A randomized controlled trial of a smartphone-based application for the treatment of anxiety

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Abstract

Introduction: Generalized anxiety disorder (GAD) is prevalent among college students. Smartphone-based interventions may be a low-cost method of treatment. **Method:** College students with self-reported GAD were randomized to receive smartphone-based guided self-help (n = 50), or no treatment (n = 50). Post-treatment and six-month follow-up outcomes included the Depression Anxiety Stress Scales-Short Form Stress Subscale (DASS Stress), the Penn State Worry Questionnaire (PSWQ-11), and the State-Trait Anxiety Inventory-Trait (STAI-T), as well as diagnostic status assessed by the GAD-Questionnaire, 4th edition. **Results:** From pre- to post-treatment, participants who received guided self-help (vs. no treatment) experienced significantly greater reductions on the DASS Stress (d = -0.408) and a greater probability of remission from GAD (d = -0.445). There was no significant between-group difference in change on the PSWQ-11 (d = -0.208) or STAI-T (d = -0.114). From post to six-month follow-up there was no significant loss of gains on DASS stress scores (d = -0.141) and of those who had remitted, 83.3% remained remitted. Yet rates of remitted participants no longer differed significantly between conditions at follow-up (d = -0.229). **Conclusion:** Smartphone-based interventions may be efficacious in treating some aspects of GAD. Methods for improving symptom reduction and long-term outcome are discussed.

Keywords: Mobile Intervention, generalized anxiety disorder, cognitive-behavioral therapy

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Anxiety disorders comprise the most common class of mental disorder, with a lifetime prevalence of 31% in the United States (Kessler et al., 2007). College students are especially affected by anxiety, with a survey of over 400 universities documenting anxiety as the most common complaint at college counseling centers (Center for Collegiate Mental Health, 2016). Of the anxiety disorders, generalized anxiety disorder (GAD) is particularly severe, associated with a chronic relapsing-remitting course (Bruce et al., 2005), risk for physical illness (Batelaan, ten Have, van Balkom, Tuithof, & de Graaf, 2014), role impairment, and other economic costs (Hoffman, Dukes, & Wittchen, 2008). GAD prevalence estimates among college students are high, ranging from 8% to 17.5% (Farrer, Gulliver, Bennett, Fassnacht, & Griffiths, 2016; Kanuri, Taylor, Cohen, & Newman, 2015). Among college students and young adults, GAD is associated with reduced academic success, greater probability of dropping out (Eisenberg, Golberstein, & Hunt, 2009; Kessler, Foster, Saunders, & Stang, 1995), and suicidality (Boden, Fergusson, & Horwood, 2007). Thus, treatment for GAD, particularly among college students, is important for long-term individual and societal outcomes.

Despite the need for treatment, fewer than half of United States adults (43.2%; Wang et al., 2005) and college students (49.5%; Eisenberg, Hunt, Speer, & Zivin, 2011) with GAD reported having received medication, psychotherapy, or counseling in the past year. The most commonly reported reasons for not seeking treatment in the general population are preferences to deal with problems independently and low perceived need for treatment, as well as structural concerns such as cost, availability, and ease of accessing treatment (Mojtabai et al., 2011). College students report similar barriers to treatment, in addition to time and privacy concerns (Czyz, Horwitz, Eisenberg, Kramer, & King, 2013; Hunt & Eisenberg, 2010). College

counseling centers also have difficulty meeting demand for treatment from those who do want services (Watkins, Hunt, & Eisenberg, 2012). Thus, easily accessible treatments that allow recipients autonomy and do not place additional strain on treatment supply may close the treatment gap, especially among college students. Internet-delivered treatments have shown potential to meet this need, because they can be accessed privately and completed at the preferred location and pace of the user. A meta-analysis supported the efficacy of internet-delivered interventions in treating anxiety among university students (Davies, Morriss, & Glazebrook, 2014). Furthermore, in a meta-analysis of GAD trials, Andrews et al. (2018) found Hedge's *g* effect sizes ranging from 0.07 to 1.42 and averaging 0.73 in favor of internet-delivered treatments over waitlist controls, with differences significant ($p < .05$) in 7 of the 9 trials.

Although efficacious, internet-delivered treatments face obstacles to their implementation. Many internet-delivered treatments for GAD have attempted to replicate 60-minute therapy sessions and have only been accessible via desktop or laptop computer (e.g., Christensen et al., 2014). These treatments might not be acceptable to college students, who prefer short internet-based treatment sessions lasting under 10 minutes (Nitsch et al., 2016). Smartphones may be especially useful devices through which to deliver brief treatment sessions, given that nearly all college students own smartphones (Harris Poll, 2015), and interventions can be accessed in short increments throughout the day (Stolz et al., 2018). Moreover, a growing proportion (37%) of United States adults report that smartphones are the primary device used to access the internet (Pew Research Center, 2019), suggesting that smartphone compatibility could greatly increase the reach of internet-delivered treatments. Accordingly, recent years have seen a

dramatic increase in the number of smartphone-accessible mental health treatments (Van Ameringen, Turna, Khalesi, Pullia, & Patterson, 2017).

Despite their growth, few smartphone-delivered treatments have been evaluated in randomized controlled trials (Donker et al., 2013). A recent meta-analysis found a significant effect of smartphone-delivered treatments on anxiety relative to control conditions (Firth et al., 2017), though there was significant heterogeneity, suggesting that some treatments are more efficacious than others. More favorable outcomes have been observed when users proceed through a sequence of modules adapted from traditional or third-wave cognitive-behavioral therapy (CBT; Ivanova et al., 2016; Stolz et al., 2018), rather than being trained in a specific skill (e.g., cognitive bias modification; Firth et al., 2017) or receiving non-CBT interventions (e.g., interpersonal therapy; Dagöö et al., 2014; Firth et al., 2017). The self-help literature also suggests that the inclusion of a coach to monitor progress, personalize the intervention, enhance motivation, and answer questions can increase the likelihood that participants will use and benefit from the program (Newman, Szkodny, Llera, & Przeworski, 2011). Guided-self-help has demonstrated significantly larger effects on symptoms than unguided self-help (Taylor, Graham, Flatt, & Fitzsimmons-Craft, in press), and one trial of smartphone-delivered treatment for social anxiety found somewhat greater symptom reductions in a guided condition compared to an unguided condition, with a significant difference in depressive symptom reductions (Ivanova et al., 2016). Thus, guided, smartphone-accessible CBT self-help may be both an efficacious and scalable form of treatment for GAD. At colleges, where counseling centers are overburdened, providing students access to an internet program supported by an in-house coaching staff of the commercial provider represents a potentially cost-effective solution.

The goal of the current study was to conduct a pilot test of a smartphone-based guided self-help intervention for GAD. As with other smartphone anxiety treatments with empirical support (Dagöö et al., 2014; Ivanova et al., 2016; Stolz et al., 2018), the anxiety application used CBT and mindfulness techniques found to be efficacious in the treatment of anxiety. The treatment was developed specifically for smartphone use, but could also be accessed via tablet or desktop computer. Sessions were designed to take about 10 minutes. Coaches were available to motivate and prompt use, answer questions, and provide personalized help.

The study used a randomized, no-treatment controlled design. Comparing change in GAD symptoms and diagnostic status between participants receiving the intervention and participants in a no treatment control condition enabled a preliminary evaluation of efficacy by ruling out change due to regression to the mean and spontaneous remission (Comer & Kendall, 2013). We predicted that, compared to no treatment, the intervention would generate larger reductions in GAD symptoms and a higher rate of remission among college students who met diagnostic criteria for GAD. We further predicted that these effects would be maintained through a six-month follow-up period. Finally, we conducted secondary analyses to determine whether there were associations between program usage and outcome.

Method

Participants

One-hundred undergraduate participants with self-reported GAD were randomized to either the guided self-help intervention (N = 50, 82% Female, M_{age} = 21.62, Age range = 18-42, 68% Caucasian/White, 4% Arab/Middle Eastern/Arab American, 16% Hispanic/Latino, 20% Asian/Asian American, 2% Asian Indian, 2% Pacific Islander) or no treatment (N = 50, 72% Female, M_{age} = 21.18, Age range = 18-37, 62% Caucasian/White, 12% African American/Black,

2% American Indian/Alaska Native, 2% Arab/Middle Eastern/Arab American, 10% Hispanic/Latino, 10% Asian/Asian American, 8% Asian Indian, 2% Other). Note that, although all participants met full criteria for GAD at the pre-screen, eight participants ($N = 3$ in intervention; $N = 5$ in control) no longer met full criteria by the baseline assessment. Because these participants still endorsed partial GAD criteria, they were retained in the study and all analyses unless otherwise noted.

Procedure

Please see Figure 1 for a summary of recruitment, randomization, and outcome assessment. Participants were recruited from flyers posted around Penn State University and Stanford University campuses and online bulletin boards for recruitment. The flyers invited individuals experiencing excessive worry, anxiety, or stress to participate in a study on a phone application and included links and QR codes to access a Qualtrics screening survey. The survey obtained participants' informed consent, and then screened them for full Diagnostic and Statistical Manual – Fifth Edition (DSM-5; American Psychiatric Association, 2013) criteria for GAD based on the Generalized Anxiety Disorder Questionnaire for DSM-IV (Newman et al., 2002). Participants who met full diagnostic criteria for GAD were then sent a link to complete the pre-assessment. Those who completed the pre-assessment were randomly assigned to the intervention group or a no treatment control group. Adaptive biased-coin randomization, which promotes even group sizes, was administered automatically via Qualtrics's built-in randomizer, concealing treatment allocation from the researchers. The intervention group was directed to the mobile program's treatment portal (see below for details). Participants were then contacted via email three months later for the post assessment, and six months after this for the six-month

follow-up assessment. Participants received up to $30 in Amazon gift cards for their completion of baseline, post, and follow-up surveys ($10 per survey).

Measures

Generalized Anxiety Disorder Questionnaire for DSM-IV. The Generalized Anxiety Disorder Questionnaire for DSM-IV (GAD-Q-IV; Newman et al., 2002) assesses the diagnostic criteria for GAD as stated in the DSM-5 (American Psychiatric Association, 2013). Participants met criteria for GAD if they endorsed item one or two, as well as item six, and listed three or more worry topics in item five (Criterion A: excessive worry about a number of topics more days than not for at least six months), endorsed item three or four (Criterion B: difficulty controlling worry), endorsed three or more somatic symptoms in item seven (Criterion C: associated somatic symptoms), and provided ratings of four or greater (out of eight) on item eight or nine (Criterion D: clinically significant distress or impairment caused by worry and associated symptoms).

Depression Anxiety Stress Scales-Short Form. The Depression Anxiety Stress Scales-Short Form (DASS; Antony, Bieling, Cox, Enns, & Swinson, 1998) is a 21-item self-report measure of depression, anxiety, and stress. We used only the DASS Stress subscale, which captures symptoms of anxiety, such as over-arousal, inability to relax, and feeling nervous or fidgety. Individuals with generalized anxiety disorder (GAD) scored significantly higher on the DASS Stress subscale than those with panic disorder, social phobia, and specific phobia (Brown, Chorpita, Korotitsch, & Barlow, 1997), suggesting that the scale measures tension characteristic of GAD. The scale has been used in several GAD treatment studies as a primary outcome measure (Hayes-Skelton, Calloway, Roemer, & Orsillo, 2015; Hayes-Skelton, Roemer, & Orsillo, 2013). Internal consistencies across the three study waves were .780, .835, and .851.

Penn State Worry Questionnaire. The Penn State Worry Questionnaire (PSWQ; Meyer,

Miller, Metzger, & Borkovec, 1990) is a 16-item self-report measure of worry with strong convergent and divergent validity (Brown, Antony, & Barlow, 1992). Hazlett-Stevens, Ullman, and Craske (2004) found that the scale's five reverse-scored items comprised a separate method factor with lower convergent validity than the remaining items, and that scoring only the 11 straightforwardly worded items was more sensitive in classifying individuals with GAD than the entire 16-item scale. Therefore, we only scored the 11 straightforwardly worded items (PSWQ-11). Internal consistencies across the three study waves were .845, .888, and .920.

State-Trait Anxiety Inventory-Trait Version. The State-Trait Anxiety Inventory-Trait Version (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) is a 20-item self-report measure of trait anxiety with strong factorial, convergent and discriminant validity (Spielberger et al., 1983). The scale includes item content explicitly assessing worry and bothersome thoughts, as well as physical problems such as restlessness, suggesting that it is a strong overall measure of GAD severity. Internal consistencies across the three study waves were .887, .912, and .917.

Treatment use characteristics. Among participants in intervention group, we recorded: (1) the number of sessions completed by the user, (2) the number of messages sent from the coach to the user, (3) the number of messages sent from the user to the coach, (4) the number of times the user visited the mobile program portal, and (5) the total time (in seconds) spent using the mobile program.

Mobile Program Guided Self-Help Intervention

The guided self-help mobile program was a CBT intervention accessible via any internet-enabled computer, mobile phone, or tablet. The intervention was adapted from an evidence-based psychotherapy protocol for GAD (Newman, Consoli, & Taylor, 1999; Newman,

Przeworski, Consoli, & Taylor, 2014; Newman, 1999). Content was divided into 8 units, broken into 40 10-minute sessions. The units covered an introduction to anxiety, automatic thoughts, cognitive reframing, introduction to behavior change, imaginal exposure, situational exposure, mindfulness, and habit formation. The program used both cognitive (e.g., cognitive restructuring) and behavioral (e.g., applied relaxation) techniques. Each session included psychoeducational lessons (e.g., information about logical errors), tools for skill practice (e.g., identifying one's own logical errors), and regular anxiety check-ins. Users could access one new session per day, and each new session became available after the completion of the previous session. Once unlocked, sessions remained available during the entire course of the intervention. The program prompted users to complete sessions and practice techniques, and users could also set their own reminders to use the program. The mobile program complied with the United States Health Insurance Portability and Accountability Act (HIPAA). The program was provided by Lantern, a for-profit company that is no longer in business.

Coaching. Lantern trained and provided the coaches for the program. The coach's role included supporting and enhancing user motivation, monitoring progress, facilitating goal setting and offering accountability, providing feedback on technique usage and encouraging practice, answering user questions, and monitoring for/responding to clinical risk. Communication with users was primarily via two-way, asynchronous messaging (i.e., users and coaches could send or respond to messages at any time, without having to be simultaneously logged in). The program also offered optional, supplementary phone calls to enhance goal setting. Coach messaging was done via a web-based "dashboard," and delivered to users within the mobile application. The dashboard allowed coaches to aggregate across population-level data to efficiently monitor multiple users at one time. Messages were mostly unscripted to allow for personalization,

although some common situations (especially risk-related) were guided by editable templates. Messaging was intended to reinforce key intervention messages, support individualized application of techniques, and promote engagement with content. Messages may have included: providing feedback on technique completion; helping users apply program content to personal goals; and engaging motivational interviewing techniques such as affirmation and open-ended questioning. Coaches were selected by Lantern and had various educational backgrounds, including clinical psychology, marriage and family therapy, and health coaching. All had at least a bachelor's degree, and most had advanced degrees. Coaches completed a three- to five-day training in CBT, motivational interviewing, risk management, and the Lantern mobile program platform. Each coach was paired with a supervisor who monitored their coaching and provided weekly individual supervision. A rotating on-call supervisor was also available at all times to consult; at no time was a coach working without access to immediate support.

Planned Analyses

Symptom reduction as measured by the DASS Stress, PSWQ-11, and STAI-T was analyzed with multilevel models using robust estimation (Koller, 2016). These models retain all of the traditional positive properties of multilevel models (i.e. accounting for non-independence of errors within repeated measures). Notably, robust estimators account for the effect of outliers without altering or transforming the data (Koller, 2016). Altering or transforming the data has notable downsides including changing the scale of the observed data and/or censoring observed values entirely (Kwak & Kim, 2017). Fixed effects in all multilevel models included an intercept, pre-post time, post-follow-up time, treatment condition, the two-way interaction between pre-post time and treatment condition, and the two-way interaction between post-follow-up time and the treatment condition. The random effects included intercepts nested within

individuals, which reflected person-specific deviations from the fixed intercept estimated for the whole sample and accounted for the non-independence of observations due to repeated measures.

To evaluate the intervention's effect on remission from GAD, we examined the proportion of participants in each condition who met full diagnostic criteria for GAD as measured by the GAD-Q-IV at post-treatment and follow-up using logistic regression. Because some participants did not meet full criteria for GAD at pre-treatment, we conducted these analyses both in the full sample and again in the sample excluding participants who did not meet full diagnostic criteria at pre-treatment. Finally, to examine the durability of GAD remission in the intervention group, we calculated the percentage of remitted intervention participants who relapsed at follow-up.

In additional exploratory analyses, we tested whether aspects of treatment usage (number of sessions completed on the platform, messages sent to coach, messages received from coach, number of visits to the platform, and total time spent on the platform) predicted symptom change from pre to post and post to follow-up. Models included orthogonal linear and quadratic effects for each usage variable, as well as their interactions with pre-post time and post-follow-up time. Each usage variable was tested in a separate model. To reduce the number of statistical tests in these exploratory analyses, we created a composite symptom severity index using the percent of maximum score technique recommended by Cohen, Cohen, Aiken, and West (1999). Specifically, for the DASS Stress, PSWQ-11, and STAI-T, we calculated the observed score divided by maximum possible score, and summed each percentage score into a single variable.

Missing data on all variables were handled with multilevel multiple imputation using predictive mean matching, which accommodates nested data under a range of distributions (Grund, Lüdtke, & Robitzsch, 2018; Horton & Kleinman, 2007). We used 40 imputations (as recommended by Graham, 2009). Cohen's *d* was calculated from *Z* statistics using the methods

outlined by (Rosenthal & DiMatteo, 2001).

Results

Descriptive Statistics

Please see Table 1 for descriptive statistics on symptoms and GAD status across conditions and time points, as well as treatment usage within the intervention group. There were no significant differences between conditions in gender, ethnicity, baseline symptoms, or baseline GAD status (all Zs < 1.960, ps > .050, ds < .400). Post- and follow-up assessment completion statistics are shown in Figure 1. Compared to those who did not complete post- and follow-up assessments, those who completed all assessments were more likely to meet full criteria for GAD at pre-treatment (β = 2.773, SE = 1.093, Z = 2.537, p = 0.011, d = 0.525), but did not differ significantly in terms of treatment condition, gender, ethnicity, or continuous symptom measures (all Zs < 1.960, ps > .050, ds < .400). Within the intervention group, there were 33 total coaches with an average of 1.424 users (SD = 0.936) per coach.

Symptom Change

Please see Table 2 for complete results from symptom change analyses. In analyses of DASS Stress scores, there was a significant two-way interaction between pre-post time and treatment condition (β = -3.332, p = .046, d = -0.408), as well as a non-significant two-way interaction between post-follow-up time and treatment condition (β = 0.089, p = .964, d = 0.009). Simple slopes analyses suggested that the intervention group experienced a significant decline in DASS Stress scores from pre to post and no further change from post to six-month follow-up, whereas the control group experienced a significant but weaker decline in DASS Stress scores from pre to post and no further change from post to follow-up. There were no significant interactions between pre-post time or post-follow-up time and treatment condition in analyses of

PSWQ-11 scores (pre to post: β = -1.422, p = .300, d = -0.208; post to follow-up: β = 1.502, p = .330, d = 0.196) or STAI-T scores (pre to post: β = -0.979, p = .569, d = -0.114; post to follow-up: β = 0.734, p = .702, d = 0.077). Simple slopes analyses revealed that both groups experienced significant reductions from pre to post on PSWQ-11 and STAI-T scores, and no significant further change from post to follow-up on PSWQ-11 or STAI-T scores. Thus, the intervention group experienced significant and large-effect reductions in all symptom measures during the treatment period, though only reductions in DASS Stress scores were greater than those experienced by the control group. Neither group experienced significant symptom change across the six-month follow-up period.

Remission from GAD

At post-treatment, a significantly smaller proportion of participants in the intervention condition met full criteria for GAD (48.7%) than in the control condition (74.4%; β = -0.946, SE = 0.458, Z = -2.065, p = .039, -d = 0.422). This difference remained statistically significant when only considering participants who met full GAD diagnostic criteria at pre-treatment (51.4% vs. 75.6%; β = -1.057, SE = 0.486, Z = -2.173, p = .030, d = -0.445). Thus, during treatment, intervention participants were more likely to remit from GAD than control participants. However, the proportion of participants meeting full GAD diagnostic criteria did not differ at follow-up (full sample: 50.0% vs. 61.1%; β = -0.431, SE = 0.474, Z = -0.909, p = .363, d = -0.182; among participants who met full diagnostic criteria at pre-treatment: 50.0% vs. 64.7%; β = -0.570, SE = 0.501, Z = -1.138, p = .255, d = -0.229). Among the 18 participants in the intervention condition who experienced remission between pre-treatment and post-treatment, 15 (83.3%) participants remained remitted at follow-up.

Usage Analyses

Please see Table 3 for results from usage analyses and Supplemental Figure 1 for a scatterplot of the relationship between sessions completed and symptom change. Within each time point, all symptom measures were at least moderately correlated (*r*s from .479 to .739, all *p*s < .001), supporting the construction of the symptom composite. There were no significant linear or quadratic associations between any usage variable and change in the symptom composite from pre to post-treatment or from post-treatment to follow-up. Thus, we did not find any linear or nonlinear associations between treatment usage and the degree or durability of symptom change.

Discussion

This pilot trial provided partial support for the efficacy of smartphone-accessible guided self-help in treating GAD. On the DASS Stress subscale, students in the intervention condition (vs. no treatment) experienced significantly greater change from pre- to post-treatment with no significant loss in gains from post-treatment to 6 month follow-up. Moreover, a greater proportion of participants in the intervention group experienced remission from GAD (74.4% vs. 48.7%) by the end of treatment, and 83.3% of treated individuals in remission remained remitted at follow-up. At the same time, from pre- to post-treatment, reductions in worry and trait anxiety were not significantly greater in the treatment group than in the no treatment group. Furthermore, although there was little evidence of relapse among intervention participants who achieved remission, the proportion of remitted participants did not differ significantly across conditions at follow-up. Thus, smartphone-accessible guided self-help may be efficacious in reducing tension-related symptoms of GAD, yet additional work is required to identify methods of targeting worry-related symptoms and promoting long-term continued improvement.

Support for the intervention's efficacy, as suggested by DASS Stress reductions and remission from GAD at post-treatment, is consistent with prior trials of internet-delivered

interventions for GAD (Andrews et al., 2018). The DASS Stress primarily assesses tension and difficulty relaxing. A major focus of the mobile program was to teach self-monitoring and relaxation techniques that promote early recognition of anxiety and deployment of coping skills, as in traditional applied relaxation therapy for GAD (e.g., Borkovec & Costello, 1993). Notably, applied relaxation therapy often incorporates a diary for the identification of anxiety cues, and the intervention's smartphone accessibility and frequent anxiety check-ins may have served a similar function. Combined with training in relaxation techniques, these features might have helped users recognize and alleviate their anxiety in real time, contributing to the intervention's effects on DASS Stress scores and GAD diagnostic status from pre- to post-treatment.

Despite some evidence for the program's efficacy, the intervention group did not demonstrate significantly greater reductions than the control group on the PSWQ-11 or STAI-T. Notably, both of these measures have item content assessing worry, suggesting that the program might not have been effective in teaching cognitive therapy techniques (e.g., cognitive restructuring) that are particularly effective in reducing worry (Hanrahan, Field, Jones, & Davey, 2013) but complex to acquire. This shortcoming could have arisen in part from technical aspects of the program, which only allowed users to access new intervention content if they completed the preceding session. Whereas early intervention content focused primarily on self-monitoring and relaxation skills that could have accounted for the DASS Stress reductions, more complex cognitive skills were not introduced until later in the program. Users who discontinued treatment prematurely thus received limited instruction on methods for challenging and disengaging from worrisome thoughts. Allowing earlier access to cognitive therapy content might have improved the intervention's effects on the PSWQ-11 or the STAI-T. A better understanding of the optimal timing of intervention content could be efficiently addressed in future research using an adaptive

trial design that allows optimization of the intervention over stages of data collection (Finucane, Martinez, & Cody, 2018).

Beyond the structure of the intervention, even users who were exposed to cognitive techniques could have had difficulty learning these skills in the implemented app-based format. Consistent with this interpretation, in a randomized controlled trial comparing guided self-help to face-to-face CBT for panic disorder, guided self-help users had significantly lower therapist-rated client understanding of therapeutic content (Kiropoulos et al., 2008). In this intervention, coaches were required to respond to messages within 24 hours. More frequent synchronous interaction may be necessary for coaches to deliver cognitive interventions (e.g., Socratic questioning; Braun, Strunk, Sasso, & Cooper, 2015) that help users grasp challenging CBT concepts and apply them to their own worries. Other evidence suggests that worry outcome monitoring can also be adapted to an efficacious self-help format (LaFreniere & Newman, 2016). By tracking evidence contrary to worrisome predictions, users may become better equipped to challenge apprehensive expectations and curb their worries (LaFreniere & Newman, 2020). Thus, more intensive interaction with therapists or greater use of evidence from daily life could improve the efficacy of smartphone-accessible guided self-help in worry reduction.

At six-month follow-up, differences between the treatment and control group in GAD status were no longer significant. Although this suggests some loss of gains, simple slope analyses showed that for those who received the intervention, there was no significant change in DASS stress scores from post-treatment to follow-up, and 83.3% of treated participants who had remitted from GAD status at post-treatment were still remitted at follow-up. Thus, treatment effects were maintained for a large majority of those remitted at post-treatment. Given that college counseling centers commonly provide time-limited interventions to minimize strain on

provider supply (Smith et al., 2007), and rates of sustained remission may be low following low-intensity psychotherapy for anxiety and depression (e.g., as low as 60% remaining remitted at six-month follow-up; Ali et al., 2017), these results suggest that smartphone-delivered interventions hold promise as scalable treatments with some durability of effects.

Our failure to find superior long-term outcomes in GAD status compared to no treatment differs from prior literature documenting significant differences between computer-based intervention and control conditions in anxiety symptoms at follow-up assessments (Andrews et al., 2018). In fact, some prior computer-based treatment studies have even documented continued symptom reduction after concluding the intervention (e.g., Andersson et al., 2012). Because prior computer-based treatments have more closely resembled traditional psychotherapy (e.g., content delivered in longer weekly treatment sessions), it is possible that their structured format led users to habitually practice intervention skills even after the end of the intervention. Therefore, providing greater guidance with respect to when and for how long to practice each technique from the program could have improved the intervention's long-term efficacy.

In line with college students' self-reported preference for shorter treatment sessions (Nitsch et al., 2016), the average duration of each visit to the platform was just over five minutes. However, total usage was somewhat low, with users averaging 2.76 hours on the treatment platform. It is possible that combining longer lessons and brief exercises (e.g., Ivanova et al., 2016; Stolz et al., 2018) would have promoted usage by providing more varied content and supporting habit formation. It should be noted that treatment usage did not predict symptom change in the present trial, and the association between technology-based intervention usage and outcome is often complex (e.g., Donkin et al., 2013). Whereas some users could have benefited from consistent and long-term usage of the intervention, others might have stopped accessing the

intervention after experiencing symptom reductions (i.e., a "good enough" effect; Barkham et al., 2006). Future trials should incorporate continuous symptom assessment to examine co-occurring trajectories of treatment usage and anxiety severity.

Limitations of the study include the absence of an “active” or placebo treatment control group, which is necessary to provide a more stringent test of efficacy by controlling for nonspecific factors such as outcome expectancy. Comparing smartphone-delivered guided self-help to in-person CBT is also necessary to fully examine the optimal clinical application of interventions such as Lantern. For example, although guided self-help programs are generally less resource-intensive than in-person psychotherapy, the pretreatment-to-posttreatment symptom change effect sizes in the treatment condition were smaller than those generally observed in face-to-face CBT for GAD (Bandelow et al., 2015). Face-to-face CBT for anxiety has also demonstrated other benefits not observed in the present study, such as continued improvement after terminating treatment (Bandelow et al., 2018). Thus, comparing the efficacy and cost-effectiveness smartphone-accessible guided self-help to existing GAD treatments is an important direction for future research. Additionally, although the self-report measure used to assess GAD status measures all principal criteria for the disorder, diagnostic interviewing would provide greater certainty in determining clinical severity and ruling out alternative diagnoses. Finally, including continuous symptom assessment throughout the intervention would have facilitated more sophisticated treatment usage analysis as well as a better understanding of the course of GAD severity over time.

In conclusion, this study provides partial and preliminary support for the efficacy of smartphone-based, guided self-help for treating some GAD symptoms among college students. Further efforts to optimize and test smartphone-accessible guided self-help interventions are

critical given the high prevalence of GAD among college students (Farrer et al., 2016; Kanuri et al., 2015), the importance of intervention for student achievement, health, and economic outcomes (Boden et al., 2007; Eisenberg et al., 2009; Hoffman et al., 2008; Kessler et al., 1995), and the need for interventions that do not further burden university counseling resources (Watkins et al., 2012). Additional research to improve intervention effects on worry-related symptoms, promote long-term anxiety reduction, and compare smartphone-accessible interventions to existing treatments will inform the optimal use of technology to treat GAD among college students.

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Statement of Ethics

This research was approved by the institutional review boards of all participating universities and all participants consented to their participation.

Disclosure of Interest

The fourth author of this manuscript was employed by Lantern (the guided self-help program used here) when this study was conducted but has no current financial ties to the company as she left her employment there. She was not involved in consenting participants, collection of outcome data, or data analysis of any sort. The first and last author were unpaid consultants for Lantern. After data collection was completed, Lantern ceased operations and thus nobody involved in the study has any financial interest in Lantern.

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Author Contributions

Michelle G. Newman, Nicholas C. Jacobson, and C. Barr Taylor were involved in the design of the study, recruitment of participants, running of the study and writing of the manuscript. Megan Jones Bell contributed to the design of the study and oversaw the integrity of the website. Gavin N. Rackoff and Nicholas C. Jacobson conducted data analysis and contributed to writing of the manuscript.

References

Ali, S., Rhodes, L., Moreea, O., McMillan, D., Gilbody, S., Leach, C., . . . Delgadillo, J. (2017). How durable is the effect of low intensity CBT for depression and anxiety? Remission and relapse in a longitudinal cohort study. *Behaviour Research and Therapy*, *94*, 1-8. doi:10.1016/j.brat.2017.04.006

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (DSM-5; 5th ed.). Arlington, Virginia: American Psychiatric Association. doi:10.1176/appi.books.9780890425596

Andersson, G., Paxling, B., Roch-Norlund, P., Ostman, G., Norgren, A., Almlov, J., . . . Silverberg, F. (2012). Internet-based psychodynamic versus cognitive behavioral guided self-help for generalized anxiety disorder: A randomized controlled trial. *Psychotherapy and Psychosomatics*, *81*, 344-355. doi:10.1159/000339371

Andrews, G., Basu, A., Cuijpers, P., Craske, M. G., McEvoy, P., English, C. L., & Newby, J. M. (2018). Computer therapy for the anxiety and depression disorders is effective, acceptable and practical health care: An updated meta-analysis. *Journal of Anxiety Disorders*, *55*, 70-78. doi:10.1016/j.janxdis.2018.01.001.

Antony, M. M., Bieling, P. J., Cox, B. J., Enns, M. W., & Swinson, R. P. (1998). Psychometric properties of the 42-item and 21-item versions of the Depression Anxiety Stress Scales in clinical groups and a community sample. *Psychological Assessment*, *10*, 176-181. doi:10.1037/1040-3590.10.2.176

Bandelow, B., Sagebiel, A., Belz, M., Görlich, Y., Michaelis, S., & Wedekind, D. (2018). Enduring effects of psychological treatments for anxiety disorders: Meta-analysis of

follow-up studies. *The British Journal of Psychiatry*, *212*, 333-338. doi:10.1192/bjp.2018.49

Bandelow, B., Reitt, M., Rover, C., Michaelis, S., Gorlich, Y., & Wedekind, D. (2015). Efficacy of treatments for anxiety disorders: A meta-analysis. *International Clinical Psychopharmacology*, *30*, 183-192. doi:10.1097/yic.0000000000000078

Barkham, M., Connell, J., Stiles, W. B., Miles, J. N., Margison, F., Evans, C., & Mellor-Clark, J. (2006). Dose-effect relations and responsive regulation of treatment duration: The good enough level. *Journal of Consulting and Clinical Psychology*, *74*, 160-167. doi:10.1037/0022-006X.74.1.160

Batelaan, N. M., ten Have, M., van Balkom, A. J. L. M., Tuithof, M., & de Graaf, R. (2014). Anxiety disorders and onset of cardiovascular disease: The differential impact of panic, phobias and worry. *Journal of Anxiety Disorders*, *28*, 252-258. doi:10.1016/j.janxdis.2013.12.003

Boden, J. M., Fergusson, D. M., & Horwood, L. J. (2007). Anxiety disorders and suicidal behaviours in adolescence and young adulthood: Findings from a longitudinal study. *Psychological Medicine*, *37*, 431-440. doi:10.1017 /S0033291706009147

Borkovec, T. D., & Costello, E. (1993). Efficacy of applied relaxation and cognitive-behavioral therapy in the treatment of generalized anxiety disorder. *Journal of Consulting and Clinical Psychology*, *61*, 611-619. doi:10.1037/0022-006X .61.4.611

Braun, J. D., Strunk, D. R., Sasso, K. E., & Cooper, A. A. (2015). Therapist use of socratic questioning predicts session-to- session symptom change in cognitive therapy for depression. *Behaviour Research and Therapy*, *70*, 32-37. doi:10.1016/j.brat.2015.05.004

Brown, T. A., Antony, M. M., & Barlow, D. H. (1992). Psychometric properties of the Penn State Worry Questionnaire in a clinical anxiety disorders sample. *Behaviour Research and Therapy*, *30*, 33-37. doi:10.1016/0005-7967(92)90093-V

Bruce, S. E., Yonkers, K. A., Otto, M. W., Eisen, J. L., Weisberg, R. B., Pagano, M., . . . Keller, M. B. (2005). Influence of psychiatric comorbidity on recovery and recurrence in generalized anxiety disorder, social phobia, and panic disorder: A 12-year prospective study. *American Journal of Psychiatry*, *162*, 1179-1187. doi:10.1176/appi.ajp.162.6.1179

Center for Collegiate Mental Health. (2016). Center for Collegiate Mental Health (CCMH) 2016 Annual Report. Retrieved July, 2017, from https://sites.psu.edu/ccmh/files/2017/01/2016-Annual-Report-FINAL_2016_01_09-1gc2hj6.pdf

Christensen, H., Mackinnon, A. J., Batterham, P. J., O'Dea, B., Guastella, A. J., Griffiths, K. M., . . . Hickie, I. (2014). The effectiveness of an online e-health application compared to attention placebo or Sertraline in the treatment of generalised anxiety disorder. *Internet Interventions*, *1*, 169-174. doi:10.1016/j.invent.2014.08.002

Cohen, P., Cohen, J., Aiken, L. S., & West, S. G. (1999). The problem of units and the circumstance for POMP. *Multivariate Behavioral Research*, *34*, 315-346. doi:10.1207/S15327906MBR3403_2

Comer, J. S., & Kendall, P. C. (2013). Methodology, Design, and Evaluation in Psychotherapy Research. In M. J. Lambert & A. E. Bergin (Eds.), *Bergin and Garfield's Handbook of Psychotherapy and Behavior Change* (pp. 21-48). Hoboken: John Wiley & Sons.

Czyz, E. K., Horwitz, A. G., Eisenberg, D., Kramer, A., & King, C. A. (2013). Self-reported barriers to professional help seeking among college students at elevated risk for suicide. *Journal of American College Health*, *61*, 398-406. doi:10.1080/07448481.2013.820731

Dagöö, J., Asplund, R. P., Bsenko, H. A., Hjerling, S., Holmberg, A., Westh, S., . . . Andersson, G. (2014). Cognitive behavior therapy versus interpersonal psychotherapy for social anxiety disorder delivered via smartphone and computer: A randomized controlled trial. *Journal of Anxiety Disorders*, *28*, 410-417. doi:10.1016/j.janxdis.2014.02.003

Davies, E. B., Morriss, R., & Glazebrook, C. (2014). Computer-delivered and web-based interventions to improve depression, anxiety, and psychological well-being of university students: A systematic review and meta-analysis. *J Med Internet Res.*, *16*, e130. doi: 110.2196/jmir.3142. doi:10.2196/jmir.3142

Donker, T., Petrie, K., Proudfoot, J., Clarke, J., Birch, M. R., & Christensen, H. (2013). Smartphones for smarter delivery of mental health programs: A systematic review. *Journal of Medical Internet Research*, *15*, e247. doi:10.2196/jmir.2791

Donkin, L., Hickie, I. B., Christensen, H., Naismith, S. L., Neal, B., Cockayne, N. L., & Glozier, N. (2013). Rethinking the dose-response relationship between usage and outcome in an online intervention for depression: Randomized controlled trial. *Journal of Medical Internet Research*, *15*, e231. doi:10.2196/jmir.2771

Eisenberg, D., Golberstein, E., & Hunt, J. B. (2009). Mental health and academic success in college. *B. E. Journal of Econonmics Analysis & Policy*, *9*, Article 40. doi:10.2202/1935-1682.2191

Eisenberg, D., Hunt, J., Speer, N., & Zivin, K. (2011). Mental health service utilization among college students in the United States. *Journal of Nervous and Mental Disease*, *199*, 301-308. doi:10.1097/NMD.0b013e3182175123

Farrer, L. M., Gulliver, A., Bennett, K., Fassnacht, D. B., & Griffiths, K. M. (2016). Demographic and psychosocial predictors of major depression and generalised anxiety

disorder in Australian university students. *BMC Psychiatry*, *16*, 241. doi:10.1186/s12888-016-0961-z

Finucane, M. M., Martinez, I., & Cody, S. (2018). What Works for Whom? A Bayesian Approach to Channeling Big Data Streams for Public Program Evaluation. *American Journal of Evaluation*, *39*, 109-122. doi:10.1177/1098214017737173

Firth, J., Torous, J., Nicholas, J., Carney, R., Rosenbaum, S., & Sarris, J. (2017). Can smartphone mental health interventions reduce symptoms of anxiety? A meta-analysis of randomized controlled trials. *Journal of Affective Disorders*, *218*, 15-22. doi:10.1016/j.jad.2017.04.046

Graham, J. W. (2009). Missing data analysis: Making it work in the real world. *Annual Review of Psychology*, *60*, 549–576. doi:10.1146/annurev.psych.58.110405.085530

Grund, S., Lüdtke, O., & Robitzsch, A. (2018). Multiple imputation of missing data for multilevel models. *Organizational Research Methods*, *21*, 111-149. doi:10.1177/1094428117703686

Hanrahan, F., Field, A. P., Jones, F. W., & Davey, G. C. L. (2013). A meta-analysis of cognitive therapy for worry in generalized anxiety disorder. *Clinical Psychology Review*, *33*, 120-132. doi:10.1016/j.cpr.2012.10.008

Harris Poll. (2015). Pearson student mobile device survey 2015: National report: College students. http://www.pearsoned.com/wp-content/uploads/2015-Pearson-Student-Mobile-Device-Survey-College.pdf

Hayes-Skelton, S. A., Calloway, A., Roemer, L., & Orsillo, S. M. (2015). Decentering as a potential common mechanism across two therapies for generalized anxiety disorder. *Journal of Consulting and Clinical Psychology*, *83*, 395-404. doi:10.1037/a0038305

Hayes-Skelton, S. A., Roemer, L., & Orsillo, S. M. (2013). A randomized clinical trial comparing an acceptance-based behavior therapy to applied relaxation for generalized anxiety disorder. *Journal of Consulting and Clinical Psychology*, *81*, 761-773. doi:10.1037/a0032871

Hazlett-Stevens, H., Ullman, J. B., & Craske, M. G. (2004). Factor structure of the Penn State Worry Questionnaire: Examination of a method factor. *Assessment*, *11*, 361-370. doi:10.1177/1073191104269872

Hoffman, D. L., Dukes, E. M., & Wittchen, H.-U. (2008). Human and economic burden of generalized anxiety disorder. *Depression and Anxiety*, *25*, 72-90. doi:10.1002/da.20257

Horton, N. J., & Kleinman, K. P. (2007). Much ado about nothing: A comparison of missing data methods and software to fit incomplete data regression models. *American Statistician*, *61*, 79-90. doi:10.1198/000313007X172556

Hunt, J., & Eisenberg, D. (2010). Mental health problems and help-seeking behavior among college students. *Journal of Adolescent Health*, *46*, 3-10. doi:10.1016/j.jadohealth.2009.08.008

Ivanova, E., Lindner, P., Ly, K. H., Dahlin, M., Vernmark, K., Andersson, G., & Carlbring, P. (2016). Guided and unguided Acceptance and Commitment Therapy for social anxiety disorder and/or panic disorder provided via the Internet and a smartphone application: A randomized controlled trial. *Journal of Anxiety Disorders*, *44*, 27-35. doi:10.1016/j.janxdis.2016.09.012

Kanuri, N., Taylor, C. B., Cohen, J. M., & Newman, M. G. (2015). Classification models for subthreshold generalized anxiety disorder in a college population: Implications for prevention. *Journal of Anxiety Disorders*, *34*, 43-52. doi:10.1016/j.janxdis.2015.05.011

Kessler, R. C., Angermeyer, M., Anthony, J. C., de Graaf, R., Demyttenaere, K., Gasquet, I., . . . Üstün, T. B. (2007). Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative. *World Psychiatry*, *6*, 168-176.

Kessler, R. C., Foster, C. L., Saunders, W. B., & Stang, P. E. (1995). Social consequences of psychiatric disorders, I: Educational attainment. *American Journal of Psychiatry*, *152*, 1026-1032. doi:10.1176/ajp.152.7.1026

Kiropoulos, L. A., Klein, B., Austin, D. W., Gilson, K., Pier, C., Mitchell, J., & Ciechomski, L. (2008). Is internet-based CBT for panic disorder and agoraphobia as effective as face-to-face CBT? *Journal of Anxiety Disorders*, *22*, 1273-1284. doi:10.1016/j.janxdis.2008.01.008

Koller, M. (2016). robustlmm: An R Package for Robust Estimation of Linear Mixed-Effects Models. *2016*, *75*, 24. doi:10.18637/jss.v075.i06

Kwak, S. K., & Kim, J. H. (2017). Statistical data preparation: Management of missing values and outliers. *Korean Journal of Anesthesiology*, *70*, 407-411. doi:10.4097/kjae.2017.70.4.407

LaFreniere, L. S., & Newman, M. G. (2016). A brief ecological momentary intervention for generalized anxiety disorder: A randomized controlled trial of the worry outcome journal. *Depression and Anxiety*, *33*, 829-839. doi:10.1002/da.22507

LaFreniere, L. S., & Newman, M. G. (2020). Exposing worry's deceit: Percentage of untrue worries in generalized anxiety disorder treatment. *Behavior Therapy*, *51*, 413-423. doi:10.1016/j.beth.2019.07.003

Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy*, *28*, 487-495. doi:10.1016/0005-7967(90)90135-6

Mojtabai, R., Olfson, M., Sampson, N. A., Jin, R., Druss, B., Wang, P. S., . . . Kessler, R. C. (2011). Barriers to mental health treatment: Results from the National Comorbidity Survey Replication. *Psychological Medicine*, *41*, 1751-1761. doi:10.1017/S0033291710002291

Newman, M. G., Zuellig, A. R., Kachin, K. E., Constantino, M. J., Przeworski, A., Erickson, T., & Cashman-McGrath, L. (2002). Preliminary reliability and validity of the Generalized Anxiety Disorder Questionnaire-IV: A revised self-report diagnostic measure of generalized anxiety disorder. *Behavior Therapy*, *33*, 215-233. doi:10.1016/S0005-7894(02)80026-0

Newman, M. G., Szkodny, L. E., Llera, S. J., & Przeworski, A. (2011). A review of technology-assisted self-help and minimal contact therapies for anxiety and depression: Is human contact necessary for therapeutic efficacy? *Clinical Psychology Review*, *31*, 89-103. doi:10.1016/j.cpr.2010.09.008

Newman, M. G., Consoli, A. J., & Taylor, C. B. (1999). A palmtop computer program for the treatment of generalized anxiety disorder. *Behavior Modification*, *23*, 597-619. doi:10.1177/0145445599234005

Newman, M. G., Przeworski, A., Consoli, A. J., & Taylor, C. B. (2014). A randomized controlled trial of ecological momentary intervention plus brief group therapy for generalized anxiety disorder. *Psychotherapy: Theory, Research, Practice, Training*, *51*, 198-206. doi:10.1037/a0032519

Newman, M. G. (1999). The clinical use of palmtop computers in the treatment of generalized anxiety disorder. *Cognitive and Behavioral Practice*, *6*, 222-234. doi:10.1016/S1077-7229(99)80080-7

Nitsch, M., Dimopoulos, C. N., Flaschberger, E., Saffran, K., Kruger, J. F., Garlock, L., . . . Jones, M. (2016). A guided online and mobile self-help program for individuals with eating disorders: An iterative engagement and usability study. *Journal of Medical Internet Research*, *18*, e7. doi:10.2196/jmir.4972

Pew Research Center (Producer). (2019). Mobile technology and home broadband 2019. Retrieved from https://www.pewresearch.org/internet/wp-content/uploads/sites/9/2019/06/PI_2019.06.13_Mobile-Technology-and-Home-Broadband_FINAL2.pdf

Rosenthal, R., & DiMatteo, M. R. (2001). Meta-analysis: Recent developments in quantitative methods for literature reviews. *Annual Review of Psychology*, *52*, 59-82. doi:10.1146/annurev.psych.52.1.59

Smith, T. B., Dean, B., Floyd, S., Silva, C., Yamashita, M., Durtschi, J., & Heaps, R. A. (2007). Pressing issues in college counseling: A survey of American College Counseling Association members. *Journal of College Counseling*, *10*, 64-78. doi:10.1002/j.2161-1882.2007.tb00007.x

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory STAI (Form Y)*. Palo Alto, CA: Mind Garden.

Stolz, T., Schulz, A., Krieger, T., Vincent, A., Urech, A., Moser, C., . . . Berger, T. (2018). A mobile app for social anxiety disorder: A three-arm randomized controlled trial

comparing mobile and PC-based guided self-help interventions. *Journal of Consulting and Clinical Psychology*, *86*, 493-504. doi:10.1037/ccp0000301

Taylor, C. B., Graham, A. K., Flatt, R. E., & Fitzsimmons-Craft, E. E. (in press). Current state of scientific evidence on Internet-based interventions for the treatment of depression, anxiety, eating disorders, and substance abuse: An overview of systematic reviews and meta-analyses. *European Journal of Public Health*.

Van Ameringen, M., Turna, J., Khalesi, Z., Pullia, K., & Patterson, B. (2017). There is an app for that! The current state of mobile applications (apps) for DSM-5 obsessive-compulsive disorder, posttraumatic stress disorder, anxiety and mood disorders. *Depression and Anxiety*, *34*, 526-539. doi:10.1002/da.22657

Wang, P. S., Lane, M., Olfson, M., Pincus, H. A., Wells, K. B., & Kessler, R. C. (2005). Twelve-month use of mental health services in the United States: Results from the National Comorbidity Survey Replication. *Archives of General Psychiatry*, *62*, 629-640. doi:10.1001/archpsyc.62.6.629

Watkins, D. C., Hunt, J. B., & Eisenberg, D. (2012). Increased demand for mental health services on college campuses: Perspectives from administrators. *Qualitative Social Work*, *11*, 319-337. doi:10.1177/1473325011401468

Table 1

Descriptive statistics for outcome and usage data

	Intervention			Control		
Measure	Pre	Post	Follow-up	Pre	Post	Follow-up
	M (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)
DASS Stress	24.68 (8.29)	18.67 (9.66)	17.76 (8.94)	23.26 (5.54)	21.12 (7.63)	20.18 (9.74)
PSWQ-11	45.18 (6.23)	40.13 (6.83)	40.26 (7.20)	45.72 (5.54)	42.42 (8.36)	39.71 (11.66)
STAI-T	58.50 (9.96)	52.36 (10.51)	51.91 (9.08)	59.78 (7.98)	55.56 (9.67)	54.29 (11.79)
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
GAD Status	47 (94.0)	19 (48.7)	17 (50.0)	45 (90.0)	32 (74.4)	22 (61.1)

	Intervention
	M (SD)
Sessions	12.38 (19.69)
Messages to coach	10.35 (24.16)
Messages from coach	25.08 (31.25)
Visits to platform	31.06 (52.90)
Login time (hours)	2.76 (4.46)

Note. $N = 100$. Descriptive statistics are based on observed, non-missing data. DASS Stress = Depression, Anxiety, Stress Scales Short Form-Stress subscale. PSWQ-11 = Penn State Worry Questionnaire-straightforwardly worded items. STAI-T = State-Trait Anxiety Inventory-Trait scale. GAD Status refers to the number of participants meeting full GAD criteria as assessed by the Generalized Anxiety Disorder Questionnaire, 4th edition.

Table 2

Symptom change across the intervention and control conditions.

	Pre to Post: Time X Condition Interaction				Post to Follow-Up: Time X Condition Interaction			
Measure	*β*	*SE*	*Z*	*d*	*β*	*SE*	*Z*	*d*
DASS Stress	-3.332	1.668	**-1.997**	-0.408	0.089	1.981	0.045	0.009
PSWQ-11	-1.422	1.374	-1.035	-0.208	1.502	1.540	0.975	0.196
STAI-T	-0.979	1.716	-0.570	-0.114	0.734	1.917	0.383	0.077
	Pre to Post: Intervention Simple Slope				Post to Follow-Up: Intervention Simple Slope			
	β	*SE*	*Z*	*d*	*β*	*SE*	*Z*	*d*
DASS Stress	-5.683	1.207	**-4.708**	-1.067	-0.981	1.394	-0.704	-0.141
PSWQ-11	-4.838	0.944	**-5.124**	-1.193	-0.302	0.994	-0.304	-0.061
STAI-T	-5.156	1.185	**-4.350**	-0.966	-1.040	1.314	-0.791	-0.159
	Pre to Post: Control Simple Slope				Post to Follow-Up: Control Simple Slope			
	β	*SE*	*Z*	*d*	*β*	*SE*	*Z*	*d*
DASS Stress	-2.351	1.174	**-2.002**	-0.409	-1.071	1.367	-0.783	-0.157
PSWQ-11	-3.416	0.965	**-3.540**	-0.757	-1.803	1.103	-1.635	-0.331
STAI-T	-4.177	1.213	**-3.444**	-0.734	-1.774	1.308	-1.356	-0.274

Note. $N = 100$. Bold indicates $p < .05$. DASS Stress = Depression, Anxiety, Stress Scales Short Form-Stress subscale. PSWQ-11 = Penn State Worry Questionnaire-straightforwardly worded items. STAI-T = State-Trait Anxiety Inventory-Trait scale.

Table 3

Usage characteristics as predictors of symptom change

	Pre to Post: Time X Linear Interaction				Pre to Post: Time X Quadratic Interaction			
Measure	*β*	*SE*	*Z*	*d*	*β*	*SE*	*Z*	*d*
Sessions completed	0.710	0.595	1.194	0.241	-0.540	0.583	0.926	-0.186
Messages to coach	0.547	0.589	0.929	0.186	0.048	0.585	0.082	0.016
Messages from coach	0.723	0.589	1.228	0.248	-0.147	0.583	-0.252	-0.050
Visits to platform	0.624	0.532	1.173	0.236	-0.594	0.586	-1.015	-0.204
Login time (hours)	0.572	0.580	0.987	0.198	-0.644	0.569	-1.133	-0.228
	Post to Follow-Up: Time X Linear Interaction				Post to Follow-Up: Time X Quadratic Interaction			
	β	*SE*	*Z*	*d*	*β*	*SE*	*Z*	*d*
Sessions completed	-0.040	0.611	-0.065	-0.013	0.159	0.601	0.265	0.053
Messages to coach	0.168	0.598	0.281	0.056	-0.490	0.589	-0.832	-0.167
Messages from coach	-0.112	0.606	-0.185	-0.037	0.054	0.603	0.090	0.018
Visits to platform	0.127	0.609	0.208	0.042	0.147	0.596	0.247	0.049
Login time (hours)	0.502	0.595	0.844	0.169	0.643	0.583	1.103	0.222

Note. Results based on $N = 50$ participants randomly assigned to the intervention condition. Symptom change refers to change in composite measure of Depression, Anxiety, Stress Scales Short Form-Stress subscale, Penn State Worry Questionnaire-straightforwardly worded items, and State-Trait Anxiety Inventory-Trait scale.

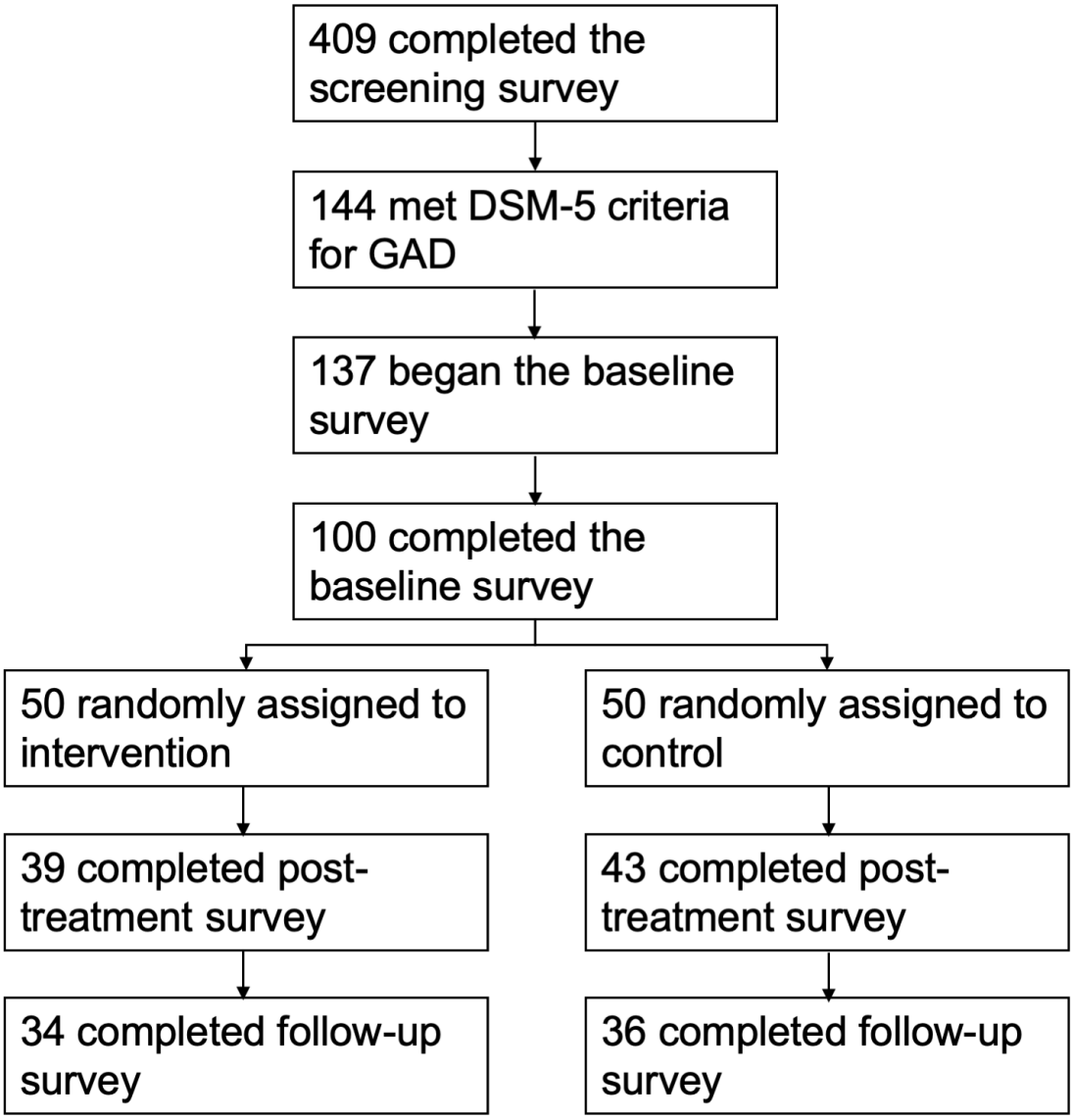

Figure 1. Participant recruitment, selection, randomization, and assessment. Post-treatment survey occurred three months following baseline. Follow-up survey occurred six months following post-treatment survey.