**Treating depression with a smartphone-delivered self-help cognitive behavioral therapy for insomnia: A parallel-group randomized controlled trial**

**Supplementary Material**

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# **Additional Information regarding the Stage 2 telephone diagnostic interview**

Stage 2 screening was a telephone diagnostic interview, in which the modified Chinese version of the Revised Clinical Schedule (CIS-R) was used to assess participants’ clinical depression, insomnia, and four clinical comorbidities. The Chinese version of CIS-R was validated (Chan et al., 2017) and used in epidemiological studies in the same context (e.g., Fung et al., 2017; Lam et al., 2015). It was modified for the purpose of the current study in consultation with the developers of the Chinese version. For example, the timeframe for items measuring ICD-10 Mild depressive episode without somatic symptoms (F32.00) was changed from “the past week” to “the past 2 weeks”. Such modifications were reported in the trial protocol. The main diagnosticians CYFW and VKYH were trained by one of the developers of the Chinese version of CIS-R. They then trained and supervised research assistants, including accompanying and monitoring their diagnostic interview sessions. CSC, a clinical psychologist, provided additional training and supervision. Disagreements were found in five obsessive and compulsive diagnoses, and they were settled by CSC.

# **Details of the *a priori* power analysis**

GPower 3.1 (ANCOVA: Fixed effects, main effects and interactions) was used to calculate the sample size for each of the three primary outcomes (i.e., insomnia severity, poor sleep quality, and depression severity). Our calculation was based on a 2 (condition: CBT-I versus waitlist control) × 2 (assessment: baseline versus post-intervention) mixed ANCOVA design. The alpha value was set at 0.05, two-sided. A total sample size of 199 will provide 80% power to detect a small effect of 0.2 (Cohen’s *f*) between two groups while controlling for 12 covariates. To account for 30% attrition, a total sample of 285 participants would be required.

The covariates consisted of: (1) five demographic variables (age, education level, marital status, occupation, and gender); four clinical comorbidities (generalized anxiety disorder, phobia, obsessive compulsive disorders, and panic disorder); (3) three treatment perception variables (cognitively and affectively based treatment expectancy, and acceptability of treatment). They were chosen to account for the confounding effects of demographics and clinical factors on primary outcomes, because failure to do so could lead to biased conclusions (Skelly et al., 2012). For example, having multiple comorbid conditions was a hindering factor in internet-delivered treatment for insomnia and depression (Blom et al., 2016); while higher expectation of therapeutic improvement was associated with greater improvement in patient outcomes (Rutherford et al., 2010)

# **Table S1. Self-help treatment module content**

|  |  |  |
| --- | --- | --- |
|  | Module content (total of 6 modules)1 | Average time needed to complete |
| 1 | Introduction to sleep and insomnia, and beliefs regarding insomnia | 30-45 minutes |
| 2 | Introduction to sleep hygiene, assessment of participant’s current sleep hygiene, and associated advice for the participants in the aspect of sleep hygiene and stimulus control | 30-45 minutes |
| 3 | Introduction to sleep diary and relaxation exercises | 45-60 minutes |
| 4 | Continuation of sleep diary exercise, introduction to thought diary, and sleep restriction practice; supplemented with various illustrations to help participants on stimulus control and promote sleep hygiene | 45-60 minutes |
| 5 | Continuation of sleep restriction practices and relaxation exercises, and introduction to cognitive alteration and modification; also supplemented with methods that could help calm the anxieties before sleep | 45-60 minutes |
| 6 | Continuation of the exercises started in module 5 (sleep restriction and cognitive modification), summary and notes for participants who worked in shifts | 30-60 minutes |

1 Each module contained a short reading and animation section for participants to learn and understand the key elements of the specific module each week. Upon the completion of the reading material and animation each week, the participants would proceed to finish the weekly homework or exercises.

# **Results on subjective mental health model**

In the multilevel model predicting subjective mental health, where ITT analysis was adopted, fixed effects for gender, marital status, and treatment condition were not significant; while both the 6-week follow-up time point (*B* = 2.36, *SE* = 0.89, *p* = .008, 95% CI [0.62, 4.10]) and the 12-week follow-up time point (*B* = 8.32, *SE* = 0.97, *p* <.001, 95% CI [6.43, 10.22]) showed significant associations with subjective mental health. Treatment condition by 6-week follow-up interaction showed a significant association with subjective mental health, *B* = 7.29, *SE* =1.32, *p* <.001, 95% CI [4.71, 9.87]. Follow-up simple effect analysis found that the treatment effect was significant at 6-week follow-up (*B* = 7.54, *SE* = 1.17, *p* <.001, 95% Cl [5.24, 9.84]) in improving subjective mental health (Supplementary Table S2). Supplementary figure S1 displays the relationships between treatment conditions and time on subjective mental health.

Post-hoc t-tests were performed to examine the between and within-group score differences on subjective mental health. For the between-group comparison at 6-week follow-up, the treatment group showed a significant improvement in the subjective mental health compared to the control group (*t*(192) = 6.19, *p* <.001, Cohen’s *d* = 0.829). No significant difference was found between the treatment and control groups at 12-week follow-up (*t*(192) = 0.93, *p* = .352). In the within-group score difference, the treatment group showed significant difference before and after the treatment at week 6 follow-up (*t*(103) = -9.38, *p* <.001, Cohen’s *d* = 0.92), while the control group corresponded to a small effect size in the change (Cohen’s *d* =0.30).

Using the cut-off score of 50 or below (Gill et al., 2007), the percentage of participants in the treatment group scoring below the threshold, daily functioning being affected, decreased from 99% to 87%. The control group had a change from 100% to 99% at the 6-week follow-up. At the 12-week follow-up, the percentage in the treatment group showed the maintaining of the treatment effect, where 84% scored below the clinical threshold, which means that 16% returned to a satisfactory and functioning daily living; and the percentage in the control group showed a decreased from 99% at the 6-week follow-up to 91% at the 12-week follow-up.

# **Table S2. Multilevel model on subject mental health (MCS)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Effect (Fixed effects) | Estimate | SE | 95% Cl | *p* |
|  |  | *LL* | *UL* |  |
|  Intercept | 25.879 | 1.044 | 23.840 | 27.917 | <.001 |
| Gender | 0.558 |  0.919 | -1.235 | 2.355 | 0.544 |
| Marital Status | -1.035 | 1.272 | -3.517 | 1.450 | 0.416 |
| Treatment condition (TC) | 0.247 | 1.029 | -1.761 | 2.255 | 0.810 |
| 6-week follow-up (6-wk) | 2.362 | 0.890 | 0.621 | 4.102 | 0.008 |
| 12-week follow-up (12-wk) | 8.325 | 0.969 | 6.432 | 10.221 | <.001 |
| TC x 6-wk | 7.289 | 1.319 | 4.712 | 9.871 | <.001 |
| TC x 12-wk | 1.501 | 1.396 | -1.228 | 4.230 | 0.283 |
| *Pseudo R*2 | .187 |  |  |  |  |

# **Figure S1. Treatment effect on subjective mental health between treatment and control groups across time points**



# **Table S3. Percentages of participants with Insomnia Severity Index scoring below 8 across conditions and time**

|  |  |
| --- | --- |
| Outcome | ISI < 8 (remission) |
| Baseline |  | Week 6 follow-up |  | Week 12 follow-up |
| Measures | Tx | WL | *χ2* | Tx | WL | *χ2* | Tx | WL | *χ2* |
| Insomnia severity | 0% | 0% | 0.613 |  | 15% | 4% |  6.637\*\* |  | 27% | 21% | 0.801 |

\*\**p* < .01

*Note*. Tx = Treatment group, WL = Waitlist control group. The treatment group received the treatment after baseline assessment and completed Week 6 follow-up assessment after given access to the treatment content. The waitlist control group had to wait 6 weeks upon the completion of baseline assessment and received the treatment after the completion of Week 6 follow-up assessment. By Week 12 follow-up assessment, both groups had been given access to the treatment.

#  **Table S4. Frequency distribution of acceptability/usability** **ratings**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Disagree (%) | Neutral (%) | Agree (%) |
| 1. I think that I would like to use proACT-S often.
 | 22 | 54 | 24 |
| 1. I found proACT-S to be very complicated.
 | 50 | 36 | 14 |
| 1. I thought proACT-S was very easy to use.
 | 9 | 37 | 53 |
| 1. I think that I would need the support of a technical person to be able to use proACT-S.
 | 75 | 16 | 9 |
| 1. I found that the different parts of proACT-S work well together.
 | 5 | 43 | 53 |
| 1. I thought there was too much inconsistency in proACT-S.
 | 58 | 35 | 7 |
| 1. I would imagine that most people would learn to use proACT-S very quickly.
 | 7 | 28 | 65 |
| 1. I felt very confident using proACT-S.
 | 7 | 33 | 60 |
| 1. I needed to learn a lot of things before I could get going with proACT-S.
 | 66 | 23 | 11 |
| 1. Overall, I am satisfied with how easy it is to use proACT-S.
 | 3 | 28 | 69 |
| 1. I was able to complete the “modules” quickly in proACT-S.
 | 19 | 34 | 47 |
| 1. I felt comfortable using proACT-S.
 | 9 | 34 | 57 |
| 1. It was easy to learn to use proACT-S.
 | 5 | 19 | 76 |
| 1. Whenever I made a mistake using proACT-S, I could recover easily and quickly.
 | 7 | 38 | 55 |
| 1. It was easy to find the information I needed.
 | 2 | 22 | 76 |
| 1. The information provided for proACT-S was easy to understand.
 | 3 | 10 | 87 |
| 1. How things appeared on the screen was clear.
 | 3 | 10 | 87 |
| 1. If I have access to proACT-S, I will use it.
 | 7 | 26 | 67 |
| 1. I am satisfied with proACT-S.
 | 3 | 30 | 66 |
| 1. I would recommend proACT-S to a friend.
 | 8 | 37 | 55 |
| 1. proACT-S works the way I want it to work.
 | 13 | 38 | 49 |
| 1. I feel I need to have proACT-S.
 | 13 | 44 | 43 |
| 1. proACT-S helped me manage my symptoms.
 | 13 | 37 | 50 |
| 1. proACT-S was interactive enough.
 | 25 | 48 | 27 |
| 1. I find proACT-S very convenient.
 | 9 | 28 | 63 |
| 1. When using proACT-S, I worry about personal privacy.
 | 48 | 38 | 14 |

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| **Table S5. Multilevel models of outcome variables with treatment expectancy as a covariate** |
| Effect (Fixed effects) | Estimate | SE | 95% Cl | *p* |
|  | *LL* | *UL* |
| *Model of Depressive Symptoms* |
|  Intercept | 38.370 | 1.062 | 36.303 | 40.438 | <.001 |
| Gender | -0.828 | 0.976 | -2.728 | 1.072 | .397 |
| Marital Status | -0.048 | 1.349 | -2.674 | 2.578 | .972 |
| Treatment Expectancy (Dep) | -0.089 | 0.279 | -0.633 | 0.454 | .749 |
| Treatment Expectancy (Sleep) | -0.310 | 0.274 | -0.843 | 0.223 | .259 |
| Treatment condition (TC)  | -0.867 | 1.004 | -2.823 | 1.089 | .388 |
| 6-week follow-up (6-wk) | -2.413 | 0.723 | -3.827 | -0.999 | <.001 |
| 12-week follow-up (12-wk) | -9.279 | 0.792 | -10.829 | -7.732 | <.001 |
| TC x 6-wk | -6.687 | 1.073 | -8.784 | -4.591 | <.001 |
| TC x 12-wk | 1.352 | 1.148 | -0.891 | 3.595 | .239 |
| *Pseudo R*2 | 0.198 |  |  |  |  |
| *Model of Insomnia Severity* |
|  Intercept | 18.897 | 0.566 | 17.595 | 20.00 | <.001 |
| Gender | -0.534 | 0.509 | -1.525 | 0.457 | .295 |
| Marital Status | 0.538 | 0.707 | -0.838 | 1.914 | .447 |
| Treatment Expectancy (Dep) | 0.051 | 0.145 | -0.231 | 0.334 | .724 |
| Treatment Expectancy (Sleep) | -0.150 | 0.142 | -0.427 | 0.127 | .293 |
| Treatment condition (TC)  | -0.205 | 0.548 | -1.272 | 0.862 | .708 |
| 6-week follow-up (6-wk) | -1.577 | 0.442 | -2.440 | -0.712 | <.001 |
| 12-week follow-up (12-wk) | -6.014 | 0.486 | -6.964 | -5.066 | <.001 |
| TC x 6-wk | -4.263 | 0.660 | -5.561 | -2.977 | <.001 |
| TC x 12-wk | -0.913 | 0.699 | -2.283 | 0.451 | .192 |
| *Pseudo R*2 | 0.276 |  |  |  |  |
| *Model of Poor Sleep Quality* |  |  |  |  |  |  |  |  |  |
|  Intercept | 12.032 | 0.366 | 11.319 | 12.745 | <.001 |
| Gender | 0.121 | 0.326 | -0.514 | 0.756 | .712 |
| Marital Status | -0.042 | 0.453 | -0.924 | 0.839 | .925 |
| Treatment Expectancy (Dep) | 0.063 | 0.091 | -0.115 | 0.240 | .493 |
| Treatment Expectancy (Sleep) | -0.101 | 0.090 | -0.277 | 0.075 | .265 |
| Treatment condition (TC)  | 0.300 | 0.352 | -0.385 | 0.985 | .394 |
| 6-week follow-up (6-wk) | -0.741 | 0.291 | -1.311 | -0.172 | .011 |
| 12-week follow-up (12-wk) | -2.797 | 0.320 | -3.423 | -2.173 | <.001 |
| TC x 6-wk | -2.706 | 0.432 | -3.553 | -1.865 | <.001 |
| TC x 12-wk | -0.533 | 0.455 | -1.425 | 0.355 | .243 |
| *Pseudo R*2 | 0.198 |  |  |  |  |
| *Model of Anxiety Severity* |
|  Intercept | 11.986 | 0.383 | 11.241 | 12.730 | <.001 |
| Gender | 0.192 | 0.345 | -0.480 | 0.863 | .579 |
| Marital Status | 0.566 | 0.476 | -0.362 | 1.493 | .236 |
| Treatment Expectancy (Dep) | -0.008 | 0.099 | -0.200 | 0.184 | .932 |
| Treatment Expectancy (Sleep) | -0.044 | 0.097 | -0.232 | 0.144 | .651 |
| Treatment condition (TC)  | -0.149 | 0.369 | -0.867 | 0.570 | .687 |
| 6-week follow-up (6-wk) | 0.268 | 0.293 | -0.307 | 0.840 | .361 |
| 12-week follow-up (12-wk) | -2.253 | 0.320 | -2.880 | -1.629 | <.001 |
| TC x 6-wk | -2.760 | 0.433 | -3.610 | -1.917 | <.001 |
| TC x 12-wk | 0.009 | 0.463 | -0.895 | 0.912 | .984 |
| *Pseudo R*2 | 0.128 |  |  |  |  |
| *Model of Subjective Physical Health* |
| Fixed effects |  |  |  |  |  |
|  Intercept | 46.549 | 1.042 | 44.520 | 48.577 | <.001 |
| Gender | -1.232 | 0.967 | -3.115 | 0.651 | .204 |
| Marital Status | -1.629 | 1.341 | -4.240 | 0.982 | .225 |
| Treatment Expectancy (Dep) | -0.132 | 0.277 | -0.671 | 0.407 | .634 |
| Treatment Expectancy (Sleep) | -0.124 | 0.272 | -0.653 | 0.405 | .648 |
| Treatment condition (TC)  | 0.643 | 0.974 | -1.254 | 2.539 | .510 |
| 6-week follow-up (6-wk) | 0.754 | 0.652 | -0.521 | 2.028 | .248 |
| 12-week follow-up (12-wk) | 1.261 | 0.715 | -0.138 | 2.657 | .078 |
| TC x 6-wk | 0.339 | 0.978 | -1.573 | 2.251 | .729 |
| TC x 12-wk | 0.191 | 1.039 | -1.838 | 2.224 | .855 |
| *Pseudo R*2 | 0.018 |  |  |  |  |

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| **Table S6. Multilevel models of outcome variables among only completers (per-protocol analysis)** |
| Effect (Fixed effects) | Estimate | SE | 95% Cl | *p* |
|  | *LL* | *UL* |
| *Model of Depressive Symptoms* |
|  Intercept | 39.454 | 2.204 | 35.185 | 43.724 | <.001 |
| Gender | -0.257 | 1.984 | -4.104 | 3.587 | .897 |
| Marital Status | 0.390 | 2.846 | -5.128 | 5.907 | .891 |
| Treatment condition (TC)  | -3.745 | 1.917 | -7.456 | -0.035 | .052 |
| 6-week follow-up (6-wk) | -3.732 | 1.317 | -6.301 | -1.169 | .005 |
| 12-week follow-up (12-wk) | -10.597 | 1.341 | -13.211 | -7.986 | <.001 |
| TC x 6-wk | -7.133 | 1.757 | -10.549 | -3.705 | <.001 |
| TC x 12-wk | 2.741 | 1.785 | -0.731 | 6.225 | .126 |
| *Pseudo R*2 | 0.244 |  |  |  |  |
| *Model of Insomnia Severity* |
|  Intercept | 18.155 | 1.106 | 16.013 | 20.296 | <.001 |
| Gender | -0.018 | 0.965 | -1.886 | 1.852 | .986 |
| Marital Status | -1.048 | 1.381 | -3.725 | 1.629 | .450 |
| Treatment condition (TC)  | 0.322 | 1.000 | -1.613 | 2.258 | .748 |
| 6-week follow-up (6-wk) | -1.357 | 0.816 | -2.950 | 0.231 | .098 |
| 12-week follow-up (12-wk) | -6.694 | 0.838 | -8.327 | -5.064 | <.001 |
| TC x 6-wk | -5.173 | 1.088 | -7.293 | -3.055 | <.001 |
| TC x 12-wk | -1.057 | 1.110 | -3.221 | 1.104 | .343 |
| *Pseudo R*2 | 0.330 |  |  |  |  |
| *Model of Poor Sleep Quality* |  |  |  |  |  |  |  |  |  |
|  Intercept | 12.200 | 0.703 | 10.839 | 13.559 | <.001 |
| Gender | -0.347 | 0.605 | -1.517 | 0.826 | .568 |
| Marital Status | -0.306 | 0.863 | -1.978 | 1.365 | .723 |
| Treatment condition (TC)  | 0.227 | 0.639 | -1.008 | 1.462 | .722 |
| 6-week follow-up (6-wk) | -0.071 | 0.524 | -1.093 | 0.946 | .893 |
| 12-week follow-up (12-wk) | -2.857 | 0.544 | -3.918 | -1.802 | <.001 |
| TC x 6-wk | -4.061 | 0.694 | -5.413 | -2.710 | <.001 |
| TC x 12-wk | -0.766 | 0.714 | -2.154 | 0.624 | .285 |
| *Pseudo R*2 | 0.268 |  |  |  |  |
| *Model of Anxiety Severity* |
|  Intercept | 12.525 | 0.714 | 11.143 | 13.906 | <.001 |
| Gender | 0.147 | 0.618 | -1.051 | 1.345 | .812 |
| Marital Status | 0.636 | 0.885 | -1.080 | 2.351 | .417 |
| Treatment condition (TC)  | -1.494 | 0.650 | -2.752 | -0.236 | .023 |
| 6-week follow-up (6-wk) | 0.186 | 0.544 | -0.875 | 1.244 | .733 |
| 12-week follow-up (12-wk) | -2.743 | 0.553 | -3.822 | -1.668 | <.001 |
| TC x 6-wk | -2.975 | 0.725 | -4.384 | -1.561 | <.001 |
| TC x 12-wk | 0.587 | 0.736 | -0.844 | 2.022 | .426 |
| *Pseudo R*2 | 0.224 |  |  |  |  |
| *Model of Subjective Health & Well-Being* |
|  Intercept | 42.41 | 2.019 | 32.384 | 45.661 | <.001 |
| Gender | 2.561 | 1.817 | -0.317 | 6.325 | .162 |
| Marital Status | 0.008 | 2.607 | -3.387 | 5.831 | .998 |
| Treatment condition (TC)  | 1.364 | 1.755 | -1.892 | 4.774 | .438 |
| 6-week follow-up (6-wk) | 1.009 | 1.206 | -0.918 | 3.686 | .404 |
| 12-week follow-up (12-wk) | 1.739 | 1.228 | -0.509 | 4.132 | .158 |
| TC x 6-wk | 0.830 | 1.608 | -2.886 | 3.225 | .607 |
| TC x 12-wk | 0.616 | 1.635 | -2.362 | 3.794 | .707 |
| *Pseudo R*2 | 0.033 |  |  |  |  |

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| **Table S7. Multilevel models of outcome variables in participants recruited during the outbreak of COVID-19** |
| Effect (Fixed effects) | Estimate | SE | 95% Cl | *p* |
|  | *LL* | *UL* |
| *Model of Depressive Symptoms* |
|  Intercept | 35.271 | 2.560 | 30.294 | 40.263 | <.001 |
| Gender | 1.931 | 1.337 | -0.677 | 4.530 | .150 |
| Marital Status | 1.478 | 2.236 | -2.876 | 5.829 | .510 |
| Treatment condition (TC)  | -1.689 | 1.373 | -4.358 | 0.979 | .219 |
| 6-week follow-up (6-wk) | -1.736 | 0.982 | -3.651 | 0.181 | .078 |
| 12-week follow-up (12-wk) | -9.404 | 1.105 | -11.560 | -7.249 | <.001 |
| TC x 6-wk | -8.291 | 1.444 | -11.116 | -5.481 | <.001 |
| TC x 12-wk | -0.081 | 1.553 | -2.197 | 3.862 | .589 |
| *Pseudo R*2 | 0.230 |  |  |  |  |
| *Model of Insomnia Severity* |
|  Intercept | 18.633 | 1.363 | 15.983 | 21.291 | <.001 |
| Gender | -0.080 | 0.707 | -1.461 | 1.295 | .910 |
| Marital Status | -0.299 | 1.197 | -2.627 | 2.032 | .803 |
| Treatment condition (TC)  | -0.094 | 0.756 | -1.564 | 1.376 | .902 |
| 6-week follow-up (6-wk) | -1.071 | 0.599 | -2.238 | 0.099 | .0748 |
| 12-week follow-up (12-wk) | -7.223 | 0.681 | -8.556 | -5.863 | <.001 |
| TC x 6-wk | -5.092 | 0.884 | -6.832 | -3.374 | <.001 |
| TC x 12-wk | -0.203 | 0.950 | -1.657 | 2.052 | .831 |
| *Pseudo R*2 | 0.311 |  |  |  |  |
| *Model of Poor Sleep Quality* |  |  |  |  |  |  |  |  |  |
|  Intercept | 11.455 | 0.876 | 9.752 | 13.157 | <.001 |
| Gender | 0.295 | 0.453 | -0.587 | 1.175 | .517 |
| Marital Status | -0.231 | 0.763 | -1.713 | 1.254 | .762 |
| Treatment condition (TC)  | 0.202 | 0.494 | -0.758 | 1.162 | .683 |
| 6-week follow-up (6-wk) | -0.768 | 0.406 | -1.561 | 0.021 | .060 |
| 12-week follow-up (12-wk) | -3.022 | 0.459 | -3.922 | -2.129 | <.001 |
| TC x 6-wk | -2.870 | 0.593 | -4.028 | -1.718 | <.001 |
| TC x 12-wk | -0.125 | 0.638 | -1.368 | 1.118 | .845 |
| *Pseudo R*2 | 0.202 |  |  |  |  |
| *Model of Anxiety Severity* |
|  Intercept | 11.058 | 0.897 | 9.315 | 12.807 | <.001 |
| Gender | 0.876 | 0.466 | -0.033 | 1.782 | .062 |
| Marital Status | 1.088 | 0.780 | -0.30 | 2.607 | .165 |
| Treatment condition (TC)  | -0.464 | 0.495 | -1.425 | 0.498 | .349 |
| 6-week follow-up (6-wk) | 0.225 | 0.385 | -0.528 | 0.977 | .559 |
| 12-week follow-up (12-wk) | -2.636 | 0.433 | -3.482 | -1.794 | <.001 |
| TC x 6-wk | -3.014 | 0.566 | -4.120 | -1.912 | <.001 |
| TC x 12-wk | -0.045 | 0.607 | -1.233 | 1.137 | .941 |
| *Pseudo R*2 | 0.189 |  |  |  |  |
| *Model of Subject Physical Health* |
|  Intercept | 48.733 | 2.428 | 44.011 | 53.463 | <.001 |
| Gender | -1.903 | 1.267 | -4.372 | 0.561 | .135 |
| Marital Status | -0.491 | 2.120 | -4.615 | 3.638 | .817 |
| Treatment condition (TC)  | 1.205 | 1.308 | -1.338 | 3.748 | .358 |
| 6-week follow-up (6-wk) | 2.009 | 0.952 | 0.148 | 3.863 | .036 |
| 12-week follow-up (12-wk) | 2.832 | 1.070 | 0.742 | 4.919 | .009 |
| TC x 6-wk | -0.607 | 1.403 | -3.346 | 2.130 | .666 |
| TC x 12-wk | -1.930 | 1.504 | -4.864 | 1.003 | .201 |
| *Pseudo R*2 | 0.023 |  |  |  |  |

|  |
| --- |
| **Table S8. Multilevel models for outcome variables among those with and without an anxiety disorder** |
| Effect (Fixed effects) | Estimate | SE | 95% Cl | *p* |
|  | *LL* | *UL* |
| *Model of Depressive Symptoms* |
|  Intercept | 37.068 | 1.364 | 34.416 | 39.721 | <.001 |
| Gender | -1.249 | 0.972 | -3.142 | 0.641 | .200 |
| Marital Status | -0.052 | 1.333 | -2.646 | 2.540 | .969 |
| Treatment condition (TC)  | -2.353 | 1.637 | -5.537 | 0.831 | .151 |
| 6-week follow-up (6-wk) | -1.105 | 1.151 | -3.346 | 1.137 | .338 |
| 12-week follow-up (12-wk) | -9.377 | 1.277 | -11.863 | -6.890 | <.001 |
| Anxiety disorder (Anxiety) | 2.761 | 1.454 | -0.067 | 5.589 | .058 |
| TC x 6-wk | -7.803 | 1.784 | -11.273 | -4.329 | <.001 |
| TC x 12-wk | 0.612 | 1.925 | -3.134 | 4.361 | .751 |
| TC x Anxiety | 1.808 | 2.025 | -2.130 | 5.746 | .372 |
| 6-wk x Anxiety | -2.101 | 1.477 | -4.978 | 0.774 | .155 |
| 12-wk x Anxiety | 0.176 | 1.625 | -2.990 | 3.338 | .914 |
| TC x 6-wk x Anxiety | 1.758 | 2.230 | -2.587 | 6.096 | .431 |
| TC x 12-wk x Anxiety | 0.961 | 2.395 | -3.705 | 5.620 | .689 |
| *Pseudo R*2 | 0.216 |  |  |  |  |
| *Model of Insomnia Severity*  |
|  Intercept | 18.314 | 0.736 | 16.884 | 19.745 | <.001 |
| Gender | -0.733 | 0.507 | -1.720 | 0.252 | .149 |
| Marital Status | 0.534 | 0.697 | -0.823 | 1.891 | .444 |
| Treatment condition (TC)  | -0.889 | 0.894 | -2.627 | 0.849 | .320 |
| 6-week follow-up (6-wk) | -1.537 | 0.704 | -2.908 | -0.165 | .030 |
| 12-week follow-up (12-wk) | -5.298 | 0.778 | -6.814 | -3.783 | <.001 |
| Anxiety disorder (Anxiety) | 1.224 | 0.795 | -0.322 | 2.769 | .124 |
| TC x 6-wk | -3.402 | 1.098 | -5.541 | -1.266 | .002 |
| TC x 12-wk | -2.290 | 1.168 | -4.566 | 0.018 | .050 |
| TC x Anxiety | 0.884 | 1.107 | -1.267 | 3.036 | .425 |
| 6-wk x Anxiety | -0.035 | 0.903 | -1.791 | 1.724 | .969 |
| 12-wk x Anxiety | -1.147 | 0.994 | -3.082 | 0.787 | .249 |
| TC x 6-wk x Anxiety | -1.369 | 1.372 | -4.043 | 1.299 | .319 |
| TC x 12-wk x Anxiety | 2.062 | 1.456 | -0.773 | 4.897 | .157 |
| *Pseudo R*2 | 0.290 |  |  |  |  |
| *Model of Poor Sleep Quality* |  |  |  |  |  |  |  |  |  |
|  Intercept | 11.768 | 0.487 | 10.823 | 12.714 | <.001 |
| Gender | 0.032 | 0.326 | -0.601 | 0.667 | .921 |
| Marital Status | -0.042 | 0.450 | -0.916 | 0.833 | .926 |
| Treatment condition (TC)  | 0.227 | 0.583 | -0.906 | 1.361 | .697 |
| 6-week follow-up (6-wk) | -0.710 | 0.473 | -1.630 | 0.210 | .134 |
| 12-week follow-up (12-wk) | -2.671 | 0.519 | -3.682 | -1.661 | <.001 |
| Anxiety disorder (Anxiety) | 0.533 | 0.524 | -0.485 | 1.551 | .309 |
| TC x 6-wk | -2.517 | 0.712 | -3.904 | -1.133 | <.001 |
| TC x 12-wk | -1.564 | 0.752 | -3.029 | -0.100 | .038 |
| TC x Anxiety | 0.058 | 0.717 | -1.336 | 1.453 | .935 |
| 6-wk x Anxiety | -0.026 | 0.560 | -1.194 | 1.141 | .966 |
| 12-wk x Anxiety | -0.188 | 0.658 | -1.468 | 1.093 | .776 |
| TC x 6-wk x Anxiety | -0.322 | 0.894 | -2.060 | 1.417 | .719 |
| TC x 12-wk x Anxiety | 1.568 | 0.944 | -0.270 | 3.402 | .097 |
| *Pseudo R*2 | 0.210 |  |  |  |  |
| *Model of Anxiety Severity* |
|  Intercept | 10.724 | 0.481 | 9.788 | 11.660 | <.001 |
| Gender | -0.070 | 0.330 | -0.711 | 0.572 | .833 |
| Marital Status | 0.572 | 0.451 | -0.307 | 1.450 | .206 |
| Treatment condition (TC)  | -0.016 | 0.586 | -1.155 | 1.123 | .978 |
| 6-week follow-up (6-wk) | 1.151 | 0.467 | 0.243 | 2.059 | .014 |
| 12-week follow-up (12-wk) | -1.777 | 0.515 | -2.781 | -0.775 | <.001 |
| Anxiety disorder (Anxiety) | 2.366 | 0.521 | 1.353 | 3.378 | <.001 |
| TC x 6-wk | -3.497 | 0.717 | -4.894 | -2.102 | <.001 |
| TC x 12-wk | -0.715 | 0.772 | -2.219 | 0.787 | .354 |
| TC x Anxiety | -0.395 | 0.725 | -1.805 | 1.015 | .586 |
| 6-wk x Anxiety | -1.417 | 0.597 | -2.581 | -0.254 | .018 |
| 12-wk x Anxiety | -0.751 | 0.655 | -2.026 | 0.524 | .252 |
| TC x 6-wk x Anxiety | 1.172 | 0.896 | -0.572 | 2.918 | .192 |
| TC x 12-wk x Anxiety | 1.077 | 0.961 | -0.794 | 2.946 | .263 |
| *Pseudo R*2 | 0.192 |  |  |  |  |
| *Model of Subjective Physical Health* |
| Fixed effects |  |  |  |  |  |
|  Intercept | 48.106 | 1.340 | 45.501 | 50.713 | <.001 |
| Gender | -0.948 | 0.971 | -2.839 | 0.940 | .329 |
| Marital Status | -1.639 | 1.334 | -4.237 | 0.956 | .220 |
| Treatment condition (TC)  | -0.639 | 1.598 | -3.746 | 2.469 | .690 |
| 6-week follow-up (6-wk) | 0.494 | 1.044 | -1.539 | 2.528 | .637 |
| 12-week follow-up (12-wk) | 1.250 | 1.161 | -1.009 | 3.510 | .282 |
| Anxiety disorder (Anxiety) | -2.760 | 1.419 | -5.519 | -0.014 | .052 |
| TC x 6-wk | 0.005 | 1.647 | -3.213 | 3.208 | .998 |
| TC x 12-wk | 0.130 | 1.757 | -3.296 | 3.547 | .941 |
| TC x Anxiety | 1.981 | 1.975 | -1.860 | 5.822 | .316 |
| 6-wk x Anxiety | 0.400 | 1.341 | -2.213 | 3.009 | .766 |
| 12-wk x Anxiety | -0.014 | 1.477 | -2.892 | 2.861 | .993 |
| TC x 6-wk x Anxiety | 0.452 | 2.054 | -3.542 | 4.467 | .826 |
| TC x 12-wk x Anxiety | 0.087 | 2.186 | -4.162 | 4.354 | .968 |
| *Pseudo R*2 | 0.024 |  |  |  |  |

# **Table S9. Regression models of baseline characteristics on treatment maintenance in the treatment group**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | SE | 95% Cl | *p* |
|  | *LL* | *UL* |
| *Maintenance of Depression Improvement* |
|  Intercept | 0.186 | 5.804 | -11.350 | 11.722 | .975 |
| Gender | 0.865 | 1.844 | -2.800 | 4.531 | .640 |
| Marital Status | 1.400 | 2.155 | -2.884 | 5.685 | .518 |
| Anxiety disorder (Anxiety) | -2.385 | 1.822 | -6.006 | 1.236 | .194 |
| Treatment Expectancy (Depression) | 1.004 | 0.494 | 0.021 | 1.987 | .045 |
| Treatment Expectancy (Insomnia) | -0.897 | 0.479 | -1.850 | 0.055 | .065 |
| Baseline Depression Severity | -0.001 | 0.097 | -0.193 | 0.191 | .993 |
| Baseline Insomnia Severity | -0.084 | 0.219 | -0.519 | 0.351 | .702 |
| *Maintenance of Insomnia Alleviation* |
|  Intercept | -0.0785 | 3.347 | -6.730 | 6.573 | .981 |
| Gender | 2.282 | 1.063 | 0.169 | 4.396 | .035 |
| Marital Status | 0.633 | 1.243 | -1.838 | 3.103 | .612 |
| Anxiety disorder (Anxiety) | -2.487 | 1.050 | -4.575 | -0.399 | .020 |
| Treatment Expectancy (Depression) | -0.075 | 0.285 | -0.642 | 0.491 | .792 |
| Treatment Expectancy (Insomnia) | -0.069 | 0.276 | -0.619 | 0.480 | .803 |
| Baseline Depression Severity | -0.072 | 0.056 | -0.183 | 0.039 | .200 |
| Baseline Insomnia Severity | 0.088 | 0.126 | -0.163 | 0.339 | .488 |
| *Maintenance of Sleep Quality Improvement* |
|  Intercept | 1.585 | 2.499 | -3.392 | 6.561 | .528 |
| Gender | 0.477 | 0.756 | -1.029 | 1.983 | .530 |
| Marital Status | 0.593 | 0.855 | -1.110 | 2.297 | .490 |
| Anxiety disorder (Anxiety) | -1.974 | 0.715 | -3.399 | -0.549 | .007 |
| Treatment Expectancy (Depression) | 0.363 | 0.222 | -0.079 | 0.805 | .106 |
| Treatment Expectancy (Insomnia) | -0.410 | 0.218 | -0.845 | 0.024 | .064 |
| Baseline Depression Severity | -0.0419 | 0.0394 | -0.120 | 0.037 | .291 |
| Baseline Insomnia Severity | 0.004 | 0.091 | -0.176 | 0.185 | .961 |
| *Maintenance of Anxiety Alleviation* |
|  Intercept | 3.136 | 2.482 | -1.797 | 8.069 | .210 |
| Gender | -0.251 | 0.773 | -1.788 | 1.286 | .746 |
| Marital Status | 1.133 | 0.929 | -0.714 | 2.981 | .226 |
| Treatment Expectancy (Depression) | 0.048 | 0.212 | -0.372 | 0.468 | .821 |
| Treatment Expectancy (Insomnia) | -0.128 | 0.206 | -0.538 | 0.282 | .537 |
| Baseline Depression Severity | -0.070 | 0.041 | -0.153 | 0.012 | .094 |
| Baseline Insomnia Severity | 0.032 | 0.092 | -0.215 | 0.152 | .734 |

*Note*. Dependent variables = the difference score between Week-6 and Week-12 follow-up. Positive/larger value indicated improvement or treatment maintenance.

# **Table S10. Sleep parameters between conditions and across time (Pittsburgh Sleep Quality Index, PSQI)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Treatment group (Tx) | Within-groupeffect size1 |  | Waitlist control group (WL) | Within-groupeffect size1 |
| Sleep parameters | n | Mean ± SD | n | Mean ± SD |
| *Total Sleep Time (TST)* |  |  |  |  |  |  |
| Baseline | 157 | 5.48 ± 1.63 |  | 137 | 5.36 ± 1.78 |  |
| Week 6 follow-up | 94 | 6.45 ± 1.63 | 0.373\*\*\* | 124 | 5.18 ± 1.72 |  0.116 |
| Week 12 follow-up | 89 | 6.14 ± 1.64 |  0.250\* | 96 | 5.92 ± 1.80 | 0.257\* |
| *Time in Bed (TIB)* |  |  |  |  |  |  |
| Baseline | 157 | 8.24 ± 2.16 |  | 137 | 7.76 ± 2.12 |  |
| Week 6 follow-up | 94 | 8.29 ± 1.69 |  0.001 | 124 | 7.45 ± 2.00 |  0.155 |
| Week 12 follow-up | 89 | 7.85 ± 1.63 |  0.190 | 96 | 7.90 ± 1.67 |  0.025 |
| *Sleep Latency (SL)* |  |  |  |  |  |  |
| Baseline | 157 | 2.76 ± 2.12 |  | 137 | 2.40 ± 1.86 |  |
| Week 6 follow-up | 94 | 1.85 ± 1.67 |  0.327\*\* | 124 | 2.28 ± 2.06 |  0.040 |
| Week 12 follow-up | 89 | 1.70 ± 1.52 | 0.428\*\*\* | 96 | 1.97 ± 1.70 | 0.231\* |
| *Sleep efficiency (SE)* |  |  |  |  |  |  |
| Baseline | 157 | 68.65 ± 17.66 |  | 137 | 70.71 ± 20.32 |  |
| Week 6 follow-up | 94 | 78.55 ± 18.02 |  0.345\*\* | 124 | 71.90 ± 21.00 |  0.030 |
| Week 12 follow-up | 89 | 78.82 ± 18.22 |  0.371\*\* | 96 | 75.79 ± 20.48 | 0.213\* |

*Note*. \* *p* < .05 \*\* *p* < .01 \*\*\* *p* <.001. 1 Within-group comparison was done by paired t-test (Baseline vs. Week 6 follow-up & Baseline vs. Week 12 follow-up). Effect size are Cohen’s *d*. Total sleep time (TST) = item 4 of PSQI (in hours). Time in bed (TIB) = the difference between item 1 and item 3 in PSQI (in hours). Sleep latency (SL)=TIB-TST. Sleep efficiency (SE) = TST divided by TIB x 100%. Participants with inconsistent entries of sleep time and time in bed were excluded to avoid creating bias to the results (i.e., indicated sleep time being greater than time in bed).

# **Table S11. Demographic background and individual characteristics between completers and withdrawn at baseline (*N* = 320)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Completer (*n* = 200) | Withdrawn (*n* = 120) | *t* | *p* | χ*2* |
|  | % | Mean (SD) | % | Mean (SD) |  |  |  |
| Age (in years) |  | 27.56 (7.84) |  | 26.79 (6.05) | 0.975 | .330 |  |
| Gender |  |  |  |  |  | .028 | 4.832 |
| Female | 77 |  | 65 |  |  |  |  |
| Education |  |  |  |  |  | .131 | 5.635 |
| At least some college | 91 |  | 84 |  |  |  |  |
| Marital Status |  |  |  |  |  | 1.00 | 0.000 |
| Married | 12 |  | 12 |  |  |  |  |
| Anxiety Disorder | 64 |  | 64 |  |  | 1.00 | 0.000 |
| Treatment expectancy |  |  |  |  |  |  |  |
| Depression |  | 0.10 (2.68) |  | -0.16 (2.74) | 0.847 | .398 |  |
| Insomnia |  | 0.12 (2.79) |  | -0.20 (2.68) | 1.025 | .306 |  |
| Depressive symptoms |  | 37.09 (8.41) |  | 37.67 (7.10) | -0.659 | .510 |  |
| Insomnia severity |  | 18.18 (4.13) |  | 18.93 (4.70) | -1.441 | .151 |  |
| Poor sleep quality |  | 12.01 (2.79) |  | 12.68 (2.57) | -2.115 | .035 |  |
| Anxiety severity |  | 11.95 (3.02) |  | 12.38 (2.64) | -1.345 | .180 |  |
| Subjective health (MCS) |  | 26.79 (7.60) |  | 25.47 (6.80) | 1.611 | .108 |  |
| Subjective health (PCS) |  | 45.72 (8.87) |  | 45.95 (8.30) | -0.234 | .815 |  |

*Note*. Withdrawn = participants who have partially completed the follow-up assessments/participants who were lost to follow-up/participants who met the withdrawal conditions by what they indicated in the follow-up assessments. Completer = participants who stayed in the study, completed all follow-up assessments, and did not meet any withdrawal conditions throughout the study. Data from partial completions were also included in the analyses.