Meta-analysis on cognitive behavioral treatment and behavioral intervention technologies for anxious youth: more than a BIT effective

Jones MK, Dickter B, Beard C, Perales R, and Bunge EL*

Department of Clinical Psychology, Faculty of Palo Alto University, 1791 Arastradero Road, Palo Alto, CA, USA

Abstract

Anxiety disorders in youth are linked to impaired social and academic functioning; however, only 20% of individuals with these disorders receive treatment. The current stigma of seeing a psychologist or the accessibility of resources may represent barriers to treatment. This study aimed to review and compare the effects of Face-to-Face Cognitive Behavioral Therapy (F2FCBT) and Behavioral Intervention Technologies (BITs) for youth anxiety disorders. BITs are electronic interventions (e.g. mobile phones, internet, virtual reality) that aim to help the user improve mental and physical health. Little research comparing the effects of the two types of modalities has been conducted previously. Methods: Systematic review methods and meta-analysis techniques were used to analyze thirty-four randomized controlled trials that included F2FCBT and/or BITs therapy. Results: Both types of interventions were effective for the reduction of childhood anxiety, with the overall effect for F2FCBT indicating less post-test anxiety (F2FCBT $g = -.84$ and BITs $g = -.40$). A subgroup analysis revealed that there were significant effect sizes for F2FCBT and for the combination of the two modalities, but not for BITs alone. Conclusion: Although F2FCBT has shown a larger effect size, BITs with guided therapist help can be an effective modality for delivering treatment for youth with anxiety disorders.

Abbreviations: F2F: face-to-face; F2FCBT: face-to-face cognitive behavioral therapy; BITs: behavioral intervention technologies; cCBT: computerized cognitive behavioral therapy; NEB: non-evidence based control condition; WLC: waitlist control condition

Introduction

Approximately three percent of children and adolescents suffer from an anxiety disorder before adulthood [1]. Anxiety lifetime prevalence rates span from 5.9% to 25.1%, often leading to poor outcomes in social and academic functioning, increased risk of serious mental illness and substance use disorder [1–3]. Although anxiety disorders cost more than one-third of the United States mental health bill (42 billion dollars), only 20% of youth with an anxiety disorder receive treatment [4]. The current stigma of seeing a psychologist and the accessibility of resources represent barriers to treatment. Early, effective, and engaging delivery of treatment for youth anxiety disorders are necessary due to the associated level of impairment. Currently, the leading psychosocial method for delivering treatment for youth anxiety is face-to-face (F2F) psychotherapy. Cognitive Behavioral Therapy (CBT) is the F2F treatment with the strongest empirical support [5–7].

Behavioral Intervention Technologies (BITs) have been developed as an alternative method of delivering evidence based treatments for anxious youth. BITs are electronic interventions (e.g. mobile phones, internet, virtual reality) that aim to help the user improve mental and physical health [8]. BITs have been shown to increase the reach of mental health resources, thus representing a potential benefit [9]. Additionally, there is an increase of applications being developed surrounding health (e.g. there are over 160,000 new health applications) [10], but most of these applications have not been tested, therefore there is a need to know the impact and efficacy of such applications.

Electronic interventions such as Cool Teens, BRAVE-ONLINE, and Camp Cope-a-Lot are just a few of the examples of evidence-based BITs specifically designed to reduce anxiety symptoms in children and adolescents [11–13].

In the last 10 years, several meta-analyses and reviews have focused on the utilization of BITs [2,3,7,14–20]. Most of the meta-analyses addressed the effectiveness of BITs for comorbid anxiety and depression. Ebert and colleagues [14] concluded that computerized CBT (cCBT) is an effective treatment for both disorders and an attractive alternative for younger generations. Similar results were found when using computerized therapies (e.g. self-help interventions) for anxiety and depression in youth [3]. Twenty-seven studies were analyzed, concluding that there were small positive effects for symptoms of anxiety and depression in young people but uncertainty around the effectiveness of cCBT in children. Likewise, Richardson, Stallard, and Velleman [16] found that cCBT yielded reductions in behaviors and cognitions related to anxiety and depression with moderate to high user satisfaction. Ye and colleagues [19] found that Internet-based interventions increased remission rates and decreased symptom severity for anxiety but did not affect depression symptoms.

Although there have been several meta-analyses reviewing BITs

---

interventions for comorbid disorders, only one completed a systematic review and meta-analysis looking at Internet-delivered CBT for childhood anxiety [17]. The review included seven studies and used interventions that were either fully delivered through technology (computer assisted program plus an online therapist) or technological interventions that included an in person contact (computer assisted program plus an in person facilitator). Though the results suggested that both therapies were effective, the researchers acknowledged that the diverse range of samples, heterogeneity in study designs, and inclusion of only seven studies were significant limitations. Additionally, the meta-analysis did not compare the effectiveness of BITs directly to any form of F2F treatment [17].

The BITs meta-analyses described above have several limitations. The majority used participants with co-morbid disorders (e.g. anxiety and depression) thereby limiting the known treatment effect on anxiety. Although anxiety and depression are highly comorbid, anxiety onset tends to be earlier developmentally in children and adolescents than depression. Also, there is a population of youth with solely anxiety and not depression, thus the efficacy of anxiety BITs treatments must be researched [21]. Many of the meta-analyses above mentioned treatment for youth and included young adults over the age of 17, making the results less representative of the children and adolescent population. Children and adolescents have varying cognitive skills and developmental differences exist that could change the outcome of treatment. Thus, separating the children and adolescent population from the young adult population and researching the differences in outcome for treatment using BITs modalities is imperative [22]. Additionally, the reviewed meta-analyses compared identical modalities (e.g. F2F vs. F2F; BITs vs. BITs) without cross comparison to determine the most effective treatment systems for youth with anxiety. The meta-analysis done by Rooksby *et al.* [17] focused only on childhood anxiety, not

adolescent anxiety, and did not compare BITs vs. F2F treatment. Lastly, previous meta-analyses did not compare inactive control groups to treatments, leading to data that does not identify the total effect of BITs treatment. This meta-analysis aims to address and expand on these limitations by comparing F2FCBT to BITs and BITs + F2FCBT interventions for anxious youth across age groups.

Methods

Selection process of articles

The search was limited to publications in English that evaluated the efficacy and effectiveness of F2FCBT and/or BITs treatment for youth anxiety. A computer-based information search was conducted in April 2015, which included (a) PsycINFO (b) PsycARTICLES (c) PsycBOOKS (d) Psychology and Behavioral Sciences Collections (e) Mental Measurements Yearbook with Tests in Print (f) Ebook Collection (EBSCOhost) (g) Academic Search Premiere (h) MEDLINE with Full Text (i) PsycTESTS (j) Ebook Academic Collection Trial (k) Funk and Wagnalls New World Encyclopedia (l) Health Source – Consumer Edition (m) Health Source: Nursing/Academic Edition by two of the study authors (MJ & BD). The references of the chosen studies were checked for other relevant publications. Details of the above search process are outlined in Figure 1.

To identify relevant articles, synonyms of the term "children and adolescents" crossed with "anxiety" were searched. This was followed by the search term "cognitive or behavioral or psychotherapy or treatment." The age range of participants within the studies was limited to birth through 17 years. Only peer-reviewed articles published between 1990 and 2015 were used. This search yielded an initial pool of 2824 articles. Duplicate articles were automatically removed by the search program, and titles and abstracts were screened for relevance
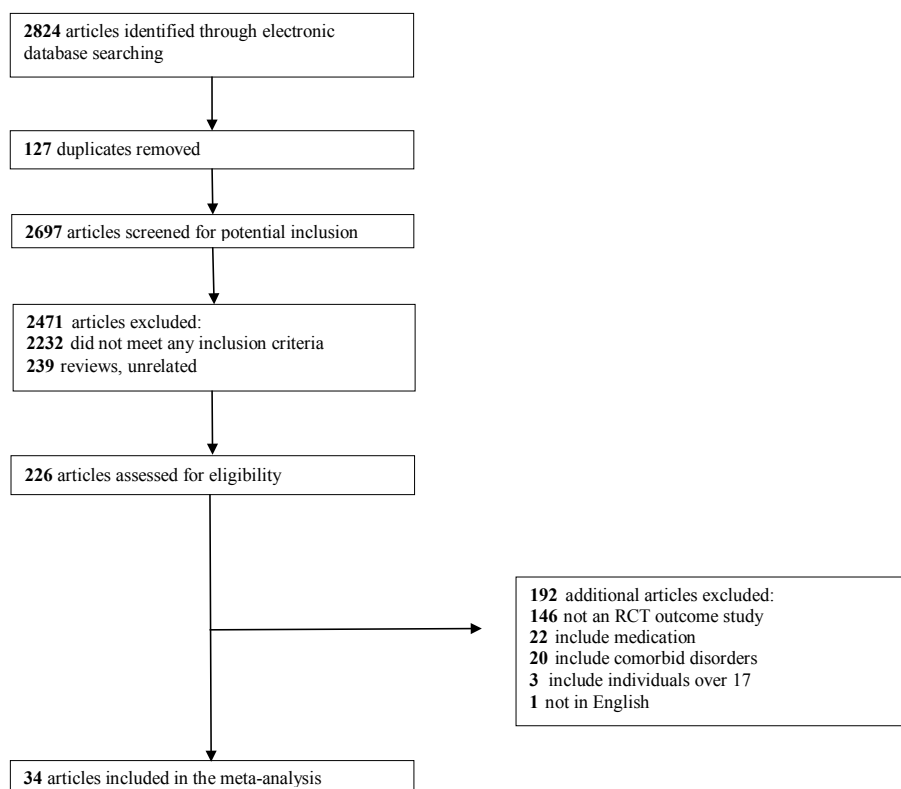

Figure 1. Method of article retrieval and inclusion in meta-analysis, April 2015.

by the authors, resulting in a pool of 226 articles (See Figure 1). The articles were each individually read and several were removed, as they did not meet the inclusion/exclusion criteria. Authors of articles with incomplete data sets were contacted to obtain means and standard deviations necessary for effect size calculations. A final set of 34 articles was included in this meta-analysis. These articles were divided into two groups: 24 F2FCBT publications and 10 BITs publications.

Inclusion/exclusion criteria

The search process for this meta-analysis was modeled after the one used by Richardson *et al.* [16]. Individuals who were 17 and younger and diagnosed with an anxiety disorder were included in the analysis. Studies that included participants who had a learning disability or a neurological disorder were excluded. Studies consisting of participants with comorbid disorders such as depression or attention-deficit hyperactivity disorder were excluded to isolate the effect on anxiety alone. In order to assess the direct effects of F2FCBT and BITs interventions, studies including medication were excluded, as this was an expected confounding variable. Studies that included a waitlist control condition (WLC) or a non-evidence based control condition (NEB) were included, in order to reduce potential confounding variables relating to treatment type. NEBs are defined as conditions currently not supported by the literature (e.g. Education Support Therapy, Computer-assisted Education/Support/Attention, or Family-based Education/Support/Attention). Finally, only articles that assessed the outcome of anxiety following CBT and/or BITs were included; pilot studies, case studies, and prevention research were excluded.

An article was considered BITs research, when the target of the intervention received active treatment alone using BITs. It was considered F2FCBT if the target client received active treatment from another person, either therapist or parent. If an intervention was targeted at child behavior but acted via the parents of that child, it was included as a F2FCBT study. Finally, a study was considered a combined treatment when the target child or adolescent at various times throughout the intervention received treatment through BITs or from another person.

Results

The studies included in this meta-analysis that are considered F2FCBT, used CBT in varying modalities including manuals such as "Coping Koala" [19] and "Coping Cat" [20]. Treatments were given in several formats including individual, group, and family. Treatment length ranged from 3 to 18 weekly sessions that were 60 minutes to 2 hours long. Included BITs studies used CBT in varying modalities such as computer programs and Internet video games. Treatments were given individually and ranged from single 3 hours sessions to 12 weekly hour sessions (refer to Table 1 for more information on the components of each treatment).

Methodological quality

Methodological quality was calculated using a 19-item author-developed measure that was adapted from relevant items from the Quality of Cohort Studies (Q-Coh) [21] and a previous meta-analysis with a researcher-created quality rating system [22]. Adaptation of these previous established measures helped ensure consistency in the items with relevancy to the studies included in the analysis. The final quality rating form included categories of study design (2 points), comparability of groups (2 points), treatment quality (3 points), measurement (8 points), attrition (3 points), and analyses (3 points).

Two raters (MJ & BD) used a blind rating system in order to calculate an overall methodological quality score for each study. A two-way mixed Intraclass Correlation Coefficient (ICC) was calculated using a two-way mixed, absolute design [23], which indicated consistent inter-rater reliability (ICC= .919). The overall mean of study quality was 15.61 with the lowest study receiving a score of 10 and the highest a score of 18. Further review revealed themes in methodological soundness, including agreement on 33 studies that did not include alternate forms on retest, 19 that did not include intention-to-treat, and 13 with treatments that were not manualized, as the highest categories of lost points. Studies had many different patterns of scores across domains, indicating the need for a standardization of F2F and BITs randomized, controlled designs in future research. However, the mean score of 15.61 indicated that most studies included in the final analysis had sound theoretical designs.

Data synthesis

The final analysis was conducted using REVMAN [24] and an inverse-variance weighted effect size model [25]. Effect sizes were calculated using post-test scores for the most relevant measure of childhood anxiety. A hierarchy of outcome measurements was created based on the most robust and reliable measures related to the construct in order to calculate a single effect size for each study. Pooled effect sizes were calculated for 11 studies that included more than one intervention within a subgroup category (e.g. family and individual F2FCBT). The overall analysis included 34 studies and a total of 1889 participants.

Heterogeneity and risk of bias

A random effects model was used due to significant heterogeneity in the overall model (T^2=0.20, X^2(33) =104.84, p < .05, I^2 = 69%). Standard mean differences (Hedges' adjusted *g*) were calculated as unbiased estimates of effect size in order to account for small sample sizes [26]. Subgroup analyses were conducted in order to identify specific areas of heterogeneity based on treatment type, control comparison, and age. Inconsistency was measured using the I^2 statistic, which ranged from 56-86%, indicating substantial to considerable heterogeneity across all groups [27]. It is also possible that the heterogeneity was present due to the variety of measures used in the assessment of childhood anxiety (i.e. wideband vs. specific, such as ADIS-CSR vs. FSSCR), however studies were not separated by type of measure. Subgroup differences are described below and in Table 2.

A funnel plot was generated in order to determine evidence of bias for F2FCBT and BITs. An overall analysis of risk of bias was tested using Egger's regression test for asymmetry [28] through the Meta-Essentials program for independent groups [29]. The test indicated no bias for small study sizes based on standard error estimates (t = 1.61, p = .118). Interpretation of the funnel plot indicated an overall acceptable distribution. A visual representation of the funnel plot is included in Figure 2.

Primary comparison

Face-to-face CBT was compared to BITs using two distinct models. The first model included 24 F2FCBT studies of single or pooled interventions that did not include any technological intervention. The second group (BITs Total) included 10 studies that had any degree of technological intervention [5,13,30–37]. Both types of intervention were effective for the reduction of childhood anxiety. Subgroup differences in this category were significant (χ^2(1) =5.78, p = 0.02), with the overall effect for F2FCBT indicating less post-test anxiety (*g* =

Jones MK (2016) Meta-analysis on cognitive behavioral treatment and behavioral intervention technologies for anxious youth: more than a BIT effective

Table 1. Evidence-Based CBT studies for anxiety disorders in youth.

Authors	Age	% of Boys	Study Conditions	n	Components	Primary Outcome Measure
F2FCBT						
[35]	7-14	53	**GCBT** **GCBTF** **WLC**	19 15 16	GCBT condition used *Coping Koala Group Workbook.* GCBTF condition used *Group Family Anxiety Management workbook.* Two-hour weekly sessions for 12 weeks.	FSSC-R
[36]	7-14	56	**ICBT** **ICBTF** **WLC**	28 25 23	ICBT condition used *Coping Koala Workbook.* ICBTF condition received the same workbook along with Family Anxiety Management therapy sessions. 60 to 80 minute weekly sessions.	FSSCR
[37]	8-12	40	**SET-C** **Test-busters**	30 20	SET-C includes one child and parent educational session, social skills training, and in vivo exposure. Test-buster was a NEB control involving study skills techniques.	ADIS-CSR
[38]	8-14	51	**ICBT** **GCBT** **WLC**	13 12 12	Both groups received *Coping Cat Workbook* to aid them in psychoeducation and learning coping techniques for anxiety; 18 weekly 60 minute sessions for the ICBT and 90 minutes sessions for the GCBT.	RCMAS
[39]	8-11	47	**GCBT** **WLC**	12 11	Treatment Consisted of psychoeducation and exposure. Three 3 hour sessions to groups of five to seven children. Homework included.	ADIS-CSR
[40]	12-17	40	**ITG** **WLC**	39 16	ITG included cognitive restructuring, psychoeducation, exposure, and relapse prevention. 8-day intensive treatment, 2 to 6 hours of treatment a day with a total of 20 hours of treatment.	ADIS-CSR
[41]	8-12	43	**CBTI** **CBTG** **AP**	21 20 16	CBTI condition participated in twelve 50 minutes sessions. CBTG condition participated in ten 90 minute sessions. Both conditions used a manual based on *The C.A.T.* Project *Manual for the Cognitive Behavioral Treatment of Anxious Adolescents.*	SPAI-C
[42]	9-13	60	**CBT** **WLC**	27 20	CBT condition used *Coping Cat* Workbook. Therapy included psychoeducation about anxiety, cognitive restructuring, and learning coping techniques. Seventeen hour long weekly sessions.	FSSC-R
[43]	9-13	62	**CBT** **WLC**	60 34	Used *The Coping Cat* Workbook in eight weekly sessions consisting of psychoeducation, practicing skills, and in vivo exposure.	FSSC-R
[44]	7-14	56	**ICBT** **FCBT** **FESA**	50 49 39	The ICBT condition followed the *Coping Cat Workbook* manual and the FCBT condition followed an anxious children manual as well as referred to *Coping Cat Workbook.* Sixteen weekly 60-min sessions, included psychoeducation, skill building, and exposure.	ADIS- CSR
[45]	6-17	18	**CBT** **ES**	20 21	CBT consisted of exposure activities and coping skills training. Homework assignments were given to encourage engagement in the treatment and to build the participants coping skills.	FSSC-R
[46]	6-11	53	**CBT** **WLC**	24 21	Treatment focused on psychoeducation, exposure and coping. Nine two-hour sessions that including puppet play, worksheets, and games.	SCAS
[47]	13-17	25	**SASS** **WLC**	18 17	Treatment focused on psychoeducation, realistic thinking, social skills training, exposure, and relapse preventions. Twelve weekly group school sessions, two brief individual meetings, two group booster sessions, four weekend social events.	ADIS
[48]	14-16	16	**SASS** **AC**	17 15	Treatment focused on psychoeducation, realistic thinking, social skills training, exposure, and relapse preventions. Twelve weekly group school sessions, two brief individual meetings, two group booster sessions, four weekend social events.	SPAI-C
[49]	9-12	33	**GCBT** **ED** **NTC**	10 10 10	Treatment adapted from the *Coping Cat* program for Australian youth. Twelve sessions focused on recognition of anxious feelings, bodily reactions to anxiety, cognitive restructuring, coping self-talk and exposure,	STAIC
[50]	7-16	45	**OST** **EST** **WLC**	85 70 41	Forty-five minute session with rapport building and analysis of phobia and one three-hour sessions including graduated exposures targeted towards the subject's phobia.	ADIS-CSR
[51]	7-17	39	**OST** **POST** **WLC**	21 20 19	Forty-five minute session with rapport building and analysis of phobia and one three-hour sessions including graduated exposures targeted towards the subject's phobia.	FSSC-R
[52]	7-16	41	**CBT** **WLC**	95 15	Treatment included psychoeducation, cognitive restructuring, and exposure. Families received nine 90-minute weekly group sessions.	FSSC
[34]	5-7	42	**CBT** **WLC**	13 21	Four weeks of child-only psychoeducation, four weeks of parent-only psychoeducation, four weeks of parent-and-child sessions focused on exposures and relapse prevention, and four weeks of parent-only sessions focused on conducting exposures at home.	RCMAS
[53]	6-10	40	**FGCBT** **WLC**	53 12	Treatment was based on the *Coping Cat* CBT program. Ten weekly sessions and two booster sessions at 1 and 3 month follow-up.	RCMAS
[54]	6-16	60	**GCBT** **WLC**	25 16	Children and parents met in separate groups that used natural group processes to discuss anxiety, self-evaluation, self-rewards, and facilitating exposure training at home.	FSSC-R
[55]	6-16	51	**SC** **CM** **ES**	32 33 16	SC sessions focused on developing SC skills that can be used out of session and CM session focused on parental positive reinforcement and shaping of fear-confronting behavior in the context of graduated exposures.	FSSC-R
[56]	7-14	61	**PI** **PNI** **WLC**	17 19 14	Sessions focused on social and problem-solving skills and social practice of learned skills. Weekly homework assigned. PI group taught parents to model and target child practice of skills, ignore anxiety-related behaviors, encourage child participation in social activities. Twelve 90-minute sessions followed by two booster sessions 3- and 6-months post treatment.	ADIS- CSR
[57]	4-8	47	**Parent + child** **Parent only** **WLC**	24 25 11	Parent + Child conditions are ten weekly sessions focusing on psychoeducation, relaxation skills, exposure, and social skills training. Parents received information on child anxiety, management techniques, positive parental coping skills, and communication and problem-solving skills. Parent Only condition covered same material without the child involved.	ADIS-CSR
BITs						
[25]	8-10	42	**ABM** **Control**	18 16	In ABM training, participants did a dot probe task with a face stimuli to reduce arousal. Contained four 60 minute over the course of two weeks	STAIC
[30]	10-17	36	**LGE** **CAVE** **WLC**	8 9 8	Participants conducted vicarious exposure by guiding computer avatars towards virtual spider pictures, plastic spiders, dead spiders, and live spiders. Participants used the computer for three sessions.	SPQ-C

[28]	3-6	46	**NET**	23	NET condition used BRAVE-ONLINE program. Ten weekly hour-long sessions consisting of Internet exercises, quizzes, homework, and games. Parents completed six weekly hour-long sessions. Parents consulted with a therapist via telephone to aid in development of an exposure hierarchy.	ADIS - CSR
			WLC	27		
[31]	10-15	36	**ETG**	18	Treatment included psychoeducation, exposure using virtual reality, training of coping techniques, and relaxation. Three sessions long.	FSSC-R
			WLC	18		
[11]	7-13	67	**ICBT**	17	Animation, videos, and cartoon characters with video game rewards. Twelve 35 min sessions. First six sessions are completed independently with the final six sessions completed with assistance from a therapist. Parents also received two sessions with the therapist.	ADIS-CSR
			CCAL	16		
			CESA	16		
[29]	7-12	45	**NET**	30	Internet exercises, quizzes, homework, and games. Adolescents complete ten weekly hour-long sessions, while parents complete six weekly hour-long sessions. Therapists provide feedback as well as homework including two phone calls to the parents and the child participants.	ADIS - CSR
			WLC	29		
[27]	12-18	41	**NET**	41	NET condition used BRAVE-ONLINE program. Booster sessions took place at 1 and 3 months after participants received treatment. Parents received five 60-minute sessions. Therapist provided feedback on homework through email. Participants received ten weekly 60-minute sessions.	ADIS-CSR
			CLIN	40		
			WLC	24		
[32]	12-15	28	**CBM**	73	ABM condition participants did a dot probe tasks with a face stimuli, along with CBM-I word fragment completion. Participants took part in two session per week over the course of ten weeks	RCADS
			CBT	69		
			Control	58		
[26]	7–13	38	**ATP**	12	ABM condition participants did a dot probe tasks with a face stimuli to lower arousal. Participants took part in four sessions a week for a total of three weeks.	ADIS-CSR
			ATC	12		
[5]	6-17	43	**ATP + OST**	17	Used one-session treatment manualized by Ost & Ollendick. Treatment consisted of a forty-five minute session that consisted of rapport-building and a brief functional analysis of the child's phobia and one three hour sessions that included graduated exposures targeted towards the subject's phobia.	ADIS-CSR
			ATC + OST	17		

Note: ABM: Attention Bias Modification Training, AC: Attention Control, ADIS-CSR: Anxiety Disorders Interview Schedule for Children-Clinician Severity Rating, AP: Attentional Placebo, ATC: Attention-Training-Control Condition, ATP: Attention-Towards-Positive Condition, BITs: Behavioral Intervention Treatments, CAVE: Computer-Aided Vicarious Exposure, CBM: Cognitive Bias Modification, CBTG: CBT-Group, CBTI: CBT-Individual, CCAL: Computer CBT (Camp Cope-a-Lot), CESA: Computer-assisted Education/Support/Attention, CLIN: Clinic-based Treatment, CM: Exposure-based Contingency Management, ED: Psychological Placebo, ES: Education Support Therapy, EST: Education Support Therapy, ETG: Exposure Treatment Group, FCBT: Family CBT, FESA: Family-based Education/Support Attention, FGCBT: Family GCBT, FSSC-R: Fear Survey Schedule for Children-Revised, GCBT: Group Cognitive-Behavioral Therapy, GCBTF: GCBT + Family, ICBT: Individual CBT, ICBTF: ICBT + Family, ITG: Immediate Treatment Group, LGE: Live-Graded Exposure, NEB: Non-evidence based control, NET: Internet-based Treatment, n: Posttreatment Sample Size, NTC: No Treatment Control, OST: One Session Treatment, PI: CBT + Parent Involvement, PNI: CBT + Parent Not Involved, POST: Parent + OST, RCADS: Revised Children's Anxiety and Depression Scale, RCMAS: Revised Children's Manifest Anxiety Scale, SASS: Skills for and Academic Success, SC: Exposure-based Cognitive Self-Control, SCAS-C: Spence Children's Anxiety Scale-Child Version, SET-C: Social Effectiveness Therapy for Children, SPAI-C: Social Phobia and Anxiety Inventory for Children, SPQ-C: Spider Phobia Questionnaire for Children, STAIC: State-Trait Anxiety Inventory for Children, WLC: Waitlist Control
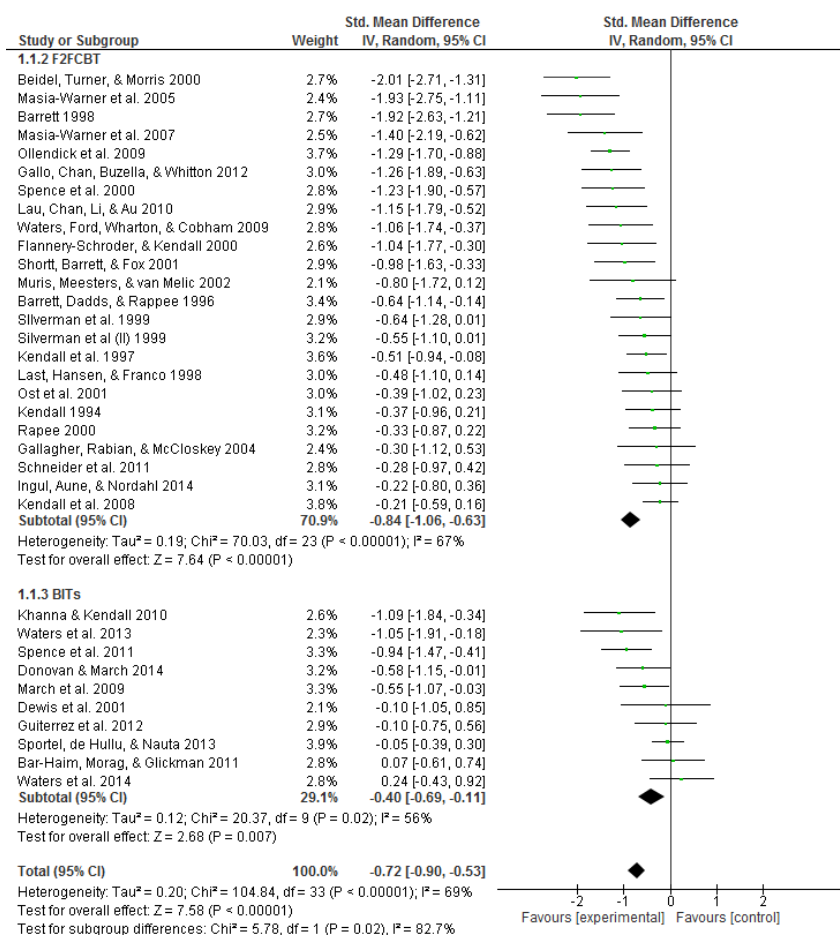

Figure 2. Forest Plot for F2FCBT vs. BITs Treatment.

-0.84, 95% C.I. = -1.06, -0.63) than interventions that included BITs (g = -0.40, 95% CI: -0.69, -0.11).

A second analysis separated the groups into F2FCBT (n = 24), BITs only, (n = 5), and BITs and F2FCBT combined (n = 5). The differences between these groups reached marginal significance ($\chi^2(2)$=5.21, p = 0.07). However, interpretation of these results should be cautious due to few studies in the BITs only and combined BITs and F2FCBT, with moderate heterogeneity still persisted with subgroups using this model (Table 2).

Secondary comparisons

Subgroup analyses were conducted for the control comparison groups as well as age differences following previous meta-analyses [14]. The control comparison groups were established to understand sources of heterogeneity based on NEB control or WLC comparisons across treatment type (F2FCBT or BITs total). The final model was also marginally significant ($\chi^2(3)$ = 6.58, p = 0.09), however the comparison did provide information about sources of heterogeneity. Inconsistency was measured using I^2, which can be visualized as the amount of overlap in the confidence intervals of study effects, and understood as the degree of variance in point estimates that is attributed to true heterogeneity [27]. The BITs with WLC group had the least amount of heterogeneity attributed to random error rather than differences between study groups (I^2=48%) while the F2FCBT group with a NEB control had the most amount of error-related heterogeneity (I^2=81%).

Subgroup comparisons were split into three age categories, including ages 0-11 (n = 11), 12-17 (n = 5), and a combined age group (n = 18). The subgroup analysis yielded no significant differences in treatment efficacy ($\chi^2 (2)$=1.29, p = 0.53).

Discussion

Due to the high prevalence rates of anxiety and the effectiveness of CBT in youth, it is imperative that researchers develop novel interventions that could make way for the future of psychology. Technology is becoming more associated with psychotherapy and mental health with over 160,000 new applications for treatment existing, but little research avilable to test the efficacy and impact of

such applications [10]. This meta-analysis analyzed different CBT modalities to further understand if new developments such as BITs are comparable to F2F psychotherapy for youth anxiety. Previous meta-analyses compared various BITs and F2F treatments separately, but none were focused on direct comparisons of these modalities. Also, previous meta-analyses included a small amount of BITs studies, whereas this meta-analysis included ten studies. Because CBT represents the most empirically supported approach for youth anxiety, this meta-analysis compared the efficacy of F2FCBT and BITs treatments for youth with anxiety disorders. Although anxiety and depression are often comorbid disorders, anxiety tends to be more prevalent in children and precedes the onset of depression [21]. Thus, assessing the impact of interventions only on anxiety may yield a better understanding of effectiveness of treatment for youth with anxiety disorders and potentially prevent the later onset of depression. This meta-analysis focused solely on the children and adolescent population as previous analyses have included young adults, thus making the results not completely representative of youth and not taking into consideration the differing cognitive skills between the children and adolescent population and young adults [22]. The results showed that both types of modalities were effective for the reduction of childhood anxiety, with the overall effect for F2FCBT indicating less post-test anxiety than BITs (F2FCBT g = -.84 and BITs g = -.40). Effect sizes of BITs for anxious youth were slightly lower than those found in a previous meta-analysis on computerized CBT for depression and anxiety in youth (g = 0.68) (14) and adults (g = 0.88) (38). In order to develop a better understanding of the unique contribution of BITs, we compared the studies using solely BITs with those combining BITs with some F2F component. A subgroup analysis revealed that there were significant effect sizes for F2FCBT (g = -0.84) and for the combination of the two modalities (g = -.41) but not for BITs alone (g = -.39). This is the first subgroup analysis done to identify the efficacy of the combined modality.

Based on these findings, although F2FCBT yields a higher effect size, a combined BITs and F2FCBT modality can be a useful treatment to decrease symptoms of anxiety in youth populations. Combined treatment has some potential benefits that may be taken into consideration such as greater accessibility, increased engagement of a tech savvy population, and decreased stigma of therapy with a

Table 2. Subgroup Comparisons.

	Nco	g	95% CI	Z	I2	Subgroup Differences
Overall effect**	34	-0.72	-0.90, -0.53	7.58**	69%	
Intervention Characteristics*						
Face to face	24	-0.84	-1.06, -0.63	7.64**	67%	$\chi^2(1)$=5.78, p=0.02
BITs total	10	-0.40	-0.69, -0.11	2.68**	56%	
Subgroup analysis†						
Face to face	24	-0.84	-1.06, -0.62	7.56**	68%	
BITs Only	5	-0.39	-0.87, -0.08	1.62	66%	$\chi^2(2)$=5.21, p=0.07
BITs and Face to face	5	-0.41	-0.81, -0.01	2.01*	52%	
Control Comparision†						
Face to face with WLC	18	-0.88	-1.10, -0.65	7.58**	58%	
Face to Face with non EB control	6	-0.76	-1.30, -0.22	2.76**	81%	
BITs with WLC	6	-0.40	-0.71, -0.08	2.47*	48%	$\chi^2(3)$=6.58, p=0.09
BITs with non EB control	4	-0.43	-1.12, 0.27	1.21	72%	
Age						
Ages 0-11	11	-0.71	-1.04, -0.38	4.17**	64%	
Ages 12-17	5	-1.07	-1.77, -0.36	2.97**	86%	$\chi^2(2)$=1.29, p=0.53
Ages combined	18	-0.64	-0.87, -0.41	5.37**	64%	

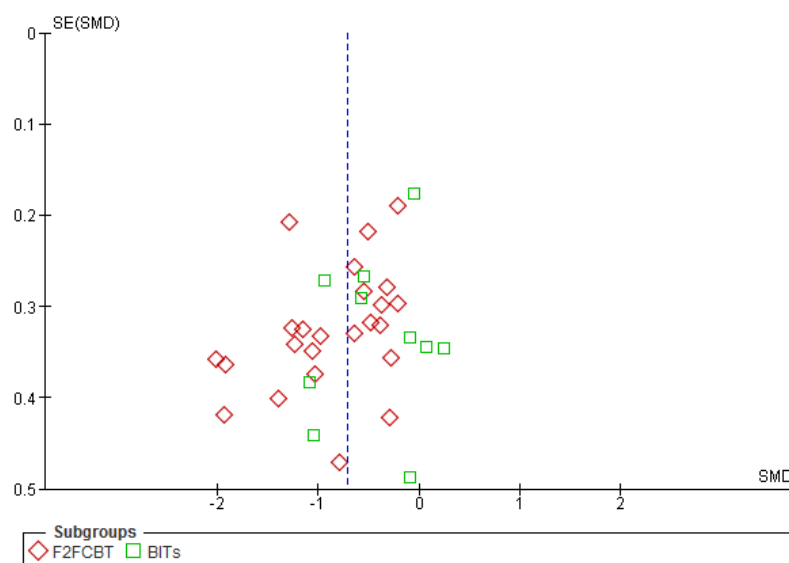†: 0.10 significance
*: 0.05 significance
**: 0.01 significance

Figure 3. Funnel Plot: Risk of Bias based on Subgroups.

mental health professional. For example, in cases where accessibility, engagement and stigma act as barriers to treatment, an online program such as BRAVE-ONLINE [33] can be effective in treating anxiety disorders. However, further research is necessary to determine these advantages.

Subgroup comparisons based on treatment and control type (F2FCBT, BITs, WLC, and NEB control) were conducted in order to gain insight into the sources of heterogeneity. The present study indicates a marginal effect for subgroup differences, with WLC groups representing a more homogenous effect; and studies that included NEB control groups had high levels of heterogeneity, which can be expected by the various methods employed as control comparisons across these studies. Studies on F2FCBT and BITs that used WLC had a larger effect size, than those that used NEB controls. Additionally, the F2FCBT studies that used NEB controls found significant effects of treatment, while BITs with NEB controls did not. This finding is congruent with findings that F2FCBT has a higher effect size than BITs. Another subgroup analysis showed that F2FCBT and BITs were effective across age groups with no significant difference between groups, which is expected given known effectiveness of CBT with this population [39]. This shows that BITs can be engaging for not only young children in elementary school but also adolescents in high school.

The inclusion of modern technologies familiar to today's youth may increase interest and engagement with mental health resources. Technologies that were used in BITs and combined treatments included in the present analysis may not be representative of modern technology. None of the studies in this meta-analysis included smartphones or tablets, which are currently a dominant form of Internet access for this population. It is possible that children and adolescents present differences in the utilization of technologies, thus affecting the impact of BITs used for the treatment of anxiety disorders. Thus assessing the impact and including up-to-date technologies in psychotherapy with youth may make BITs more user friendly and will increase the amount of interventions a mental health professional could deliver. Currently there is a wide selection of anxiety-directed smart phone and tablet applications that have yet to be empirically tested.

Limitations

There are several limitations that must be considered in the current meta-analysis. This analysis only included publications focused on CBT for youth anxiety disorders and did not take into consideration other types of treatments (psychosocial or psychopharmacological) for this specific population. Because our focus was to compare F2FCBT and BITs, we have excluded articles that were comparing active and evidence based control conditions. Within the 34 articles included in this analysis, significantly more treatments were F2FCBT (n= 24) rather than BITs (n= 10). This could have resulted in heavily weighted inaccurate BITs studies. Across studies, sample size varied greatly, which may have resulted in biased comparisons and increased heterogeneity. Although this analysis attempted to compare studies using common assessments tools, the wide breadth of assessments used by the various studies reviewed was a critical source of heterogeneity. With regard to treatment design, though methodological quality was assessed, all studies that passed the inclusion criteria were included in the current analysis due to a limited number of overall treatment studies. Future analyses would benefit from looking at methodological quality across the field of BITS and F2F research. Finally, this meta-analysis implemented several exclusion criteria in order to maintain consistency across articles. Variables such as psychopharmacology, learning disabilities, non-English studies, follow-up analyses, and active controls were excluded in order to increase homogeneity within the analysis. Intent-to-treat samples were not included and only data showing the outcome of participants who completed treatment within a study were used.

Clinical implications

The current meta-analysis suggests that youth with anxiety disorders may benefit from F2FCBT and the combination of F2FCBT+BITs treatments. While F2FCBT has higher efficacy rates, the combination of F2FCBT+BITs show significant improvement in anxiety and can provide increased accessibility to clients. However, BITs alone do not currently have a significant effect size, future research including newer technologies (e.g., smartphones or tablets) may yield more positive

outcomes and may help to increase therapy's reach. Various barriers exist to seeking treatment for children and adolescents with diagnosed anxiety. For example, those living in geographically remote locations may have difficulty attending treatments, which are generally focused within cities. In addition, F2F therapy can be expensive, inhibiting access for those with low-income levels. Additionally, the stigma of mental health treatment represents a barrier to the treatment-seeking process, especially among children and adolescents. In this respect, BITs have the ability to reach youth who may be struggling with these barriers and can simultaneously treat more individuals at a lower cost than F2F interventions.

Conclusion

This meta-analysis compared the available research of F2FCBT and BITs treatments for children and adolescents with diagnosed anxiety. While F2FCBT has a larger effect size, combined interventions (F2FCBT + BITs) show marginal significance and have the potential to lower barriers to effective anxiety treatments for youth. However, studies including BITs alone did not yield a significant effect size and were relatively small in number compared to F2FCBT studies. Therefore current evidence does not support the utilization of BITs as a stand-alone treatment and future research including newer BITs is imperative to draw further conclusions.

Conflict of interest

The author(s) confirm that this article content has no conflict of interest.

Acknowledgments

References

1. Merikangas KR, He JP, Burstein M, Swanson SA, Avenevoli S, et al., (2010) Lifetime prevalence of mental disorders in U.S adolescents: results from the National Comorbidity Survey Replication--Adolescent Supplement (NCS-A). *J Am Acad Child Adolesc Psychiatry* 49: 980-989. [Crossref]

2. Brendel KE, Maynard BR (2014) Child-Parent Interventions for Childhood Anxiety Disorders: A Systematic Review and Meta-Analysis. *Res Soc Work Pract* 1: 24: 287–295.

3. Pennant M, Loucas CE, Whittington C, Creswell C, Fonagy P, et al., (2015) Computerised therapies for anxiety and depression in children and young people: a systematic review and meta-analysis. *Behav Res Ther* 67: 1-18. [Crossref]

4. Massachusetts Child Psychiatry Access Project (2015) MCPAP June 2015 Newsletter. pdf. Massachusetts Child Psychiatry Access Project 1–5.

5. Waters AM, Farrell LJ, Zimmer-Gembeck MJ, Milliner E, Tiralongo E, et al., (2014) Augmenting one-session treatment of children's specific phobias with attention training to positive stimuli. *Behav Res Ther* 62:107–119. [Crossref]

6. In-Albon T, Schneider S (2007) Psychotherapy of childhood anxiety disorders: A meta-analysis. *Psychother Psychosom* 76: 15-24. [Crossref]

7. Ishikawa S, Okajima I, Matsuoka H, Sakano Y (2007) Cognitive Behavioural Therapy for Anxiety Disorders in Children and Adolescents: A Meta-Analysis. *Child Adolesc Ment Health* 12: 164–172. [Crossref]

8. Mohr D, Schueller S, Montague E, Burns M, Rashidi P, et al., (2014) The Behavioral Intervention Technology Model: An Integrated Conceptual and Technological Framework for eHealth and mHealth Interventions. *J Med Internet Res*: 16. [Crossref]

9. Munoz R, Bunge E, Chen K, Schueller S, Bravin J, et al., Massive Open Online Interventions (MOOIs): A Novel Model for Delivering Behavioral Health Services Worldwide. n.d.

10. Things are looking app: Mobile health apps are becoming more capable and potentially rather useful. The Economist 2016 Mar.

11. Wuthrich VM, Rapee RM, Cunningham MJ, Lyneham HJ, Hudson JL, et al., (2012) A randomized controlled trial of the Cool Teens CD-ROM computerized program for adolescent anxiety. *J Am Acad Child Adolesc Psychiatry* 51: 261–270. [Crossref]

12. Anderson REE, Spence SH, Donovan CL, March S, Prosser S, et al., (2012) Working Alliance in Online Cognitive Behavior Therapy for Anxiety Disorders in Youth: Comparison With Clinic Delivery and its Role in Predicting Outcome. *J Med Internet Res* 28 14: e88. [Crossref]

13. Khanna MS, Kendall PC (2010) Computer-assisted cognitive behavioral therapy for child anxiety: results of a randomized clinical trial. *J Consult Clin Psychol* 78: 737-745. [Crossref]

14. Ebert DD, Zarski AC, Christensen H, Stikkelbroek Y, Cuijpers P, et al., (2015). Internet and Computer-Based Cognitive Behavioral Therapy for Anxiety and Depression in Youth: A Meta-Analysis of Randomized Controlled Outcome Trials. Wallander JL editor *PLOS ONE* 10(3): e0119895. [Crossref]

15. Reynolds S, Wilson C, Austin J, Hooper L (2012) Effects of psychotherapy for anxiety in children and adolescents: a meta-analytic review. *Clin Psychol Rev* 32: 251-262. [Crossref]

16. Richardson T, Stallard P, Velleman S (2010) Computerised cognitive behavioural therapy for the prevention and treatment of depression and anxiety in children and adolescents: a systematic review. *Clin Child Fam Psychol Rev* 13: 275-290. [Crossref]

17. Rooksby M, Elouafkaoui P, Humphris G, Clarkson J, Freeman R, et al., (2015) Internet-assisted delivery of cognitive behavioural therapy (CBT) for childhood anxiety: Systematic review and meta-analysis. *J Anxiety Disord* 29: 83–92. [Crossref]

18. Ung D, Selles R, Small BJ, Storch EA (2015) A Systematic Review and Meta-Analysis of Cognitive-Behavioral Therapy for Anxiety in Youth with High-Functioning Autism Spectrum Disorders. *Child Psychiatry Hum Dev* 46: 533–547. [Crossref]

19. Ye X, Bapuji SB, Winters SE, Struthers A, Raynard M, et al., (2014) Effectiveness of internet-based interventions for children youth, and young adults with anxiety and/or depression: a systematic review and meta-analysis. *BMC Health Serv Res* 14: 313. [Crossref]

20. Yen C-F, Chen Y-M, Cheng J-W, Liu T-L, Huang T-Y, et al., (2014) Effects of Cognitive-Behavioral Therapy on Improving Anxiety Symptoms Behavioral Problems and Parenting Stress in Taiwanese Children with Anxiety Disorders and Their Mothers. *Child Psychiatry Hum Dev* 45: 338–347. [Crossref]

21. Higa McMillan CK, Francis SE, Rith-Najarian L, Chorpita BF (2016) Evidence Base Update: 50 Years of Research on Treatment for Child and Adolescent Anxiety. *J Clin Child Adolesc Psychol* 45: 91-113. [crossref]

22. Holmbeck G, Devine K, Bruno E. Developmental issues and considerations in research and practice (2010) In: Weisz J, Kazdin A, editors. Evidence-based psychotherapies for children and adolescents. 2nd ed. New York NY US: Guilford Press p. 28–39.

23. Hallgren KA (2012) Computing Inter-Rater Reliability for Observational Data: An Overview and Tutorial. *Tutor Quant Methods Psychol* 8: 23-34. [Crossref]

24. Review Manager (RevMan) (2014). Copenhagen: The Cochrane Collaboration.

25. Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions [Internet]. Version 5.1.0. The Cochrane Collaboration: 2011. Available from: www. cochrane-handbook.org

26. Hedges L, Olkin I. Statistical Methods for Meta-Analysis (1985). Orlando, FL.

27. Higgins JP, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. *BMJ* 327: 557-560. [Crossref]

28. Egger M, Davey Smith G, Schneider M, Minder C (1997) Bias in meta-analysis detected by a simple graphical test. *BMJ* 315: 629-634. [Crossref]

29. van Rhee H, Suurmond R, Hak T (2015) User manual for Meta-Essentials: Workbooks for meta-analyses.

30. Bar-Haim Y, Morag I, Glickman S (2011) Training anxious children to disengage attention from threat: a randomized controlled trial: Training anxious children to disengage attention from threat. *J Child Psychol Psychiatry* 52: 861–869. [Crossref]

31. Waters AM, Pittaway M, Mogg K, Bradley BP, Pine DS, et al., (2013) Attention training towards positive stimuli in clinically anxious children. *Dev Cogn Neurosci* 4: 77-84. [Crossref]

32. Spence SH, Donovan CL, March S, Gamble A, Anderson RE, et al., (2011) A randomized controlled trial of online versus clinic-based CBT for adolescent anxiety. *J Consult Clin Psychol* 79: 629-642. [Crossref]

33. Donovan CL, March S (2014) Online CBT for preschool anxiety disorders: a randomised control trial. *Behav Res Ther* 58: 24-35. [Crossref]

34. March S, Spence SH, Donovan CL (2009) The Efficacy of an Internet-Based Cognitive-Behavioral Therapy Intervention for Child Anxiety Disorders. *J Pediatr Psychol* 34: 474–487.

35. Dewis LM, Kirkby KC, Martin F, Daniels BA, Gilroy LJ, et al. (2001) Computer-aided vicarious exposure versus live graded exposure for spider phobia in children. *J Behav Ther Exp Psychiatry* 32: 17–27. [Crossref]

36. Gutierrez-Maldonado J, Magallón-Neri E, Rus-Calafell M, Peñaloza-Salazar C (2009). Virtual reality exposure therapy for school phobia. *Anu Psicol UB J Psychol* 40: 223–236.

37. Sportel BE, de Hullu E, de Jong PJ, Nauta MH (2013). Cognitive Bias Modification versus CBT in Reducing Adolescent Social Anxiety: A Randomized Controlled Trial. Mazza M editor PLoS ONE 8: e64355. [Crossref]

38. Andrews G, Cuijpers P, Craske MG, McEvoy P, Titov N, et al., (2010) Computer therapy for the anxiety and depressive disorders is effective acceptable and practical health care: a meta-analysis. *PLoS One* 5: e13196. [Crossref]

39. Schneider S, Blatter-Meunier J, Herren C, Adornetto C, In-Albon T, et al., (2011) Disorder-Specific Cognitive-Behavioral Therapy for Separation Anxiety Disorder in Young Children: A Randomized Waiting-List-Controlled Trial. *Psychother Psychosom* 80: 206–215. [Crossref]

40. Barrett PM (1998) Evaluation of cognitive-behavioral group treatments for childhood anxiety disorders. *J Clin Child Psychol* 27: 459-468. [Crossref]

41. Barrett PM, Dadds MR, Rapee RM (1996) Family treatment of childhood anxiety: a controlled trial. *J Consult Clin Psychol* 64: 333-342. [Crossref]

42. Beidel DC, Turner SM, Morris TL (2000) Behavioral treatment of childhood social phobia. *J Consult Clin Psychol* 68: 1072-1080. [Crossref]

43. Flannery-Schroeder EC, Kendall PC (2000) Group and individual cognitive-behavioral treatments for youth with anxiety disorders: A randomized clinical trial. *Cogn Ther Res* 24: 251–278.

44. Gallagher HM, Rabian BA, McCloskey MS (2004) A brief group cognitive-behavioral intervention for social phobia in childhood. *J Anxiety Disord* 18: 459-479. [Crossref]

45. Gallo KP, Chan PT, Buzzella BA, Whitton SW, Pincus DB, et al., (2012) The impact of an 8-day intensive treatment for adolescent panic disorder and agoraphobia on comorbid diagnoses. *Behav Ther* 43: 153-159. [Crossref]

46. Ingul JM, Aune T, Nordahl HM (2014). A Randomized Controlled Trial of Individual Cognitive Therapy, Group Cognitive Behaviour Therapy and Attentional Placebo for Adolescent Social Phobia. *Psychother Psychosom* 83: 54–61. [Crossref]

47. Kendall PC1 (1994) Treating anxiety disorders in children: results of a randomized clinical trial. *J Consult Clin Psychol* 62: 100-110. [Crossref]

48. Kendall PC, Flannery-Schroeder E, Panichelli-Mindel SM, Southam-Gerow M, Henin A, et al., (1997) Therapy for youths with anxiety disorders: A second randomized clincal trial. *J Consult Clin Psychol* 65: 366. [Crossref]

49. Kendall PC, Hudson JL, Gosch E, Flannery-Schroeder E, Suveg C, et al., (2008) Cognitive-behavioral therapy for anxiety disordered youth: A randomized clinical trial evaluating child and family modalities. *J Consult Clin Psychol* 76: 282–297. [Crossref]

50. Last CG, Hansen C, Franco N (1998) Cognitive-behavioral treatment of school phobia. *J Am Acad Child Adolesc Psychiatry* 37: 404-411. [Crossref]

51. Lau WY, Chan CK, Li JC, Au TK (2010) Effectiveness of group cognitive-behavioral treatment for childhood anxiety in community clinics. *Behav Res Ther* 48: 1067-1077. [Crossref]

52. Masia-Warner C, Klein RG, Dent HC, Fisher PH, Alvir J, et al., (2005) School-Based Intervention for Adolescents with Social Anxiety Disorder: Results of a Controlled Study. *J Abnorm Child Psychol*. 33: 707–722. [Crossref]

53. Masia Warner C, Fisher PH, Shrout PE, Rathor S, Klein RG, et al., (2007) Treating adolescents with social anxiety disorder in school: an attention control trial. *J Child Psychol Psychiatry* 48: 676–686. [Crossref]

54. Muris P, Meesters C, van Melick M (2002) Treatment of childhood anxiety disorders: A preliminary comparison between cognitive-behavioral group therapy and a psychological placebo intervention. *J Behav Ther Exp Psychiatry* 33: 143–158. [Crossref]

55. Ollendick TH, Öst LG, Reuterskiöld L, Costa N, Cederlund R, et al., (2009) One-session treatment of specific phobias in youth: A randomized clinical trial in the United States and Sweden. *J Consult Clin Psychol* 77: 504–516. [Crossref]

56. Ost LG1, Svensson L, Hellström K, Lindwall R (2001) One-Session treatment of specific phobias in youths: a randomized clinical trial. *J Consult Clin Psychol* 69: 814-824. [Crossref]

57. Rapee RM (2000). Group treatment of children with anxiety disorders: Outcome and predictors of treatment response. *Aust J Psychol* 52: 125–129.

58. Shortt AL, Barrett PM, Fox TL (2001) Evaluating the FRIENDS program: a cognitive-behavioral group treatment for anxious children and their parents. *J Clin Child Psychol* 30: 525-535. [Crossref]

59. Silverman WK, Kurtines WM, Ginsburg GS, Weems CF, Lumpkin PW, et al., (1999). Treating anxiety disorders in children with group cognitive-behavioral therapy: A randomized clinical trial. *J Consult Clin Psychol* 67: 995. [Crossref]

60. Silverman WK, Kurtines WM, Ginsburg GS, Weems CF, Rabian B, et al., (1999) Contingency management, self-control, and education support in the treatment of childhood phobic disorders: A randomized clinical trial. *J Consult Clin Psychol* 67: 675. [Crossref]

61. Spence SH, Donovan C, Brechman Toussaint M (2000) The treatment of childhood social phobia: The effectiveness of a social skills training-based, cognitive-behavioural intervention, with and without parental involvement. *J Child Psychol Psychiatry* 41: 713–726.

62. Waters AM, Ford LA, Wharton TA, Cobham VE (2009) Cognitive-behavioural therapy for young children with anxiety disorders: Comparison of a Child + Parent condition versus a Parent Only condition. *Behav Res Ther* 47: 654–662. [Crossref]