology; formal analysis; project administration; supervision. **Kristi E. Pruiksma:** Writing – review and editing; methodology; conceptualization; resources. **Karen R. Konkoly:** Conceptualization; investigation; writing – original draft; writing – review and editing; visualization; methodology. **Clair Casiello-Robbins:** Conceptualization; writing – original draft; writing – review and editing; methodology; formal analysis. **Michael R. Nadorff:** Conceptualization; writing – review and editing; methodology. **Rachel-Clair Franklin:** Writing – review and editing; methodology. **Sunaina Karanth:** Investigation; writing – review and editing. **Nina Byskosh:** Methodology; writing – review and editing. **Daniel J. Morris:** Investigation; writing – review and editing. **S. Gabriela Torres-Platas:** Investigation; writing – review and editing. **Remington Mallett:** Conceptualization; writing – review and editing; methodology. **Kiran Maski:** Methodology; writing – review and editing. **Ken A. Paller:**

Conceptualization; resources; writing – review and editing; methodology; project administration; supervision.

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CONFLICT OF INTEREST STATEMENT

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DATA AVAILABILITY STATEMENT

Data available on request due to privacy/ethical restrictions.

PATIENT CONSENT

All participants provided written informed consent prior to completing study procedures.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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