A Meta-Analysis of Computerized Cognitive-Behavioral Therapy for the Treatment of *DSM-5* Anxiety Disorders

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ABSTRACT

Objective: Access to qualified cognitive-behavioral therapy (CBT) remains a major barrier to improving clinical outcomes in anxiety disorders. The current meta-analysis examined the efficacy of computerized CBT (cCBT) for anxiety disorders and the durability of treatment gains during follow-up.

Data Sources: We searched PubMed and references from included trials and previous meta-analyses in the area.

Study Selection: We included randomized controlled trials assessing the efficacy of cCBT for non-OCD and non-PTSD anxiety disorders.

Data Extraction: Forty trials involving 2,648 participants were included in this meta-analysis. We used a fixed-effect model to examine standardized mean difference in posttreatment anxiety levels. cCBT was compared to wait-list, in-person CBT, and Internet control. We also examined moderators of cCBT treatment gains over follow-up.

Results: Meta-analysis indicated that cCBT was significantly more effective than wait-list control in the treatment of anxiety disorders (standardized mean difference [SMD] = 0.92 [95% CI, 0.83 to 1.02], k = 31, $z = 18.8$, $P < .001$). Moderator analyses also found that cCBT targeting specific anxiety disorders had greater efficacy than that targeting mixed anxiety symptoms. The efficacy of cCBT was equivalent to in-person CBT in studies that compared them head-to-head, for both children and adults (SMD = 0.05 [95% CI, −0.09 to 0.19], k = 15, $z = 0.7$, $P = .46$). Longitudinal studies indicate that individuals undergoing cCBT tended to continue to improve after completion of treatment, with longer follow-up periods associated with greater symptom reduction.

Conclusions: cCBT represents an efficacious intervention for the treatment of anxiety disorders and may circumvent barriers to accessing traditional CBT treatments. Further research is needed to examine the effectiveness of cCBT in real-world settings, for individuals with clinical comorbidities, and in comparison with more ecologically valid comparison conditions.

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Anxiety disorders represent a significant public health concern, affecting an estimated 21% of adults and 25% of adolescents in the United States each year.[1] Left untreated, anxiety disorders are likely to persist[2] and represent a risk factor for the development of other psychological disorders, including depression and substance abuse.[3] Fortunately, anxiety disorders are highly responsive to treatment. Cognitive-behavioral therapy (CBT) is an effective treatment for anxiety disorders,[4] with a majority of individuals showing clinically significant symptom reduction following engagement in CBT.[5]

Despite the proven effectiveness of cognitive-behavioral interventions, many individuals with anxiety disorders never seek appropriate professional treatment.[6,7] Those who do seek treatment for anxiety disorders often wait years to do so, with the median delay in treatment seeking in the United States estimated to be 23 years after symptom onset.[8] Commonly cited barriers to treatment-seeking include perceived stigma, high costs, lack of insurance, poor access to treatment in rural or remote regions, and a relative dearth of clinicians qualified to provide CBT for anxiety disorders.[9]

In response to evidence that such factors may limit treatment access, there has been a surge of interest in computer-based cognitive-behavioral therapy (cCBT) for anxiety disorders. Computerized treatments typically provide time-limited, manualized CBT interventions, via Internet or computer software, with varying levels of therapist involvement. Because they are accessible to anyone with a computer and an Internet connection, computer-based CBT programs provide one promising solution to increase access to effective treatment for anxiety disorders. Computer-based cognitive-behavioral therapy can be delivered to individuals living in remote regions, does not rely on the local availability of skilled clinicians, can be significantly more cost-effective than traditional CBT, and can circumvent concerns related to perceived stigma.

Dozens of studies have been conducted over the past decade to determine the feasibility and effectiveness of cCBT for anxiety disorders.[10,11] These studies have varied widely in their quality, focus, sample size, and methodology, resulting in ongoing uncertainty regarding the true effectiveness of computer-based interventions for anxiety disorders. An updated, systematic meta-analysis of randomized controlled trials (RCTs) is needed to determine the true effectiveness of computer-based cognitive-behavioral treatment of anxiety disorders among both children and adults. Additionally, meta-regression can be an effective method to examine moderating factors that may influence reported efficacy of treatment. Although at least 3 comprehensive meta-analyses of cCBT for anxiety disorders have been conducted in recent years,[12–14] the number of RCTs examining cCBT for anxiety disorders has nearly doubled since 2010, making previously underpowered moderator analyses now feasible. Furthermore, the exclusion of obsessive-compulsive disorder (OCD) and posttraumatic stress disorder (PTSD) from

Clinical Points

- Meta-analysis of all published randomized controlled trials of computer-based cognitive behavioral therapy (cCBT) for anxiety disorders indicated that cCBT represents an equally efficacious alternative to in-person CBT for anxiety disorders, among both children and adults.
- Treatments targeting specific anxiety disorders were significantly more effective than those targeting mixed anxiety symptoms or multiple disorders.
- Individuals undergoing cCBT tended to continue to improve after completion of treatment, with longer follow-up periods associated with greater symptom reduction.
- Dropout rates were smaller in cCBT trials that included some therapist involvement either in-person or through e-mail/telephone.

DSM-5 anxiety disorders category highlights the need for a meta-analysis that distinguishes these from other anxiety disorders in examining treatment efficacy. The current meta-analysis examines cCBT efficacy for non-PTSD, non-OCD anxiety disorders along multiple dimensions, including treatment efficacy by comparison condition, diagnostic target, level of therapist involvement, study quality, and participant age group.

METHOD

Search Strategy

Two reviewers (C.A.B., A.B.) searched PubMed (1965–July 2013) for relevant citations. Within PubMed, we used the search strategy ((*Cognitive Therapy*[Mesh]) AND (*Software*[Mesh] OR *Computer Systems*[Mesh] OR *Therapy, Computer-Assisted*[Mesh]) AND *Anxiety Disorders*[Mesh]) and further limited the findings to RCTs. The references of related review articles, meta-analyses, and included articles were also searched for additional eligible citations. There were no language limitations placed on studies.

Inclusion/Exclusion Criteria

Trials were included in our meta-analysis if they were RCTs assessing the efficacy of cCBT for anxiety disorders. Trials were included if they enrolled subjects who met criteria for generalized anxiety disorder, panic disorder, social anxiety disorder, or a specific phobia based on *DSM-IV* criteria.[15] Trials that enrolled subjects with OCD or PTSD were excluded from this meta-analysis. Trials were also required to compare cCBT to wait-list or an in-person CBT control condition. OCD and PTSD trials were not included because (1) the underlying neuropathology of these conditions and (2) the CBT techniques used to treat these conditions were considered to be sufficiently different from the other anxiety disorders, and (3) the *DSM-5* classifies OCD and PTSD within diagnostic categories that are distinct from the anxiety disorders included in this meta-analyses.[16] Trials were also excluded if they enrolled less than 10 participants. Randomized controlled trials were identified if the investigator defined them as such in the methods section of the article. A CBT intervention was considered "computerized" if the computer was the primary manner by which subjects received information in CBT therapy. Trials were stratified by type of comparison condition (eg, wait-list or in-person CBT).

Meta-Analytic Procedures

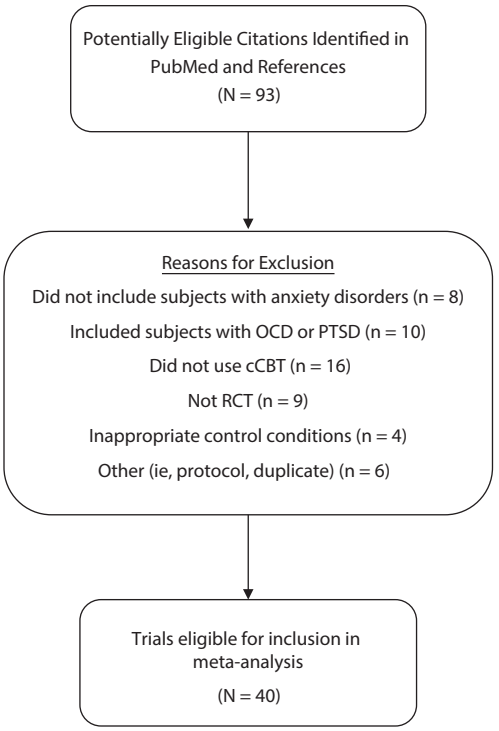
To extract data from included articles, we used customized Microsoft Excel spreadsheets. Data extracted included characteristics of the CBT intervention (eg, specific anxiety disorder targeted [social anxiety disorder, generalized anxiety disorder, specific phobia, panic disorder, or mixed anxiety], duration of treatment (measured as number of sessions), manner of therapist involvement, type of comparison condition (eg, wait-list, in-person CBT, or Internet control condition), sample size, age group of sample (adult or child), number of dropouts, and method of analysis (intention-to-treat or completers). We also recorded Jadad scale ratings of study quality.[17]

Our primary outcome measure was the endpoint score on a rating scale used to measure anxiety in the trial. For trials of cCBT that targeted mixed anxiety conditions, we used general measures of anxiety as the primary outcome. For trials that targeted specific anxiety disorders, we utilized rating scales that measured the specific anxiety disorder as the primary outcome. For each anxiety disorder and in the mixed anxiety samples, we developed a prespecified hierarchy of preferred outcome for each condition based on frequency of use of available rating scales in clinical trials. For the mixed anxiety samples, the preferred order of rating scales was the Hamilton Anxiety Rating Scale (HARS),[18] the Generalized Anxiety Disorder Scale (GAD-7),[19] the Depression and Anxiety Severity Scale-21 (DASS-21),[20] and the Spence Children's Anxiety Scale–Child Version (SCAS-C).[21] For social anxiety disorder, the preferred order of rating scales was the Liebowitz Social Anxiety Scale (LSAS),[22] Social Phobia Scale (SPS),[23] and then the Social Interaction Anxiety Scale (SIAS).[23] For generalized anxiety disorder, every trial utilized the Penn State Worry Questionnaire (PSWQ).[24] For panic disorder, the preferred order of rating scales was the Panic Disorder Severity Scale (PDSS)[25] and then the Body Sensation Questionnaire (BSQ).[26]

We examined the difference between cCBT and comparison condition by calculating the standardized mean difference (SMD) using Comprehensive Meta-Analysis version 2 (Biostat, Englewood, New Jersey). This measure was favored over weighted mean difference because rating scales differed between the included studies. Meta-analysis results were stratified by type of comparison condition (wait-list or in-person CBT). We used a fixed-effects model for this meta-analysis but report the results of the random-effects models in a sensitivity analyses.

Publication bias was assessed by plotting the effect size against standard error for each trial (ie, funnel plot). In addition, publication bias was statistically tested by the Egger test.[27] Heterogeneity between trials was determined by Q-statistic and I^2 statistic.

Figure 1. Selection of Studies



Abbreviations: cCBT = computerized cognitive-behavioral therapy, OCD = obsessive-compulsive disorder, PTSD = posttraumatic stress disorder, RCT = randomized controlled trial.

For secondary analyses, we performed several subgroup analyses within the trials that employed a wait-list comparison. Stratified subgroup analysis in Comprehensive Meta-Analysis was used to assess the effects of (1) diagnostic target of CBT (generalized anxiety disorder, social anxiety disorder, panic disorder, specific phobia, or mixed anxiety disorder), (2) method of therapist involvement in cCBT (no involvement, e-mail contact only during cCBT, or telephone/in-person contact during cCBT), (3) age group of participants (child or adult), and (4) statistical accounting for dropouts (did the trial employ strict intention-to-treat principles after randomization or not). We additionally conducted meta-regressions to examine the association of treatment duration (as measured by the number of therapy sessions) and study methodological quality (measured by the Jadad scale) on the reported efficacy of cCBT. Our threshold for statistical significance was selected to be $P < .05$ for the primary analysis, as well as for all subgroups analyses Any significant findings in secondary analyses should be regarded as exploratory because we did not adjust for inflation of false-positive error from our 10 secondary analyses.

We also compared proportion of dropouts in the cCBT and control conditions (wait-list and in-person CBT). Our summary measure was pooled odds ratio (OR) using a fixed effects model. For the wait-list control condition, we additionally stratified studies according to method of therapist involvement in cCBT.

Lastly, we examined durability of anxiety symptoms to remain improved during the 3- to 12-month period after cCBT treatment. For this analysis, our main outcome was change in severity of anxiety symptoms between endpoint and follow-up evaluation. Standardized mean difference was used as the overall summary measure to examine durability of benefits in anxiety symptoms during the follow-up interval. We also conducted a meta-regression analysis to examine whether the change in severity of anxiety symptoms during follow-up was associated with the duration of the follow-up interval.

RESULTS

Included Trials

Forty trials involving 2,648 participants were included in this meta-analysis.[28–67] These trials were identified from the 93 citations located using our PubMed search as well as searching of the references of included trials and appropriate reviews in the area. Figure 1 depicts the algorithm for selection of the included trials. Table 1 depicts the characteristics of trials included in this meta-analysis. A total of 46 treatment arms were included in our meta-analysis from the 40 eligible citations. Thirty-one trials compared cCBT to a wait-list condition, and 15 trials compared cCBT to in-person CBT. Thirty-six trials examined the efficacy of cCBT for anxiety in adults, and 4 trials examined the efficacy of cCBT in children.

Efficacy of cCBT in the Treatment of Anxiety Disorders

Meta-analysis of 31 trials involving 1,939 subjects demonstrated a significant benefit of cCBT compared to wait-list control (SMD = 0.92 [95% confidence interval (CI), 0.83 to 1.02], k = 31, $z = 18.8$, $P < .001$).* There was a significant amount of heterogeneity between trials ($Q_{30} = 111.90$, $P < .001$, $I^2 = 73.2\%$), but no evidence of publication bias (Egger test intercept: 1.84 [95% CI, −1.23 to 4.91], $t = 1.2$, $P = .23$). We also demonstrated no significant association between reported effect size of cCBT and study methodological quality (β = −0.10 [95% CI, −0.25 to 0.05], $z = -1.36$, $P = .17$). The measured efficacy of cCBT compared to wait-list control was similar (test for subgroup differences $Q_1 = 0.6$, $P = .42$) in trials that did (SMD = 0.96 [95% CI, 0.83 to 1.09], k = 19, $z = 14.8$, $P < .001$) or did not (SMD = 0.88 [95% CI, 0.73 to 1.02], k = 12, $z = 11.5$, $P < .001$) adhere to intention-to-treat principles. Computerized CBT also demonstrated a significant benefit compared to wait-list control when a random-effects model was utilized (SMD = 0.96 [95% CI, 0.77 to 1.15], k = 31, $z = 9.86$, $P < .001$).

Moderators of cCBT Efficacy in the Treatment of Anxiety Disorders When Compared to Wait-List Control

The diagnostic target of cCBT was significantly associated with the efficacy of therapy (test for subgroup differences $Q_4 = 12.5$, $P = .02$). cCBT treatments targeting specific anxiety disorders (social anxiety disorder: SMD = 0.91 [95% CI, 0.74

*References 28, 31, 32, 34–36, 38–41, 44, 46, 47, 50, 51, 53–67.

Table 1. Characteristics of Trials Included in the Meta-Analysis of Computerized Cognitive-Behavioral Therapy (cCBT) in *DSM-5* Anxiety Disorders

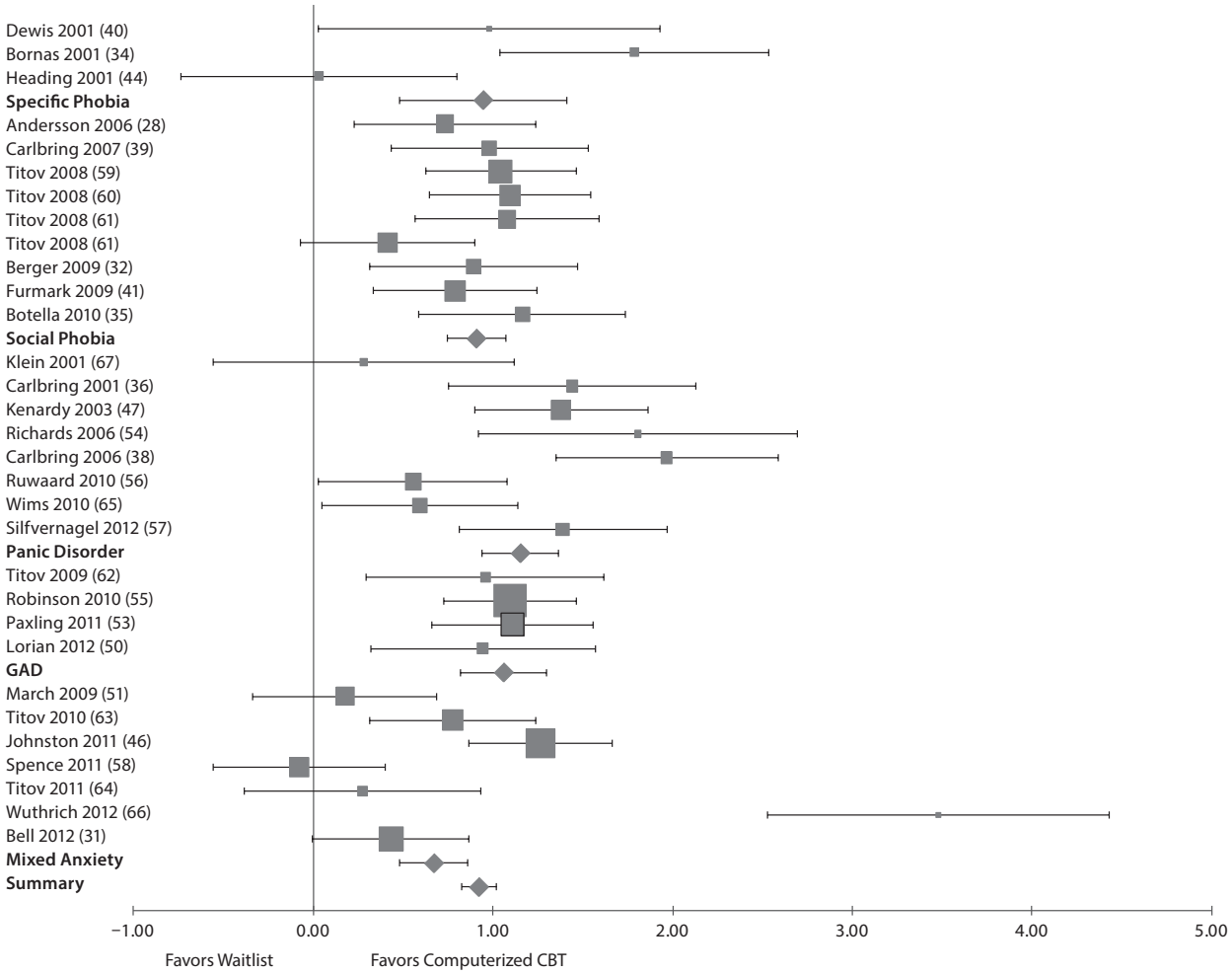
cCBT Study	Year	cCBT, n	Control, n	Age	Therapeutic Target	Primary Outcome	Jadad Score	Therapist Involvement?	Follow-Up Period
Wait-List Control									
Bornas et al[34]	2001	28	14	Adult	SP—flight	FFQ-II	2	Yes-in person	Yes
Dewis et al[40]	2001	10	9	Child (10–17 y)	SP—spider	SPQ-C	2	Yes-in person	No
Klein and Richards[67]	2001	11	11	Adult	Panic disorder	Anxiety Sensitivity Index	2	No	No
Heading et al[44]	2001	13	14	Adult	SP—spiders	SPQ	1	Yes-in person	No
Carlbring et al[36]	2001	21	20	Adult	Panic disorder	BSQ	2	Yes—Not in person	No
Kenardy et al[47]	2003	41	41	Adult	Panic disorder	BSQ	2	Yes-in person	Yes
Carlbring et al[38]	2006	30	30	Adult	Panic disorder	BSQ	4	Yes-in person	Yes
Richards et al[54]	2006	23	9	Adult	Panic disorder	PDSS	3	Yes—Not in person	Yes
Andersson et al[28]	2006	32	32	Adult	Social phobia	Liebowitz	3	Yes-in person	Yes
Carlbring et al[39]	2007	29	28	Adult	Social phobia	Liebowitz	3	Yes-in person	Yes
Titov et al[59]–Shyness 1	2008	50	49	Adult	Social phobia	SPS	3	Yes—Not in person	No
Titov et al[60]–Shyness 2	2008	43	45	Adult	Social phobia	SPS	3	Yes—Not in person	No
Titov et al[61]–Shyness 3–clinican assisted	2008	32	35	Adult	Social phobia	SPS	3	Yes—Not in person	No
Titov et al[61]–Shyness 3–self-guided	2008	31	35	Adult	Social phobia	SPS	3	No	No
Furmark et al[41]	2009	40	40	Adult	Social phobia	Liebowitz	2	Yes—Not in person	Yes
Berger et al[32]	2009	31	21	Adult	Social phobia	Liebowitz	3	Yes—Not in person	No
March et al[51]	2009	30	29	Child (7–12 y)	Anxiety disorders	SCAS-C	4	Yes-in person	Yes
Titov et al[62]	2009	20	19	Adult	GAD	PSWQ	3	Yes—Not in person	No
Ruwaard et al[56]	2010	27	31	Adult	Panic disorder	PDSS	2	Yes—Not in person	No
Robinson et al[55]	2010	97	48	Adult	GAD	PSWQ	3	Yes	Yes
Wims et al[65]	2010	29	25	Adult	Panic disorder	PDSS	3	Yes—Not in person	No
Botella et al[35]	2010	30	25	Adult	Social phobia	FPSQ	3	No	Yes
Titov et al[63]–Transdiagnostic	2010	40	38	Adult	Anxiety disorders	GAD-7	2	Yes-in person	Yes
Paxling et al[53]	2011	44	45	Adult	GAD	PSWQ	2	Yes—Not in person	Yes
Titov et al[64]	2011	19	17	Adult	Anxiety disorders	DASS-21	3	Yes-in person	No
Spence et al[58]	2011	44	27	Child (12–18 y)	Anxiety disorders	SCAS-C	3	Yes—Not in person	Yes
Johnston et al[46]	2011	89	42	Adult	Anxiety disorders	GAD-7	3	Yes-in person	Yes
Lorian et al[50]	2012	24	20	Adult	GAD	PSWQ	2	Yes-in person	No
Wuthrich et al[66]	2012	24	19	Child (14–17 y)	Anxiety disorders	Cool Teens	2	Yes-in person	Yes
Silfvernagel et al[57]	2012	29	28	Adult	Panic disorder	PDSS	3	Yes-in person	Yes
Bell et al[31]	2012	40	43	Adult	Anxiety disorders	FQ	4	Yes—Not in person	No
CBT Comparison									
Ghosh and Marks[42]	1987	15	11	Adult	Social phobia	FQ	3	Yes-in person	Yes
Gilroy et al[43]	2000	15	15	Adult	SP—spiders	SQ	2	Yes-in person	Yes
Dewis et al[40]	2001	10	9	Child (10–17 y)	SP—spiders	SPQ-C	2	Yes-in person	No
Heading et al[44]	2001	13	13	Adult	SP—spider	SPQ	1	Yes-in person	No
Kenardy et al[47]	2003	41	39	Adult	Panic disorder	BSQ	2	Yes-in person	Yes
Marks et al[52]	2004	37	29	Adult	Panic disorder	FQ Global Phobia	3	No	No
Carlbring et al[37]	2005	25	24	Adult	Panic disorder	BSQ	4	Yes—Not in person	Yes
Kiropoulos et al[49]	2008	46	40	Adult	Panic disorder	PDSS	4	Yes—Not in person	No
Andersson et al[29]	2009	13	14	Adult	Spider phobia	Spider Phobia Questionnaire	3	Yes—Not in person	Yes
Bergström et al[33]	2010	44	49	Adult	Panic disorder	PDSS	3	Yes—Not in person	Yes
Botella et al[35]	2010	30	22	Adult	Social phobia	FPSQ	3	No	Yes
Khanna and Kendall[48]	2010	16	17	Child (7–13 y)	Anxiety disorders	MASC	3	Yes-in person	Yes
Andrews et al[30]	2011	21	14	Adult	Social phobia	SPS	3	Yes-in person	No
Spence et al[58]	2011	44	44	Child (12–18 y)	Anxiety disorders	SCAS-C	3	Yes—Not in person	Yes
Hedman et al[45]	2011	64	62	Adult	Social phobia	Liebowitz	3	Yes—Not in person	Yes

Abbreviations: BSQ = Body Sensation Questionnaire, DASS-21 = Depression and Anxiety Severity Scale-21, FFQ-II = Fear of Flying Questionnaire-II, FPSQ = Fear of Public Speaking Questionnaire, FQ = Fear Questionnaire, GAD-7 = Generalized Anxiety Disorder Scale, MASC = Multidimensional Anxiety Scale for Children, PDSS = Panic Disorder Severity Scale, PSWQ = Penn State Worry Questionnaire, SCAS-C = Spence Children's Anxiety Scale–Child Version, SP = specific phobia, SPQ-C = Spider Phobia Questionnaire for Children, SPS = Social Phobia Scale, SQ = Spider Questionnaire.

to 1.07], k = 9, $z = 10.8$, $P < .001$; panic disorder: SMD = 1.15 [95% CI, 0.94 to 1.37], k = 8, $z = 10.5$, $P < .001$; generalized anxiety disorder: SMD = 1.06 [95% CI, 0.82 to 1.30], k = 4, $z = 8.6$, $P < .001$; specific phobia: SMD = 0.95 [95% CI, 0.48 to 1.41], k = 3, $z = 4.0$, $P < .001$) reported greater effects than cCBT targeting mixed anxiety samples (SMD = 0.67 [95% CI, 0.48 to 0.86], k = 7, $z = 7.0$, $P < .001$) compared to wait-list comparison groups. Figure 2 depicts a forest plot of the reported efficacy of cCBT compared to wait-list control stratified by the anxiety condition targeted.

Increased therapist involvement in cCBT was not significantly associated with increased reported effect size of cCBT (test for subgroup differences $Q_3 = 4.4$, $P = .11$). However, cCBT trials in which participants had no contact with clinicians or coaches (SMD = 0.66 [95% CI, 0.32 to 1.00], k = 3, $z = 3.78$, $P < .001$) reported smaller effects compared

Figure 2. Forest Plot: Efficacy of Computerized Cognitive-Behavioral Therapy (cCBT) Versus Wait-List Control[a]



[a]Forest plot depicting standardized mean difference in improvement of anxiety symptoms in subjects randomly assigned to cCBT compared to wait-list controls. cCBT was significantly more effective than placebo (standardized mean difference [SMD] = 0.92 [95% confidence interval (CI), 0.83 to 1.02], k = 31, $z = 18.8$, $P < .001$). Additionally, cCBT targeting specific anxiety disorders demonstrated a significantly larger effect size compared to placebo when trials were stratified by type of anxiety disorder targeted.

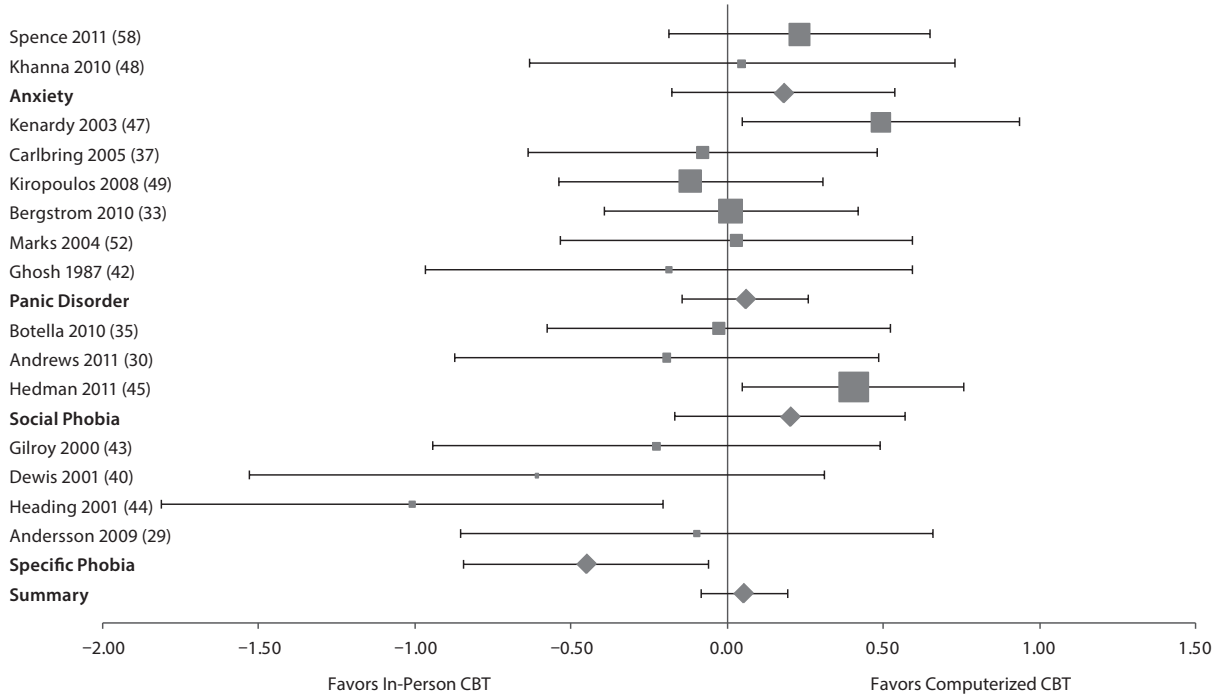
to wait-list control than trials that employed cCBT with e-mail contact only (SMD = 0.89 [95% CI, 0.76 to 1.02], k = 15, $z = 13.4$, $P < .001$) or cCBT with telephone/in-person contact (SMD = 1.03 [95% CI, 0.87 to 1.19], k = 13, $z = 12.7$, $P < .001$).

Age group of study samples was significantly associated with reported efficacy of cCBT compared to wait-list controls (test for subgroup differences $Q_1 = 7.6$, $P = .006$). cCBT trials targeting child samples (SMD = 0.51 [95% CI, 0.20 to 0.82], k = 4, $z = 3.2$, $P = .001$) demonstrated a significantly smaller benefit of cCBT therapy compared to cCBT trials targeting adult samples (SMD = 0.97 [95% CI, 0.87 to 1.07], k = 27, $z = 18.7$, $P < .001$). Duration of cCBT therapy was not significantly associated with reported effect size ($\beta = 0.02 \pm 0.02$ [95% CI, −0.03 to 0.06], $z = 0.7$, $P = .46$).

Efficacy of cCBT Compared to In-Person CBT

Meta-analysis of 15 trials involving 821 participants demonstrated no significant difference in efficacy between cCBT and in-person CBT (SMD = 0.05 [95% CI, −0.09 to 0.19], k = 15, $z = 0.7$, $P = .46$).[29,30,33,35,37,40,42–45,47–49,52] There was no evidence of significant heterogeneity between trials ($Q_{14} = 19.5$, $P = .15$, $I^2 = 28\%$). However, there was some evidence of publication bias (Egger test intercept: −3.02 [95% CI, −4.68 to −1.35], $t = 3.9$, $P = .001$), suggesting that trials more strongly favoring cCBT were excluded. Model results were similar when a random-effects model was used rather than a fixed-effects model in sensitivity analysis (SMD = 0.02 [95% CI, −0.15 to 0.19], k = 15, $z = 0.2$, $P = .86$). We demonstrated no association between reported effect size of cCBT compared to in-person CBT and study methodological quality ($\beta = 0.04$ [95% CI, −0.16 to −0.25], $z = 0.4$, $P = .67$). The measured efficacy of cCBT compared to in-person CBT control was similar (test for subgroup differences $Q_1 = 0.4$, $P = .53$) in trials that did (SMD = 0.09 [95% CI, −0.10 to 0.28], k = 7, $z = 1.0$, $P = .33$) or did not (SMD = 0.00 [95% CI, −0.20 to 0.21], k = 8, $z = 0.04$, $P = .97$) adhere to intention-to-treat principles.

Figure 3. Forest Plot: Efficacy of Computerized CBT Versus In-Person CBT[a]



[a]Forest plot depicting standardized mean difference (SMD) in improvement of anxiety symptoms in subjects randomly assigned to cCBT compared to in-person CBT. There was no significant difference between anxiety symptom improvement in subjects randomly assigned cCBT compared to in-person CBT (SMD = 0.05 [95% CI, −0.09 to 0.19], k = 15, $z = 0.7$, $P = .46$).

Moderators of cCBT Efficacy in the Treatment of Anxiety Disorders When Compared to CBT Control

The diagnostic target of cCBT was significantly associated with the measured efficacy of therapy compared to an in-person CBT control (test for subgroup differences $Q_3 = 7.9$, $P < .05$). cCBT treatments targeting specific phobia (specific phobia: SMD = −0.45 [95% CI, −0.85 to −0.06], k = 4, $z = -2.4$, $P = .03$) appeared less effective than cCBT programs targeting other anxiety disorders (social anxiety disorder: SMD = 0.20 [95% CI, 0.74 to 1.07], k = 9, $z = 10.8$, $P < .001$; panic disorder: SMD = 0.06 [95% CI, −0.14 to 0.26], k = 6, $z = 0.58$, $P = .57$) or targeting mixed anxiety samples (SMD = 0.18 [95% CI, −0.18 to 0.54], k = 2, $z = 1.0$, $P = .32$) when compared to in-person CBT. Figure 3 depicts a forest plot of the reported efficacy of cCBT compared to in-person CBT stratified by the anxiety condition targeted.

Increased therapist involvement in cCBT was not significantly associated with increased reported effect size of cCBT compared to in-person CBT control (test for subgroup differences $Q_2 = 1.3$, $P = .53$). cCBT trials in which participants had no contact with clinicians or coaches (SMD = 0.00 [95% CI, −0.39 to 0.39], k = 2, $z = 0.01$, $P = .99$) reported similar effects compared to wait-list control than trials that employed cCBT with e-mail contact only (SMD = 0.12 [95% CI, −0.06 to 0.30], k = 6, $z = 1.3$, $P = .20$) or cCBT with telephone/in-person contact (SMD = −0.06 [95% CI, −0.31 to 0.20], k = 7, $z = -0.43$, $P = .67$).

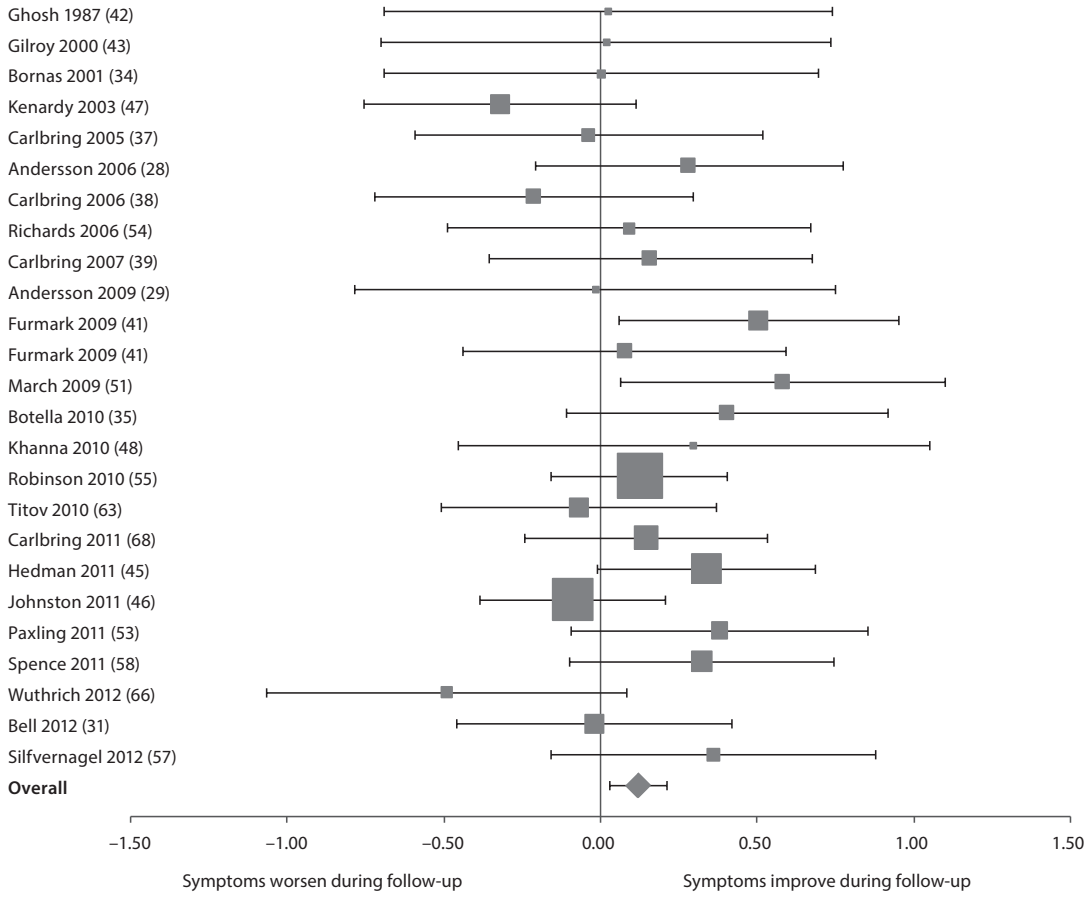
Age group of study samples was not significantly associated with reported efficacy of cCBT compared to CBT control condition (test for subgroup differences $Q_1 = 0.03$, $P = .87$). cCBT trials targeting child samples (SMD = 0.08 [95% CI, −0.26 to 0.41], k = 3, $z = 2.6$, $P = .26$) demonstrated similar effects compared to cCBT trials targeting adult samples (SMD = 0.05 [95% CI, −0.11 to 0.20], k = 12, $z = 0.6$, $P = .55$) when compared to CBT conditions. Duration of cCBT therapy was significantly positively associated with reported efficacy of cCBT compared to CBT control conditions ($\beta = 0.07 \pm 0.02$ [95% CI, 0.03 to 0.11), $z = 3.8$, $P < .001$).

Dropout Risk in cCBT

Meta-analysis of 24 trials involving 1,746 participants demonstrated an increased risk of dropout with cCBT compared to wait-list control (OR = 1.76 [95% CI, 1.27 to 2.44], $z = 3.4$, $P = .001$). There was no evidence of significant heterogeneity between trials ($Q_{23} = 17.1$, $P = .80$, $I^2 = 0$). Model results were identical when a random-effects model was used rather than a fixed-effects model in sensitivity analysis. Stratifying trials based on method of therapist involvement in cCBT indicated a significant association with risk of dropout compared to wait-list (test for subgroup differences $Q_2 = 6.8$, $P = .03$). cCBT trials involving no therapist involvement (OR = 6.28 [95% CI, 2.23 to 17.70], k = 2, $z = 3.5$, $P = .001$) had a greater risk of dropout than trials that included therapist involvement either in person (OR = 1.36 [95% CI, 0.79 to 2.33], k = 9, $z = 1.1$, $P = .27$) or not in person (OR = 1.67 [95% CI, 1.07 to 2.58], k = 13, $z = 2.3$, $P = .02$).

Meta-analysis of 13 trials involving 850 participants demonstrated a mildly elevated, although not statistically

Figure 4. Forest Plot: Change in Anxiety Symptom Severity During Follow-Up Period After Computerized CBT[a]



[a]Forest plot depicting standardized mean difference (SMD) of change in anxiety symptoms over the follow-up interval of included trials. There was a small but statistically significant improvement in anxiety symptoms during the period (SMD = 0.12 [95% CI, 0.03 to 0.21], k = 25, $z = 2.5$, $P = .01$).

significant, increased risk of dropout with cCBT compared to in-person CBT (OR = 1.36 [95% CI, 0.93 to 2.00], $z = 1.6$, $P = .12$). There was no evidence of significant heterogeneity between trials ($Q_{12} = 8.4$, $P = .75$, $I^2 = 0$). Model results were identical when a random-effects model was used rather than a fixed-effects model in sensitivity analysis. Risk of dropout did not differ when trials were stratified by method of therapist involvement (test for subgroup differences $Q_2 = 1.7$, $P = .43$).

Durability of cCBT Outcomes

Figure 4 is a forest plot that depicts the change in anxiety symptoms in the 3–12 months following cCBT in individual trials. Meta-analysis involved 25 trials including 906 subjects.* There was small significant improvement in anxiety symptoms during the period following cCBT treatment using a fixed-effects model (SMD = 0.12 [95% CI, 0.03 to 0.21], k = 25, $z = 2.5$, $P = .01$). This improvement remained significant when a random-effects model was utilized in sensitivity analysis (SMD = 0.12 [95% CI, 0.02 to 0.22], k = 25, $z = 2.4$, $P = .02$). There was little heterogeneity between trials, but it did not reach statistical significance ($Q_{24} = 25.9$, $P = .36$, $I^2 = 7\%$). There was no evidence of publication bias (Egger test intercept: −0.02 [95% CI, −1.70 to 1.64], $t = 0.04$, $P = .97$). There was a significant association between change in anxiety severity and duration of the follow-up period (β = 0.03 [95% CI, 0.01 to 0.05], $z = 2.5$, $P = .01$). Improvement in anxiety symptoms was significantly greater in trials that included a longer follow-up duration.

DISCUSSION

Our meta-analysis demonstrated that cCBT is significantly more effective than wait-list control in treating a variety of anxiety disorders. These results are consistent with previous meta-analysis on this subject.[12–14] Additionally, meta-analysis demonstrated that cCBT may represent an equally efficacious alternative to traditional, in-person CBT for anxiety disorders, for both children and adults.

Analysis of treatment effectiveness by diagnostic treatment targets indicated that while cCBT treatments targeting both specific anxiety disorders (eg, social anxiety disorder, panic disorder, generalized anxiety disorder) and mixed anxiety disorders demonstrated large benefits, compared to wait-list comparison groups, treatments targeting specific anxiety disorders were significantly more effective than those

*References 28, 29, 31, 34, 35, 37–39, 41–43, 45–48, 51, 53–55, 57, 58, 63, 66, 68.

targeting mixed anxiety disorders. This finding indicates that cCBT is an efficacious treatment regardless of the anxiety disorder targeted, although it is less efficacious when mixed anxiety symptoms rather than specific anxiety symptoms are targeted. The finding raises at least 2 possibilities: first, computer-based programs may lack the flexibility to target multiple or mixed anxiety disorders as well as they target specific anxiety disorders; alternatively, it is possible that symptom change across multiple or mixed anxiety disorders is more difficult to measure accurately than change within a single, specified anxiety disorder. It will be important for future iterations of cCBT programs to specifically address comorbidity among anxiety disorders, given that over half of individuals diagnosed with a *DSM-IV* anxiety disorder are estimated to meet criteria for at least 1 additional anxiety disorder.[69]

The current meta-analysis also provides preliminary evidence that available cCBT programs may be less efficacious for youth with anxiety than for adults, although it appears that cCBT's efficacy in children is equivalent to that of in-person CBT. Given that there are a relatively limited number of published child-focused cCBT studies, more research is needed to determine the feasibility and relative efficacy of cCBT for children at different developmental phases. Considering the rapid cognitive, social, and emotional changes that occur throughout childhood and adolescence, in combination with the well-established changes in anxiety presentation that may occur throughout development, it seems likely that multiple, developmentally sensitive programs are needed to address anxiety disorders in children and adolescents. Given that cCBT is typically delivered in the home setting, without the presence of a therapist to provide structure and oversight during sessions, it may be especially important for child-focused cCBT programs to include the parents/family in reinforcing treatment gains and helping with exposure-based tasks. Future studies are needed to determine the effects of factors such as child age, parental involvement, efficacy of child-focused self-report measures, and developmental specificity of cCBT program on treatment outcomes among children and adolescents.

Meta-analysis of longitudinal studies indicated that individuals undergoing cCBT tend to continue improving after completion of treatment, with longer follow-up periods associated with greater symptom reduction. However, this result must be interpreted with caution, as this finding may be accounted for by regression to the mean over time, or naturally occurring symptom remission. It is not possible to determine whether the unique effects of treatment held up over time, as this would require comparison with a stable control condition over time (eg, wait-list control), and individuals in the control conditions often entered treatment during the follow-up period.

Analyses of treatment duration as a moderator of cCBT treatment efficacy were equivocal. While treatment duration was not significantly associated with reported effect size for cCBT versus wait-list control, there was a significant positive association between treatment duration and cCBT efficacy when compared to an in-person CBT control condition. While it is tempting to conclude that cCBT programs that are longer in duration are more efficacious, at least as an alternative to in-person CBT, the heterogeneity of cCBT programs for different anxiety disorders complicates interpretation of this finding. cCBT programs differ according to a number of factors, including the diagnostic target of treatment. Further studies comparing cCBT programs of varying lengths by specific program content and by diagnostic target are needed in order to better determine the unique effect of treatment duration as a moderator of treatment success.

Several important limitations of this study warrant consideration in interpreting the findings presented within this meta-analysis. First, there is a fair amount of heterogeneity among cCBT treatments, and this meta-analysis did not control for individual program-level factors (eg, specific program content, session length, and treatment quality) that may have influenced treatment outcomes. While Jadad ratings allow for rating the methodological quality of studies, there is not yet a standard rating system to indicate the quality of cCBT interventions. Therefore, no metric was available to control for the quality of the cCBT intervention delivered. Future research is needed to determine which cCBT treatment factors (eg, method and extent of therapist involvement, session length, treatment length, specific content included, client control over the pace of the program) best predict treatment outcomes for individuals with anxiety disorders.

Additionally, the results of any meta-analysis are limited by the quality of the underlying studies, and there are certain flaws inherent in the treatment studies included. One common issue associated with conducting cCBT treatment outcome studies is that the trials are not blinded. Wait-list controls also may not represent the most ecologically valid control condition, as computer-based interventions are very unlikely to have wait-lists in the community (the lack of a waiting period for treatment is, indeed, an advantage of cCBT treatments). Treatment as usual or medication management quite likely represents a more ecologically valid comparison condition, particularly given that cCBT is intended to overcome treatment access barriers that may prevent participation in traditional CBT. The effect size of cCBT in the treatment of anxiety disorders in this meta-analysis (ES = 0.92) compares favorably to that demonstrated for antidepressants in the treatment of anxiety disorders (ES = 0.65).[70] However, caution is warranted when comparing the effect sizes of different treatments in meta-analyses across trials. Differences in estimated effect size between interventions can be attributed not just to differences in actual efficacy but also to differences in study design and underlying sample population. For example, the control condition in medical trials (ie, placebo) is generally more rigorous than that in psychotherapy trials (ie, wait-list). Therefore, head-to-head trials comparing the efficacy of cCBT and antidepressant medication would be imperative in making an informed clinical choice between the 2 interventions.

Despite these limitations, the current meta-analysis demonstrated the efficacy of cCBT for treatment of anxiety disorders, did so in a larger group of studies than has ever been previously analyzed, and allowed for important moderator analyses that were previously untenable. The findings of this meta-analysis have meaningful implications for mental health care, particularly in remote regions with limited access to well-trained CBT providers. The results of this meta-analysis are largely consistent with earlier meta-analyses of cCBT, indicating that the effectiveness of cCBT has held up in light of dozens more studies examining its efficacy in treating individuals with anxiety disorders. As discussed in the previous sections, future studies are needed to address the shortcomings of the existing cCBT literature, and to provide a more complete picture of the treatment factors and patient factors that influence cCBT's efficacy.

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