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# Effectiveness of the Coping Skills Training in Youth With Type 1 Diabetes: A Systematic Review and Meta-Analysis

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## ABSTRACT

**Objectives:** This study aimed to synthesize the effectiveness of coping skills training (CST) interventions on glycemic control, psychosocial variables, and diabetes self-management over 3, 6, and 12 months in youth with type 1 diabetes mellitus (T1DM).

**Method:** CINAHL, PubMed, Web of Science, Embase, PsycINFO, the Cochrane Central Register of Controlled Trials, and other gray literature sources were searched up to March 2025. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) was used to assess the certainty of evidence. A narrative synthesis was performed to evaluate the effectiveness of CST interventions on key outcomes, including glycemic control, psychosocial variables, and diabetes self-management compared with conventional diabetes education. Subgroup analyses were conducted using Review Manager 5.4 software to assess the effectiveness of CST over 3, 6, and 12 months for key outcomes.

**Results:** Ten randomized controlled trials (RCTs) from western and eastern countries, involving 1029 participants, were included. Compared with conventional diabetes education, CST reduced HbA1c levels over 3 months (mean difference [MD]: −0.29, 95% confidence interval [CI]: −0.56 to −0.02), with this effectiveness sustained at 6 (MD: −0.55, 95% CI: −0.88 to −0.21) and 12 months (MD: −0.56, 95% CI: −1.03 to −0.10). Significant improvements in self-efficacy (standardized MD [SMD]: 0.35, 95% CI: 0.01–0.68) and quality of life (SMD: 0.27, 95% CI: 0.01–0.54) were observed over 12 months. No significant differences were found in stress, depressive symptoms, or coping between groups over 3, 6, or 12 months. The quality of evidence ranged from very low to moderate.

**Conclusion:** The available evidence suggests that CST may contribute to improved glycemic control over 3 months, with possible sustained benefits observed over 6 and 12 months. For self-efficacy and quality of life, no significant improvements were observed over 3 or 6 months, though some positive effects emerged over 12 months. More RCTs are needed to evaluate the effectiveness of CST on anxiety and diabetes self-management.

Jiaxin Luo and Yan Jiang contributed equally to this work.

## 1 | Introduction

Type 1 diabetes mellitus (T1DM) is a chronic condition characterized by absolute insulin deficiency and is one of the most common chronic illnesses in childhood [1, 2]. Poor glycemic control in T1DM can lead to severe complications and premature mortality [3]. There are several interventions with an ultimate aim of improving glycemic control, focusing on developing strategies to improve diabetes self-management and psychological variables (e.g., stress, depressive symptoms, and anxiety) in youth with T1DM [4–6].

Psychological interventions have shown promise in improving glycemic control and quality of life across various age groups of T1DM patients (13.6–47.3 years) [7]. However, the specific impact of these interventions on youth (under 20 years) has not been separately synthesized. Among these psychological interventions, coping skills training (CST), a cognitive behavioral therapy–based intervention, has emerged as a promising intervention due to its emphasis on enhancing self-efficacy and developing adaptive coping mechanisms [8]. Theoretically, CST equips youth with problem-solving, communication, cognitive restructuring, and stress management skills, which are hypothesized to improve diabetes self-management behaviors and glycemic outcomes [9].

However, existing studies on CST in youth with T1DM report inconsistent results. While some randomized controlled trials (RCTs) report significant improvements in glycated hemoglobin (HbA1c) levels, quality of life, and diabetes self-management [10, 11], others show no measurable benefits [12]. A systematic review conducted in 2020 indicated that 67% (four out of six) of CST interventions improved coping and HbA1c over follow-up periods ranging from 3 months to 3 years [13]. However, no meta-analysis has comprehensively evaluated the effectiveness of CST on HbA1c, psychosocial variables, or diabetes self-management in youth with T1DM. Identifying the critical time points when CST's effectiveness is significant may offer valuable insights for its implementation in clinical practice.

This systematic review and meta-analysis aims to address these gaps by synthesizing evidence on the efficacy of CST in youth with T1DM. Specifically, we will (1) evaluate its effectiveness on HbA1c, psychosocial variables (including stress, depression, anxiety, self-efficacy, coping, and quality of life), and diabetes self-management; (2) assess the sustainability of these effectiveness over 3, 6, and 12 months. This work seeks to inform clinical practice and guide future research in improving the health and well-being of youth with T1DM.

## 2 | The Review

### 2.1 | Aims

The primary objective of this study was to synthesize existing research on CST for youth with T1DM and quantitatively evaluate its effectiveness in improving glycemic control, psychosocial variables, and diabetes self-management. Additionally, the study aimed to assess the effectiveness of CST on these outcomes over 3, 6, and 12 months through subgroup analysis.

### 2.2 | Design

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [14] and the Cochrane Handbook for Systematic Reviews of Interventions [15]. To ensure transparency and accountability, the study protocol was registered in PROSPERO with enrollment number CRD42023433647.

### 2.3 | Search Methods

A thorough systematic literature search was conducted across multiple electronic databases through a three-phase process, with the final search update completed in March 2025 to ensure inclusion of all relevant studies published up to that date.

The initial phase involved a targeted search within the PubMed and CINAHL databases, which included a meticulous examination of both the textual content of titles and abstracts and the indexing terms assigned to the articles. In the second phase, a comprehensive search was conducted across multiple English-language databases, including Web of Science, Embase, PsycINFO, and the Cochrane Central Register of Controlled Trials. The search strategy was developed based on predefined keywords and indexing terms. The third phase involved manually screening the reference lists of retrieved articles to identify any additional studies that might have been missing in the database search results. Additionally, the search was extended to include the retrieval of gray literature and unpublished studies via the ProQuest Dissertations and Theses electronic databases. The search strategy employed a combination of medical subject headings (MeSHs) terms and free-text words using the Boolean operators ("AND" and "OR") to form effective search queries. All searches were conducted independently by two authors (Jiaxin Luo and Yan Jiang) to ensure reliability.

The complete search strategy is provided in the File S1. Here is an example of a complete search strategy for a Pubmed database:

> #1 "diabetes mellitus, type 1"[MeSH Terms] OR "type 1 diabetes"[All Fields] OR "T1D"[All Fields] OR "insulin dependent diabetes"[All Fields]
>
> #2 "child*"[All Fields] OR "adolescen*"[All Fields] OR "teen*"[All Fields] OR "youth"[All Fields] OR "pediatric*"[All Fields] OR "school-age"[All Fields] OR "young people"[All Fields]
>
> #3 "adaptation, psychological"[MeSH Terms] OR "Coping Skills"[MeSH Terms] OR "stress, psychological/therapy"[MeSH Terms] OR "Cognitive Behavioral Therapy"[MeSH Terms] OR "coping skill* train*"[All Fields] OR "problem solv* train*"[All Fields] OR "communication skill*"[All Fields] OR "cognitive behavio*r modif*"[All Fields] OR "conflict resolution"[All Fields] OR "stress management"[All Fields] OR "psycho* education"[All Fields] OR "resilience training"[All Fields]
>
> #4 #1 AND #2 AND #3 AND (randomized controlled trial [Filter]).

### 2.4 | Eligibility Criteria

The inclusion criteria for this systematic review were defined using the well-established PICOS framework (Patient, Population, or Problem, Intervention, Comparison, Outcome, Study Design, or Setting) [16].

Studies were included if they met the following criteria: P: The participants were clinically diagnosed with T1DM and aged 8–20 years (subdivided into school-aged children [8–12 years] and adolescents [13–20 years]). I: The interventions involved structured CST programs containing at least three of five core modules (problem-solving skills, communication skills, cognitive–behavioral modification, conflict resolution, and stress management). C: The control groups received standard diabetes care, alternative non-CST interventions, or no active treatment. O: The outcome measures included, but were not limited to, the following variables: stress, depressive symptoms, anxiety, coping, self-efficacy, diabetes self-management, HbA1c, and quality of life. S: The study design was RCTs.

Exclusion criteria comprised: (a) participants with major comorbidities (e.g., thyroid disease and hypertension) that potentially confound outcomes; (b) studies that included a mixed sample of individuals with both T1DM and type 2 diabetes; (c) single-arm clinical trials, case series, reports, conference abstracts, or comments on other studies; (d) interventions focusing on cost-effectiveness or economic evaluations.

### 2.5 | Study Selection

The study selection process was strictly implemented in duplicate across all four phases (title/abstract screening, full-text review, reverse search, and critical appraisal). Each phase involved two reviewers, with training and experience in conducting and publishing systematic reviews and meta-analyses, independently performing parallel assessments. Before formal screening, a pilot test on 50 articles were performed and the criterion consistency was acceptable ($\kappa = 0.85$). Title/abstract screening required both reviewers to independently apply inclusion criteria to 10% of records ($\kappa = 0.85$), followed by full-scale duplicated screening. Full-text review involved two authors independently evaluating each article, with discrepancies resolved via consensus until $\kappa \geq 0.80$ (almost perfect agreement). Reverse search results were also verified in duplicate, and critical appraisal of methodological quality followed the same dual-review process, with disagreements adjudicated by a third reviewer.

### 2.6 | Quality Appraisal

Risk of bias was assessed independently by two reviewers using the Cochrane RoB 2.0 tool [17], with studies classified as low, high, or unclear risk across seven domains. To enhance objectivity, IRR was formally assessed: two reviewers independently evaluated a 20% random sample of studies using the same criteria. Cohen's $\kappa$ was calculated, with $\kappa \geq 0.75$ deemed acceptable [18]. The evidence level and grade of recommendation used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) standards, which cover five domains: risk of bias, inconsistency, imprecision, indirectness, and publication bias [19]. Evidence can be categorized into four levels: high, moderate, low, and very low. High-certainty evidence indicates that we are very confident that the true effect lies close to the estimate. Moderate-certainty evidence indicates that the true effect is likely to be close to the estimated effect, though possibly substantially different; low-certainty evidence implies limited confidence in the effect estimate, with a substantial likelihood that the true effect differs; very low-certainty evidence indicates very little confidence in the estimated effect, with a high probability that the true effect is markedly different. Risk of bias, assessed with the Cochrane tool, led to a downgrade if high-risk studies were judged to influence the pooled effects. Inconsistency, evaluated with $I^2$ estimates, resulted in a downgrade when $I^2$ was 60% or higher, indicating substantial heterogeneity. Indirectness was downgraded when factors related to participants, interventions, or outcomes affected the generalizability of the findings. Imprecision was downgraded if the 95% confidence interval (CI) included half or less of the minimal important difference for continuous outcomes or included a relative risk (RR) of 1 for dichotomous outcomes, or when the study included fewer than 400 participants, indicating an insufficient sample size. Publication bias was assessed by evaluating funnel plot asymmetry. Evidence certainty was downgraded if selective reporting was identified or if significant funnel plot asymmetry suggested unreported studies likely influenced the overall effect estimate. GRADEpro GDT (https://gradepro.org/) was used to generate a GRADE evidence table. Disagreements in quality assessments were arbitrated by a third reviewer.

### 2.7 | Data Extraction

The Effective Practice and Organization of Care's data collection checklist [20] was used as a framework to collate data and input it into a database. The essential characteristics of the included literature were determined by extracting data on study authors, publication year, study country, population, sample, inclusion and exclusion criteria, and intervention grouping. Research data on outcome variables including stress, depression, anxiety, coping, self-efficacy, diabetes self-management, HbA1c, and quality of life were extracted to compare the effectiveness of the included interventions. To ensure accuracy, IRR was evaluated by having both reviewers independently extract data from a 20% random sample of studies. Percentage agreement and Cohen's $\kappa$ were calculated, with $\kappa \geq 0.70$ considered acceptable [21]. Discrepancies were resolved through consensus, and the finalized extraction form was applied to all studies. A third reviewer resolved persistent disagreements.

### 2.8 | Synthesis

A descriptive analysis and classification of the data were performed for the systematic review. Meta-analyses were conducted using RevMan 5.4 software for outcomes reported in a minimum of two included studies [22]. For HbA1c, the mean difference (MD) was used as the effect size. A random-effects model was applied to estimate the pooled standardized MD (SMD) along with a 95% CI for the continuous variables of stress, depressive symptoms, coping, self-efficacy, and quality of life. These variables were assessed using different scales across studies, and the model accounted for the heterogeneity in measurement scales. The presence of a zero within the 95% CI was considered indicative of no significant difference. Statistical heterogeneity among the studies was tested using the $I^2$ statistic. A significance threshold of $p < 0.10$ (two-tailed) was predefined to address the heightened risk of Type 2 errors in underpowered meta-analyses of behavioral interventions. Conventional thresholds (e.g., $p < 0.05$) may fail to detect clinically relevant effects in such contexts due to limited statistical power [15]. Subgroup analyses

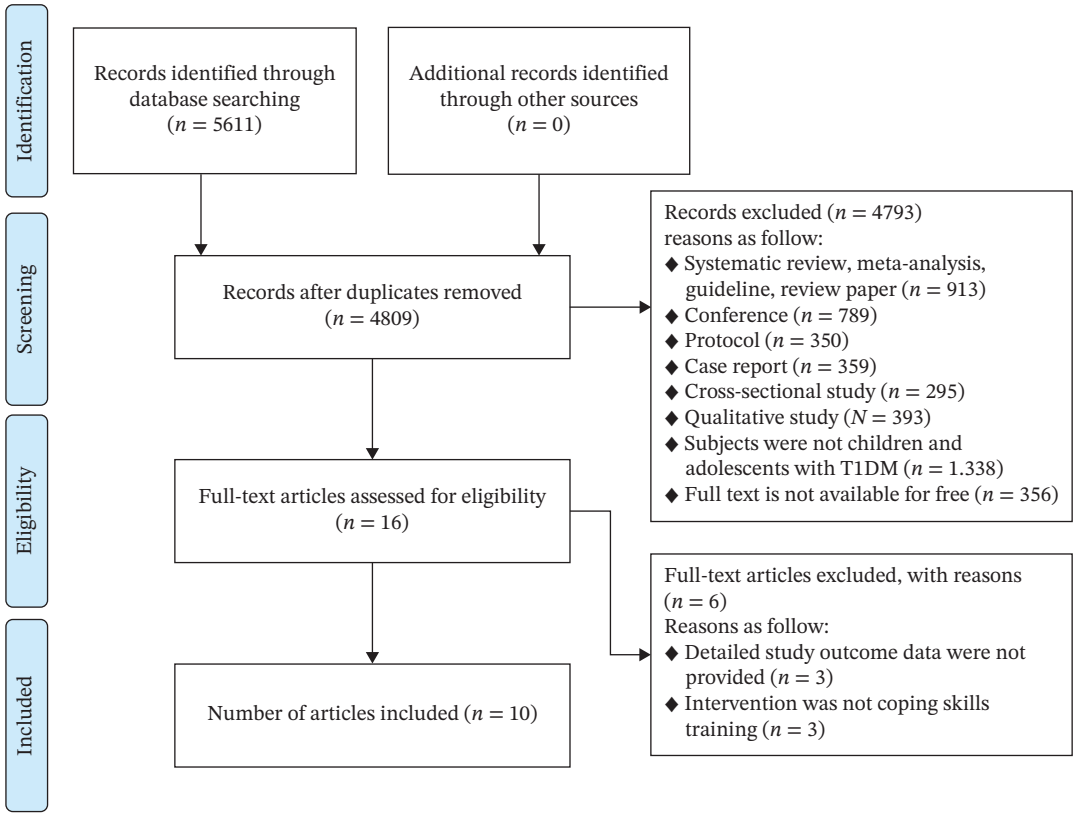



**FIGURE 1** | Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

were conducted for varying follow-up durations, categorized as 3, 6, or 12 months, to investigate potential heterogeneity within these subgroups. Subgroup analysis based on CST completeness (≥3 vs. <3 core modules) was not conducted due to an insufficient number of studies, which does not meet the minimum requirements for meta-analysis. Notably, a preliminary small-scale trial (eight in CST group versus nine in control group) which was conducted prior to the era of intensive insulin therapy, revealed that 25% (two out of eight) of the CST group experienced significant clinical deterioration following viral infections [23]. These events could have influenced HbA1c, stress, self-efficacy, and coping at the 3- and 6-month follow-up assessments, resulting in deviations from anticipated trends. To address concerns regarding potential bias introduced by these outliers, we conducted sensitivity analyses that excluded this study to assess the robustness of our findings [15]. Any potential publication bias was evaluated by visual inspection of the funnel plot for the primary outcome of HbA1c [24].

## 3 | Results

### 3.1 | Search Results

A total of 5611 studies were retrieved through the literature search. After eliminating duplicates, 4809 studies were identified as potentially relevant. Based on a review of the titles and abstracts, 16 studies were included for full-text review because they potentially met the inclusion/exclusion criteria. Six studies were excluded from the full-text review, leaving 10 studies. The sampling and screening procedures are summarized in the PRISMA flow diagram in Figure 1. In the various stages, we achieved very good interrater reliability, with Cohen's $\kappa$ ranging from 0.78 to 0.90.

### 3.2 | General Characteristics

Detailed features of the included studies are reported in Table 1. Ten studies were included in this systematic review, with a total of 1029 participants from four countries, including the USA ($n = 7$), China ($n = 1$), Australia ($n = 1$), and Iran ($n = 1$). Most of the studies were conducted at a single center, and the participants were enrolled through medical facilities, with the exception of one multicenter trial. In two studies, the sample included school-aged (8–12 years) participants; one study included both school-aged children and adolescents (13–20 years) participants, and the remaining seven studies included adolescents. The sample sizes of the studies ranged from 19 to 320. The age range of the participants varied from 8 to 20 years, and the mean age was 12.99 years. All participants had been diagnosed with T1DM for a duration of 3–12 months.

### 3.3 | Intervention Information

Of the 10 studies, nine fully adhered to the core components of CST, while one study partially implemented CST. Eight studies had intervention groups that underwent CST, which includes five components: cognitive behavior modification, problem-solving, communication skills, conflict resolution, and stress management. The remaining two studies had intervention groups that participated in experiences similar to CST but were labeled as stress management training (SMT) and the best of coping (BOC). The content of the SMT intervention encompasses

**TABLE 1** | Characteristics of the included studies.

| Author/year | Country | Population | Location of recruitment | Sample size | Mean age | Forms of intervention | Intervention intensity | Intervention team | Intervention duration | Evaluation time point | Category of measured outcomes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ambrosino et al., 2008 [25] | USA | T1DM children aged 8–12 years | The Yale Pediatric Diabetes Program | N0 = 54<br>N1 = 33 | N0: 9.91 ± 1.48<br>N1: 9.91 ± 1.40 | N0: CST<br>N1: GE | N0: six sessions, 1.5 h each;<br>N1: No | N0: mental health professional; N1: nurse practitioner | N0: no<br>N1: no | Baseline; 1 month; 3 months | 1. Coping<br>2. Self-efficacy<br>3. HbA1c<br>4. Quality of life |
| Edrki, 2018 | Iran | T1DM children aged 12–18 years | Diabetes Clinic | N0 = 50<br>N1 = 50 | N0: 14.36 ± 1.71<br>N1: 14.06 ± 1.99 | N0: CST<br>N1: SC | N0: eight sessions, twice a week, each session lasting 90 min;<br>N1: no | N0: pediatric nurse;<br>N1: no | N0: 4 weeks<br>N1: no | Baseline; 2 months | 1. Stress<br>2. Depression<br>3. Anxiety<br>4. Self-efficacy |
| Grey et al., 1998 [10] | USA | T1DM children aged 12–20 years | The Yale Children's Diabetes Clinic | N0 = 34<br>N1 = 31 | N0: 15.8 ± 2.1<br>N1: 15.0 ± 2.3 | N0: CST + IDM<br>N1: IDM | N0: 4–8 weekly sessions, monthly follow-ups;<br>N1: no | N0: master's-prepared nurse practitioner<br>N1: no | N0: no<br>N1: no | Baseline; 1 month; 3 months | 1. Depression<br>2. Coping<br>3. Self-efficacy<br>4. HbA1c<br>5. Quality of life |
| Grey et al., 1999 [26] | USA | T1DM children aged 12.5–20 years | The Yale Pediatric Diabetes Service | N0 = 42<br>N1 = 35 | N0: 16.2 ± 2.1<br>N1: 12.6 ± 2.3 | N0: CST + IDM<br>N1: IDM | N0: no<br>N1: no | N0: master's-prepared nurse practitioner<br>N1: no | N0: no<br>N1: no | Baseline; 1 month; 3 months; 6 months | 1. Depression<br>2. Coping<br>3. Self-efficacy<br>4. HbA1c<br>5. Quality of life |
| Grey et al., 2000 [27] | USA | T1DM children aged 12.5–20 years | The Yale Pediatric Diabetes Service and out of hospital | N0 = 41<br>N1 = 34 | N0: 14. 1 ± 1.8<br>N1: 14.6 ± 2.2 | N0: CST + IDM<br>N1: IDM | N0: six weekly sessions, monthly follow-ups<br>N1: no | N0: master's-prepared nurse practitioner<br>c | N0: 12 months<br>N1: 12 months | Baseline; 3 month; 6 months; 12 months | 1. Depression<br>2. Coping<br>3. Self-efficacy<br>4. HbA1c<br>5. Quality of life |
| Grey et al., 2009 [28] | USA | T1DM children aged 8–12 years | A Pediatric Diabetes Clinic | N0 = 53<br>N1 = 29 | N0: 9.9 ± 1.5<br>N1: 9.9 ± 1.4 | N0: CST + GE<br>N1: GE | N0: 6 weekly sessions N1: 4 weekly sessions | N0: mental health professionals<br>N1: advanced practice nurse | N0: 1 year<br>N1: 1 year | Baseline; 1 month; 3 month; 6 months; 12 months | 1. Depression<br>2. Coping<br>3. Self-efficacy<br>4. HbA1c<br>5. Quality of life |
| Guo et al., 2020 [11] | China | T1DM children aged 8–20 years | The Diabetes Center of Central South University in the Capital City of Hunan province | N0 = 50<br>N1 = 50 | N0:<br>1) School aged: 22<br>2) Adolescent: 28<br>N1:<br>1) School aged: 18<br>2) Adolescent: 32 | N0: CST + SC<br>N1: SC | N0: 2-day camp + 5 monthly calls<br>N1: no | N0: Four nurses with training<br>N1: no | N0: 12 months<br>N1: 12 months | Baseline; 6 months; 12 months | 1. Stress<br>2. Self-management<br>3. Coping<br>4. Self-efficacy<br>5. HbA1c<br>6. Quality of life |

(Continues)

**TABLE 1** | (Continued)

| Author/year | Country | Population | Location of recruitment | Sample size | Mean age | Forms of intervention | Intervention intensity | Intervention team | Intervention duration | Evaluation time point | Category of measured outcomes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Boardway et al., 1993 [23] | USA | T1DM children aged 12–17 years | The Endocrinology Division of Children's Hospital of Michigan | N0 = 9<br>N1 = 10 | N0: 15.44 ± 1.19<br>N1: 14.32 ± 1.71 | N0: SMT + RC<br>N1: RC | N0: no<br>N1: every 3 months | Multidisciplinary teams | N0: no<br>N1: no | Baseline;<br>3 months;<br>6 months;<br>9 months | 1. Stress<br>2. Coping<br>3. Self-efficacy<br>4. HbA1c |
| Serlachius et al., 2016 [29] | Australia | T1DM children aged 13–16 years | The Royal Children's Hospital | N0 = 30<br>N1 = 74 | N0: 14.63 ± 1.16<br>N1: 14.31 ± 1.12 | N0: BOC + SC<br>N1: SC | N0: five 2-h weekly sessions<br>N1: no | N0: health Psychologist<br>N1: Endocrinologist and diabetes team | N0: 3 months<br>N1: no | Baseline;<br>3 months;<br>12 months | 1. Stress<br>2. Self-efficacy<br>3. HbA1c<br>4. Quality of life |
| Whittemore et al., 2012 [12] | USA | T1DM children aged 11–14 years | Yale, The Children's Hospital of Philadelphia, University of Arizona, and University of Miami | N0 = 167 N1 = 153 | N0: 1) 11–12 years old: 95 (56.9%)<br>2) 13–14 years old: 72 (43.1%) N1: 1) 11–12 years old: 90 (58.8%)<br>2) 13–14 years old: 63 (41.2%) | N0: TEENCOPE<br>N1: MD | N0: five sessions over 5 weeks<br>N1: five sessions over 5 weeks | N0: health professionals<br>N1: no | N0: 6 months<br>N1: 6 months | Baseline;<br>3 months;<br>6 months | 1. Stress<br>2. Coping<br>3. Self-management<br>4. Self-efficacy<br>5. HbA1c<br>6. Quality of life |

*Note:* N0 means the intervention group; N1 means the control group.

all five components of CST, while the BOC intervention covers four of the five components, excluding stress management. The interdisciplinary teams that administered the interventions included pediatric endocrinologists, psychologists, nutritionists, social workers, nurses, and rehabilitation specialists. The intervention durations varied from 2 to 12 months. Face-to-face interventions involved small groups of two to nine participants, with sessions lasting 1–2 h and incorporating lectures, discussions, and role playing. The intervention frequencies ranged from twice per week to 4–8 times per week and seven sessions over 2 days. Remote interventions or follow-ups were conducted via telephone communication, occurring 1–5 times per month. One study, by Whittemore et al. [12], adopted an internet-based program presented in graphic novel format, featuring a diverse group of T1DM characters navigating challenging social situations and employing problem-solving strategies. The program consisted of five weekly interactive sessions that encouraged self-assessment and coping skills.

The instruction provided to the control groups encompassed self-monitoring of blood glucose, insulin dose calculation, diet, exercise, and other knowledge crucial for maintaining a healthy lifestyle. The content adhered to globally recognized guidelines for daily diabetes management [30]. Despite the consistency in content across the control groups, the original articles used various terms to describe it, including group education (GE; $n = 2$), standard care (SC; $n = 3$), intensive diabetes management (IDM; $n = 3$), routine care (RC; $n = 1$), and management of diabetes (MD; $n = 1$). The content was primarily delivered by trained pediatric nurses in an outpatient setting through face-to-face interactions, with each session lasting 15–30 min. The frequency varied from monthly to quarterly, although one study indicated a follow-up every 3 months. Notably, one control group received an internet-based diabetes education with five sessions per week for 5 weeks, including case studies and problem-solving exercises designed to enhance adolescents' decision-making skills related to diabetes. Table 2 presents the primary outcomes measured by each study, comparing the intervention group with the control group after the intervention.

### 3.4 | Study Quality

According to the GRADE evaluation, the evidence for HbA1c was rated as moderate certainty, downgraded due to serious publication bias. The evidence for quality of life and self-efficacy was also rated as moderate certainty, downgraded due to serious risk of bias and serious publication bias. The evidence for stress was rated as moderate certainty, downgraded due to serious imprecision and serious publication bias. The evidence for depression symptoms and coping was rated as low certainty category, downgraded for serious risk of bias, serious imprecision, and serious publication bias. The evidence for anxiety was rated as very low certainty, downgraded due to very serious imprecision and serious publication bias. Last, the evidence for diabetes self-management was rated as very low certainty, downgraded for serious inconsistency, very serious imprecision, and serious publication bias. Overall, the certainty of evidence ranged from very low to moderate, as summarized in Table 3.

All RCTs provided adequate details of random sequence generation, but one study (10%) did not provide details of allocation

**TABLE 2** | Inclusion of the primary outcome measured by the studies (intervention group vs. comparison group).

| Author/year | Stress | Depression | Anxiety | Coping | Self-efficacy | Self-management | HbA1c | Quality of life |
|---|---|---|---|---|---|---|---|---|
| Ambrosino et al., 2008 [25] | N/A | N/A | N/A | Baseline: 18.14 ± 12.53 vs. 17.33 ± 3.50; 1 month: 17.37 ± 3.92 vs. 16.92 ± 3.42; 3 months: 17.36 ± 3.93 vs. 16.38 ± 3.82 | Baseline: 26.94 ± 21.96 vs. 25.25 ± 20.62; 1 month: 24.61 ± 19.96 vs. 24.61 ± 19.96; 3 months: 24.96 ± 20.57 vs. 23.98 ± 19.86 | N/A | Baseline: 6.99 ± 1.32 vs. 7.08 ± 1.15; 1 month: 7.04 ± 1.29 vs. 7.30 ± 1.23; 3 months: 7.19 ± 1.03 vs. 7.39 ± 1.20 | Baseline: 35.58 ± 19.94 vs. 34.87 ± 21.97; 1 month: 34.69 ± 20.05 vs. 34.67 ± 21.32; 3 months: 35.05 ± 21.24 vs. 34.06 ± 21.85 |
| Edrki, 2018 | Baseline: 20.66 ± 13.62 vs. 23.14 ± 11.96 ($p = 0.34$); 2 months: 7.46 ± 7.01 vs. 21.10 ± 10.94 ($p < 0.001$) | Baseline: 18.15 ± 14.13 vs. 21.16 ± 13.62 ($p = 0.29$); 2 months: 5.41 ± 4.58 vs. 19.73 ± 11.80 ($p < 0.001$) | Baseline: 17.78 ± 12.66 vs. 19.67 ± 11.24 ($p = 0.43$); 2 months: 6.44 ± 7.01 vs. 18.28 ± 10.51 ($p < 0.001$) | N/A | Baseline: 47.76 ± 15.57 vs. 49.49 ± 16.08 ($p = 0.61$); 2 months: 70.82 ± 10.84 vs. 50.13 ± 15.42 ($p < 0.001$) | N/A | N/A | N/A |
| Grey et al., 1998 [10] | N/A | Baseline: 7.9 ± 1.3 vs. 6.6 ± 1.8; 3 months : 6.3 ± 1.3 vs. 6.0 ± 1.2 | N/A | Baseline: 18.45 ± 3.45 vs. 17.80 ± 3.27; 3 months: 15.40 ± 3.06 vs. 17.30 ± 3.00 | Baseline: 47.00 ± 34.96 vs. 49.33 ± 36.74; 3 months: 51.17 ± 37.27 vs. 48.93 ± 37.11 | N/A | Baseline: 8.9 ± 1.8 vs. 9.0 ± 1.6; 1 month: 7.7 ± 1.2 vs. 8.2 ± 1.3; 3 months: 7.6 ± 1.3 vs. 8.1 ± 1.3 | Baseline: 45.53 ± 20.83 vs. 44.47 ± 21.12; 3 months: 44.87 ± 21.68 vs. 43.37 ± 22.32 |
| Grey et al., 1999 [26] | N/A | Baseline: 7.6 ± 6.4 vs. 7.0 ± 5.6; 3 months: 5.7 ± 5.3 vs. 6.6 ± 6.0; 6 months: 5.2 ± 4.5 vs. 5.6 ± 6.3 | N/A | Baseline: 18.1 ± 3.87 vs. 18 ± 3.47; 3 months: 17.4 ± 3.27 vs. 17.1 ± 3.85; 6 months: 17.0 ± 3.56 vs. 16.95 ± 3.40 | Baseline: 46.73 ± 34.89 vs. 48.8 ± 36.74; 3 months: 49.17 ± 36.56 vs. 49.87 ± 37.68; 6 months: 51.9 ± 38.35 vs. 50.8 ± 38.07 | N/A | Baseline: 9.0 ± 1.7 vs. 8.9 ± 1.5; 3 months: 8.1 ± 1.4 vs. 8.4 ± 1.3; 6 months: 7.8 ± 1.6 vs. 8.3 ± 1.3 | Baseline: 46.5 ± 21.64 vs. 43.97 ± 20.58; 3 months: 43.7 ± 21.81 vs. 44.17 ± 21.94; 6 months: 43.67 ± 23.07 vs. 44.43 ± 21.82 |
| Grey et al., 2000 [27] | N/A | Less depression ($F = 9.29$, $p = 0.001$) | N/A | Less difficulty in coping with diabetes ($F = 3.58$, $p = 0.01$); less upset in coping with diabetes ($F = 4.55$, $p = 0.004$) | Significantly improved general self-efficacy ($F = 3.45$, $p = 0.02$), diabetes self-efficacy ($F = 9.44$, $p = .001$), and medical self-efficacy ($F = 19.2$, $p = 0.001$); after 12 months of follow-up: diabetes self-efficacy ($F = 5.33$, $p = 0.002$) and medical self-efficacy ($F = 2.79$, $p = 0.04$) | N (A) | Baseline: 9.1%±1.5% vs. 9.2 ± 1.4%; 6 months: 7.9%±1.0% vs. 8.4 ± 1.1%; 12 months: 7.5%±1.1% vs. 8.4% ± 1.4%; $p < 0.001$ | Greatest improvement in quality of life occurs during the first 3 months ($F = 10.7$, $p = 0.002$) but is maintained through the ensuing 9 months ($F = 3.8$, $p = 0.04$). Differences between the CST and control groups are statistically significant at 6 ($t = 2.07$, $p = 0.04$) and 12 months ($t = 2.49$, $p = .01$) |

(Continues)

**TABLE 2** | (Continued)

| Author/year | Stress | Depression | Anxiety | Coping | Self-efficacy | Self-management | HbA1c | Quality of life |
|---|---|---|---|---|---|---|---|---|
| Grey et al., 2009 [28] | N/A | Rate of change per year: −0.47 vs. −0.612, $p = 0.574$ | N/A | Rate of change per year: −1.235 vs. −1.6, $p = 0.68$ | Rate of change per year: 5.98 vs. 5.93, $p = 0.984$ | N/A | Rate of change per year: 0.52 vs. 0.29, $p = 0.265$ | Rate of change per year: −0.407 vs. −0.12, $p = 0.598$ |
| Guo et al., 2020 [11] | (1) School aged: 6 months: 23.05 ± 5.85 vs. 24.28 ± 5.57; 12 months: 23.57 ± 6.57 vs. 21.75 ± 8.29; (2) Adolescent: 6 months: 27.8 ± 7.54 vs. 26.38 ± 6.62; 12 months: 24.36 ± 6.78 vs. 29.06 ± 5.38; | N/A | N/A | (1) School aged: 6 months: 2.47 ± 0.85 vs. 2.07 ± 0.68; 12 months: 2.52 ± 0.55 vs. 2.16 ± 0.4; (2) Adolescent: 6 months: 2.3 ± 0.68 vs. 2.46 ± 0.5; 12 months: 2.46 ± 0.5 vs. 2.5 ± 0.53 | (1) School aged: 6 months: 2.93 ± 0.61 vs. 2.41 ± 0.46; 12 months: 2.76 ± 0.56 vs. 2.34 ± 0.65; (2) Adolescent: 6 months: 2.66 ± 0.63 vs. 2.73 ± 0.64; 12 months: 2.44 ± 0.45 vs. 2.55 ± 0.58 | (1) School aged: 6 months: 16.90 ± 7.90 vs. 2 ± 0.46; 12 months: 2.76 ± 0.56 vs. 2.34 ± 0.65; (2) Adolescent: 6 months: 2.66 ± 0.63 vs. 2.73 ± 0.64; 12 months: 2.44 ± 0.45 vs. 2.55 ± 0.58 | N/A | (1) School aged: 6 months: 19.48 ± 2.87 vs. 16.67 ± 4.00; 12 months: 18.62 ± 3.19 vs. 16.88 ± 4.49; (2) Adolescent: 6 months: 17.21 ± 3.69 vs. 16.81 ± 4.15; 12 months: 17.34 ± 3.48 vs. 16.97 ± 3.24; $p = 0.531$ |
| Boardway et al., 1993 [23] | 3 months: 80.5 ± 32.5 vs. 80.8 ± 37.8; 6 months: 64.0 ± 21.1 vs. 81.7 ± 40.2; 9 months: 56.1 ± 43.7 vs. 86.4 ± 31.3; $F(3.13) = 3.54, p < 0.05$ | N/A | N/A | 3 months: 16.3 ± 3.5 vs. 14.6 ± 6.9; 6 months: 22.8 ± 4.9 vs. 16.8 ± 10.4; 9 months: 14.1 ± 7.6 vs. 17.9 ± 6.6; no significant treatment effects | 3 months: 118.2 ± 15.9 vs. 116.0 ± 10.9; 6 months: 117.8 ± 10.5 vs. 119.8 ± 18.2; 9 months: 114.0 ± 12.4 vs. 117.4 ± 14.4; no significant treatment effects | N/A | 3 months: 14.13 ± 1.69 vs. 16.35 ± 3.85; 6 months: 16.50 ± 2.65 vs. 15.65 ± 3.97; 9 months: 16.40 ± 2.41 vs. 15.69 ± 2.76; no significant treatment effects | N/A |
| Serlachius et al., 2016 [29] | 3 months: 102.2 ± 22.9 vs. 112.4 ± 26.7, $p = 0.019$; 12 months: 100.8 ± 22.9 vs. 110.8 ± 31.6, $p = 0.235$ | N/A | N/A | N/A | 3 months: 169.5 ± 15.7 vs. 161.1 ± 18.2, $p = 0.012$; 12 months: 170.8 ± 13.7 vs. 161.7 ± 18.3, $p = 0.008$ | N (A) | 3 months: 8.1 ± 1.2 vs. 8.5 ± 1.3, $p = 0.32$; 12 months: 8.2 ± 1.6 vs. 8.8 ± 1.6, $p = 0.058$ | 3 months: 90.6 ± 11.8 vs. 84.3 ± 14.0, $p < 0.001$; 12 months: 90.0 ± 10.9 vs. 84.9 ± 14.0, $p = 0.042$ |
| Whittemore et al., 2012 [12] | No significant differences | N/A | N/A | No significant differences | No significant differences | No significant differences | No significant differences | No significant differences |

**TABLE 3** | Grade evaluation.

| Outcomes | Number of participants | Effect size[g] | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias[f] | Overall certainty of evidence |
|---|---|---|---|---|---|---|---|---|
| HbA1c | 929 (9 RCTs) | MD −0.56, (−1.03 to −0.10) | Not serious | Not serious | Not serious | Not serious | Serious | Moderate |
| Quality of life | 444 (5 RCTs) | SMD 0.27, (0.01–0.54) | Serious[a] | Not serious | Not serious | Not serious | Serious | Moderate |
| Self-efficacy | 1029 (10 RCTs) | SMD 0.35, (0.01–0.68) | Serious[a] | Not serious | Not serious | Not serious | Serious | Moderate |
| Stress | 334 (4 RCTs) | SMD −0.24, (−0.51 to 0.03) | Not serious | Not serious | Not serious | Serious[c] | Serious | Medium |
| Depression symptoms | 399 (5 RCTs) | SMD −0.05, (−0.34 to 0.25) | Serious[a] | Not serious | Not serious | Serious[c] | Serious | Low |
| Anxiety | 100 (1 RCT) | N/A | Not serious | N/A | Not serious | Very serious[d] | Serious | Very low |
| Coping | 346 (5 RCTs) | SMD 0.13, (−0.15 to 0.42) | Serious[a] | Not serious | Not serious | Serious[c] | Serious | Low |
| Self-management | 420 (2 RCTs) | N/A | Not serious | Serious[b] | Not serious | Very serious[e] | Serious | Very low |

[a]Downgrading due to >25% trials with high risk in key domains (random sequence generation, allocation concealment, blinding of participants/personnel, incomplete outcome data, selective reporting).
[b]Downgrading due to unexplained heterogeneity in intervention effects across studies.
[c]Downgrading due to 95% CI crossing the null line.
[d]Downgrading due to single study with small sample size.
[e]Downgrading due to few studies.
[f]The funnel plot indicates the presence of publication bias.
[g]The longest follow-up effect size from each outcome's subgroup was selected.

concealment. Five studies (50%) clearly reported that outcome assessors were blinded to the intervention group assignment. None of the studies (100%) reported any statistical differences at the baseline. All studies used appropriate statistical analyses, such as estimating the sample size using power analysis, recruiting sufficient participants, and reporting participants' compliance with the treatments. Information on the risk-of-bias analysis for the studies is shown in Figure 2.

## 3.5 | Effectiveness of CST on Youth With T1DM

### 3.5.1 | HbA1c

Ten studies [10–12, 23, 25–29, Edrki et al., 2018] that included a total of 1029 participants reported the effectiveness of CST on HbA1c, with nine studies measuring HbA1c using the Bayer Diagnostics DCA2000 analyzer, and one study using the Bio-Rad D-10 system (BioRad Laboratories, Hercules, CA) [29]. In three studies [12, 28, 29], the data related to HbA1c could not be extracted; therefore, only seven studies were included in the meta-analysis. The pooled results revealed significant HbA1c reductions in T1DM patients for the CST group over the control group over 3 months (MD: −0.29, 95% CI: −0.56 to −0.02) and 6 months (MD: −0.55, 95% CI: −0.88 to −0.21), with no heterogeneity (0%). The intervention's effectiveness also reached significance over 12 months (MD: −0.56, 95% CI: −1.03 to −0.10), despite an increase in heterogeneity to 41% (Figure 3a). Sensitivity analysis, which excluded the study by Boardway et al. [23], yielded a slightly attenuated but still statistically significant reduction in HbA1c over 3 months ($p = 0.05$, MD: −0.27, 95% CI: −0.54 to 0.00, $I^2 = 0\%$). Over 6 months, the intervention effect remained robust ($p = 0.001$, MD: −0.56, 95% CI: −0.90 to −0.22, $I^2 = 0\%$), confirming sustained intervention efficacy unaffected by outlier exclusion (Figure 3b). The funnel plot for the seven studies displayed a slight right-skewed asymmetry, primarily due to the extreme effect size distortion observed in Boardway et al. [23]. This distortion was a statistical artifact resulting from the small-scale sample size and suggested potential publication bias (Figure 3c).

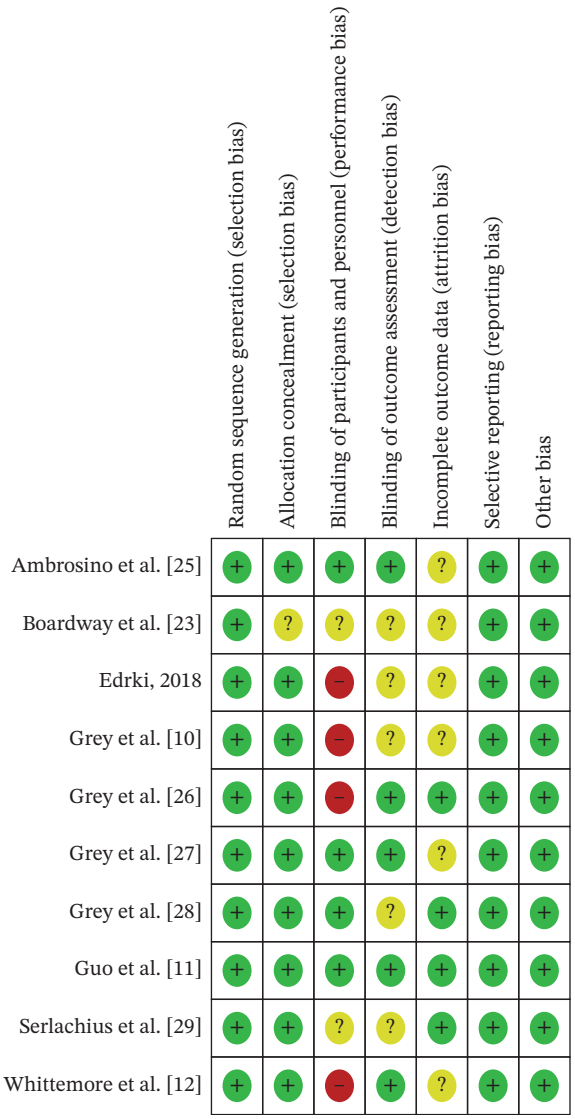



**FIGURE 2** | Risk bias analysis.

### 3.5.2 | Quality of Life

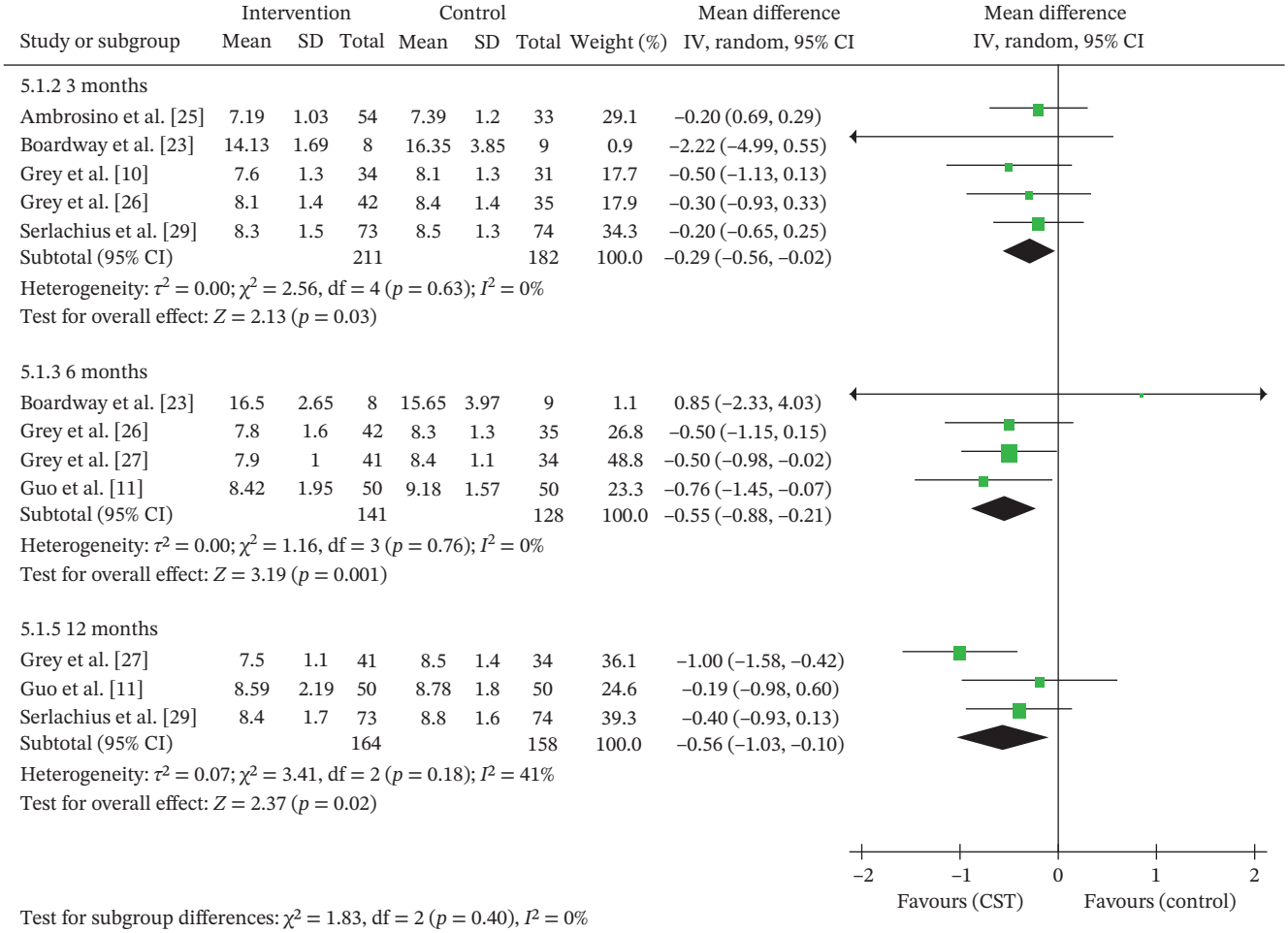
Eight studies [10–12, 25–29] with a total of 910 participants reported the effectiveness of CST on quality of life in T1DM patients. The measurement tools used included the Diabetes Quality of Life Scale for Youth ($n = 6$), the Quality-of-Life Scale for Children and Adolescents [11], and the Pediatric QOL Inventory, designed for children with chronic health conditions [12]. The pooled results showed that the CST group reported significantly improved quality of life over 12 months compared with the usual education group (SMD: 0.27; 95% CI: 0.01–0.54). The heterogeneity of the pooled results was 0%. However, there was no significant difference in quality of life between the two groups over 3 or 6 months (SMD: 0.13, 95% CI: −0.09 to 0.34; SMD: 0.18, 95% CI: −0.21 to 0.58). The heterogeneity of the pooled results was 0% and 43%, respectively (Figure 4).

### 3.5.3 | Self-Efficacy

Ten studies [10–12, 23, 25–29, Edrki et al., 2018] that included a total of 1029 participants reported the effectiveness of CST on self-efficacy. The measurement tools used included the Self-Efficacy for Diabetes Scale ($n = 8$) and the General Self-Efficacy Scale ($n = 2$) [11, 31]. The pooled data showed that, compared with the control group, the CST group showed significantly improved self-efficacy over 12 months (SMD: 0.35, 95% CI: 0.01–0.68). However, there was no significant difference in intervention effectiveness between the two groups over 3 or 6 months (SMD: 0.12, 95% CI: −0.09 to 0.33; SMD: 0.17, 95% CI: −0.11 to 0.46). The heterogeneity of the pooled results was low, at 0%, 0%, and 21%, respectively (Figure 5a). Sensitivity analysis results did not substantially alter effect sizes or heterogeneity over 3 and 6 months ($p = 0.28$, SMD: 0.12, 95% CI: −0.09 to 0.33, $I^2 = 0\%$; $p = 0.67$, SMD: 0.20, 95% CI: −0.09 to 0.50, $I^2 = 0\%$), confirming the robustness of the null findings (Figure 5b).

### 3.5.4 | Stress

Five studies [11, 12, 23, 29, 31] that included a total of 643 participants reported the effectiveness of CST on stress. The measurement tools included the Perceived Stress Scale [11, 12] and the Diabetes Stress Questionnaire [23, 29, 31]. The pooled results




(a)

**FIGURE 3** | (Continued)

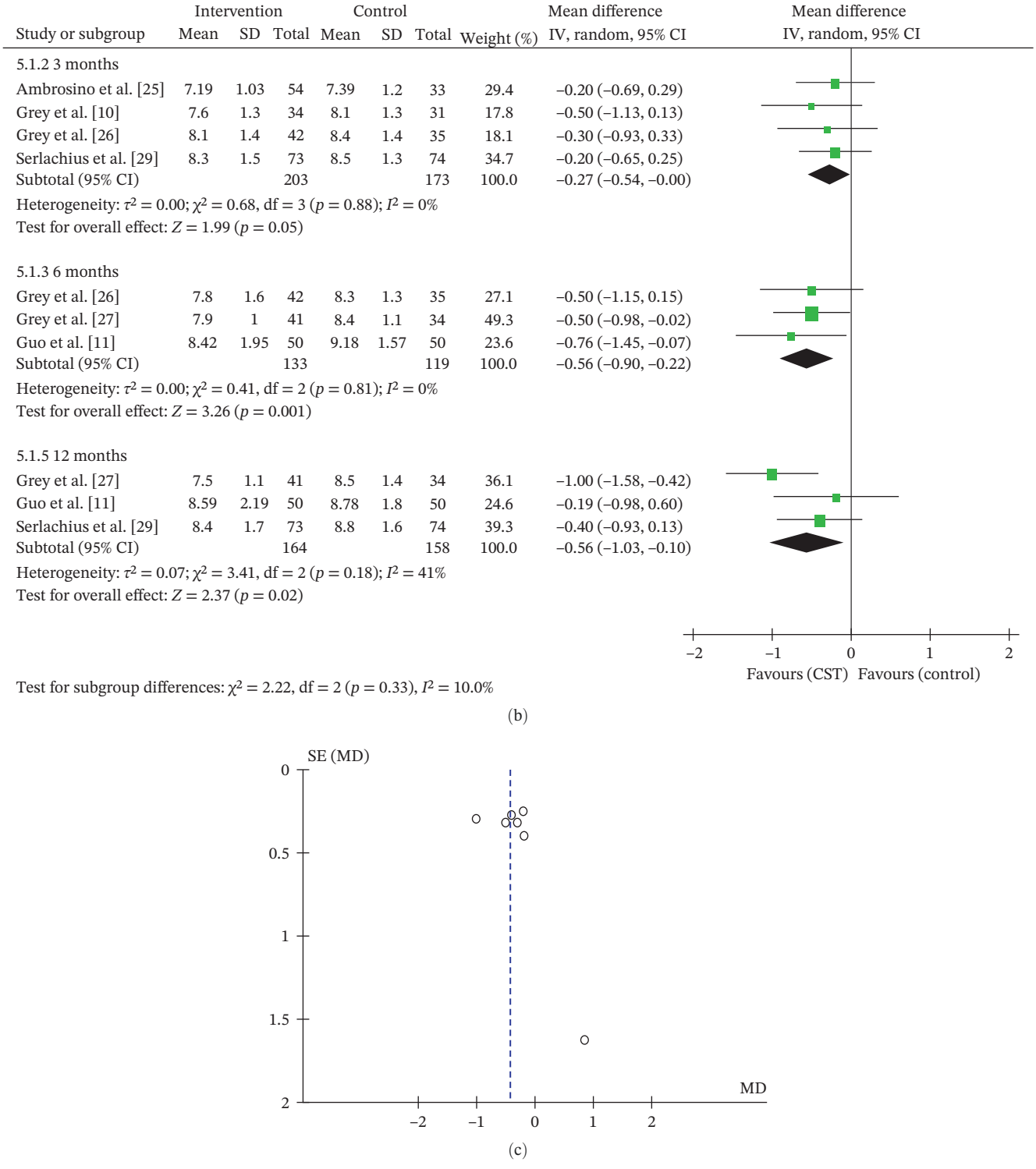



**FIGURE 3** | (a) Effect of CST on HbA1c. (b) Effect of CST on HbA1c: sensitivity analysis excluding outlier. (c) Funnel plot for HbA1c outcome.

showed no significant difference in intervention effects between the two groups over 3, 6, or 12 months (SMD: −0.19, 95% CI: −0.53 to 0.15; SMD: −0.05, 95% CI: −0.42 to 0.31; SMD: −0.24, 95% CI: −0.51 to 0.03). There was no statistically detectable heterogeneity among these studies ($I^2 = 0\%$; Figure 6). Sensitivity analyses could not be performed due to insufficient remaining studies ($n = 1$) at the 3- and 6-month intervals.

### 3.5.5 | Depressive Symptoms

Five studies [Edrki et al., 2018, 10, 26–28] that included a total of 399 participants reported the effectiveness of CST on depressive symptom outcomes. The measurement tools included the Depression Anxiety Stress Scales (Edrki et al., 2018) and the Children's Depression Inventory [10, 26–28]. Two studies

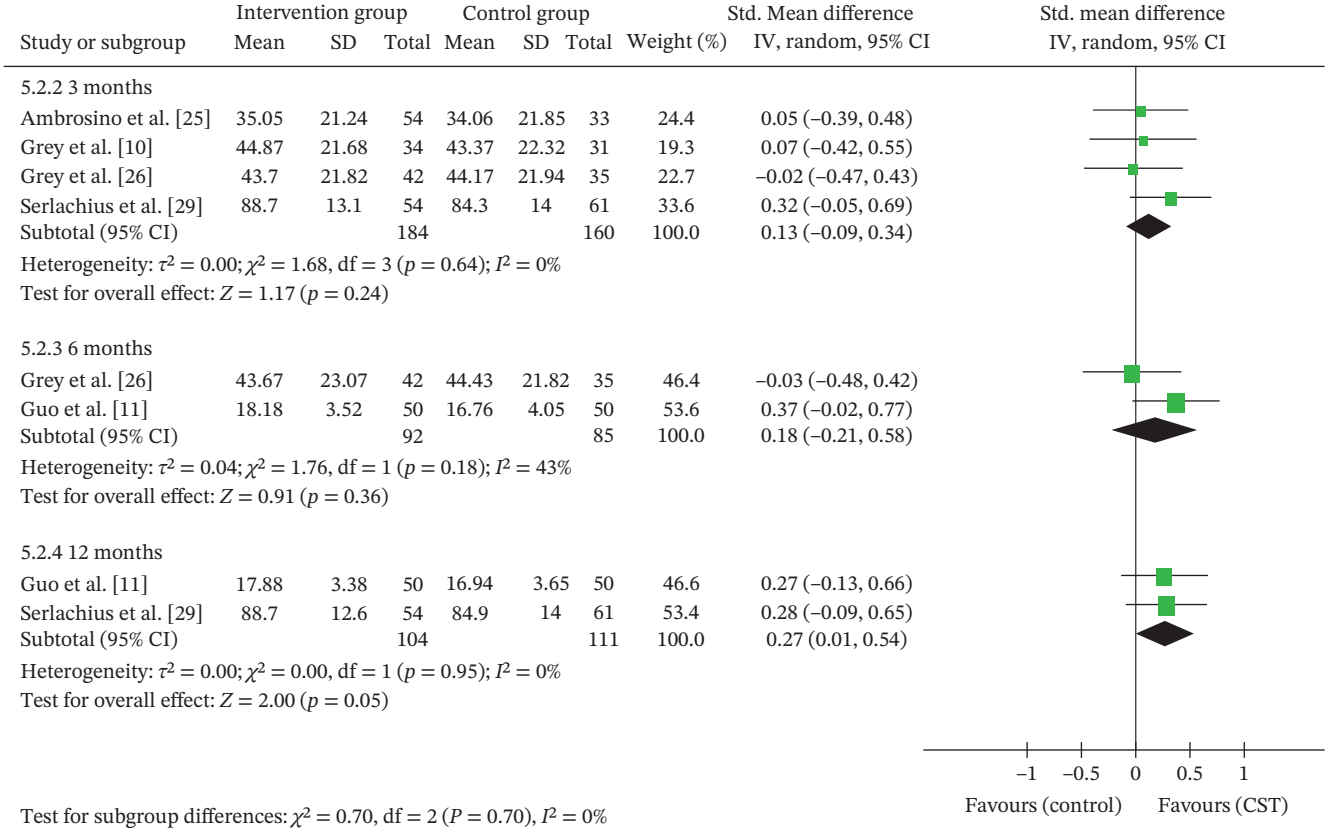



**FIGURE 4** | Effect of CST on quality of life.

[27, 28] found no significant difference in intervention effects between the two groups (2 months: 5.41 ± 4.58 vs. 19.73 ± 11.80, $p < 0.001$; 12 months: $F = 9.29$, $p = 0.001$), and three studies [10, 26, 27] found that participants in the CST group reported significantly fewer depressive symptoms compared with the control group over 2, 3, and 6 months. The meta-analysis indicated no significant difference in depression between the CST group and the control group over 3 or 6 months (SMD: 0.03, 95% CI: −0.36 to 0.41; SMD: −0.05, 95% CI: −0.34 to 0.25). The heterogeneity of the pooled results was 26% and 0%, respectively (Figure 7).

### 3.5.6 | Anxiety

Only one study (Edrki et al., 2018), which included a total of 100 participants, reported the effectiveness of CST on anxiety as measured by the Depression Anxiety Stress Scale. In this study, CST significantly reduced anxiety in participants compared with the control group over 2 months (6.44 ± 7.01 vs. 18.28 ± 10.51, $p < 0.001$).

### 3.5.7 | Coping

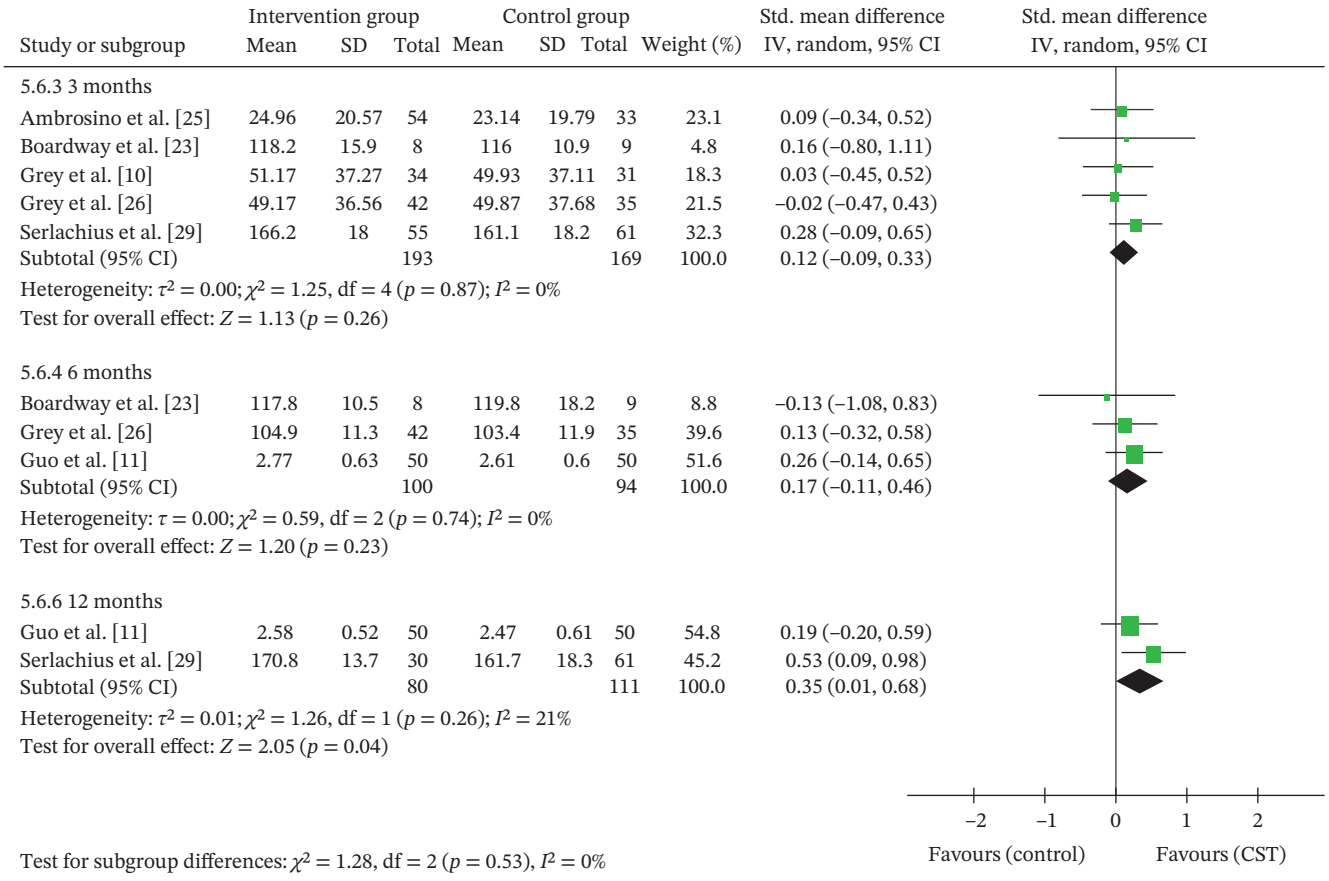
Eight studies [10–12, 23, 25–28] that included a total of 825 participants reported the effectiveness of CST on coping. The measurement tools included the Issues in Coping with IDDM-Child scale ($n = 5$), the Chinese version of the Children's Coping Strategies Scale ($n = 1$), the Coping Checklist ($n = 1$), and the Responses to Stress Questionnaire ($n = 1$). Only one study [10] indicated a significant difference between the CST and control groups over 3 months (15.40 ± 3.06 vs. 17.30 ± 3.00, $p < 0.05$). The meta-analysis suggested no significant difference in coping between the CST and control groups over 3 or 6 months (SMD: −0.03, 95% CI: −0.46 to 0.40; SMD: 0.13, 95% CI: −0.15 to 0.42). The heterogeneity of the pooled results was 60% and 0%, respectively (Figure 8a). Sensitivity analysis results did not substantially alter effect sizes or heterogeneity over 3 and 6 months ($p = 0.75$, SMD: −0.08, 95% CI: −0.59 to 0.42, $I^2 = 72\%$; $p = 0.58$, SMD: 0.08, 95% CI: −0.21 to 0.38, $I^2 = 0\%$), confirming the robustness of the null findings (Figure 8b).

### 3.5.8 | Diabetes Self-Management

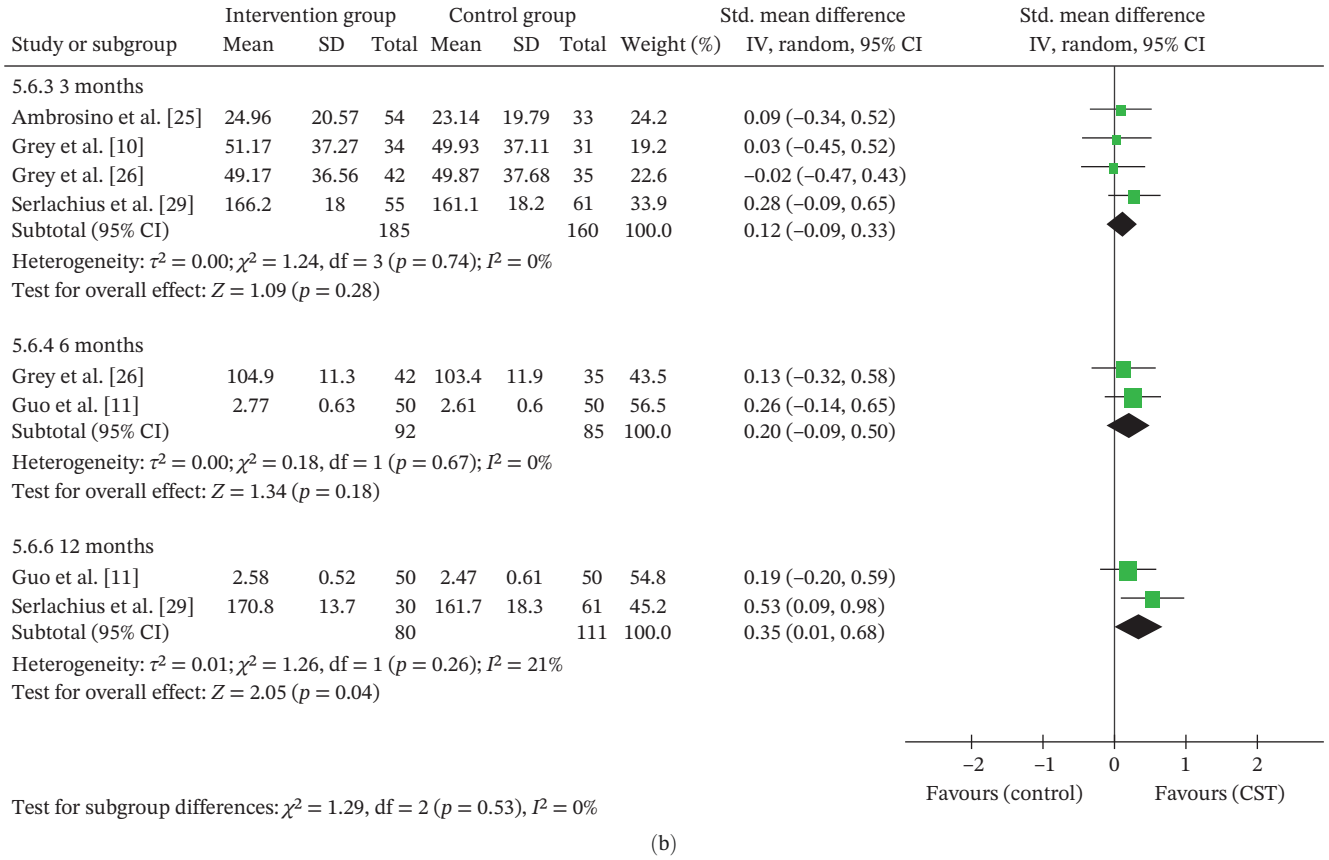
Two studies [11, 12] that included a total of 420 participants reported the effectiveness of CST on diabetes self-management outcomes. The measurement tool was the Self-Management of Type 1 Diabetes in Adolescence Scale. In one study [11], the diabetes self-management of school-aged children in the CST group was significantly improved compared to the control group (6 months: 16.90 ± 7.90 vs. 2.00 ± 0.46; 12 months: 2.76 ± 0.56 vs. 2.34 ± 0.65, $p = 0.001$); however, there was no significant change in the diabetes self-management of adolescent participants (6 months: 2.66 ± 0.63 vs. 2.73 ± 0.64; 12 months: 2.44 ± 0.45 vs. 2.55 ± 0.58, $p = 0.206$). In the other study of adolescents [12], CST had no significant effect on diabetes self-management. We did not perform a meta-analysis on this variable due to a lack of sufficient data.

## 4 | Discussion

The findings of this meta-analysis provide valuable insights into the effectiveness of CST on youth with T1DM. The significant reductions in HbA1c levels observed over 3, 6, and 12 months are noteworthy, as maintaining glycemic control is crucial for




(a)




(b)

**FIGURE 5** | (a) Effect of CST on self-efficacy. (b) Effect of CST on self-efficacy: sensitivity analysis excluding outlier.

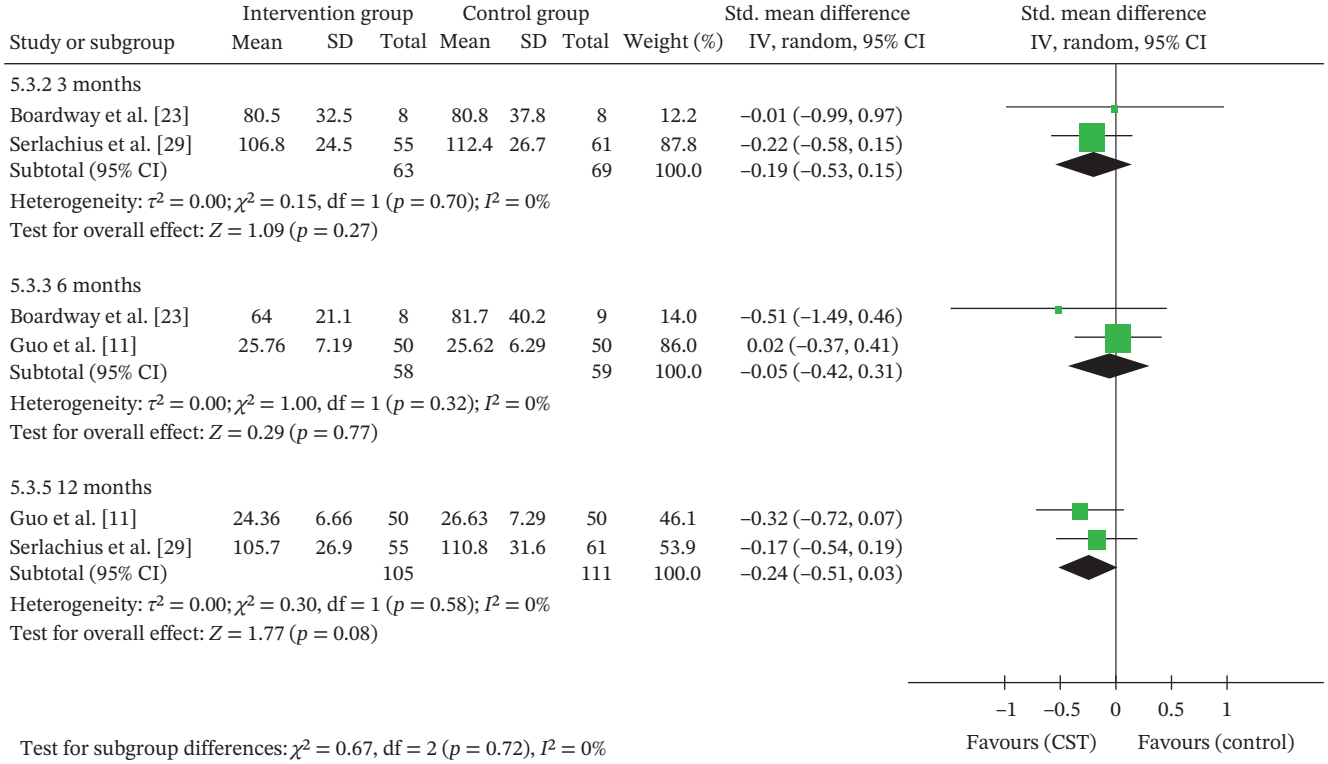



**FIGURE 6** | Effect of CST on stress.

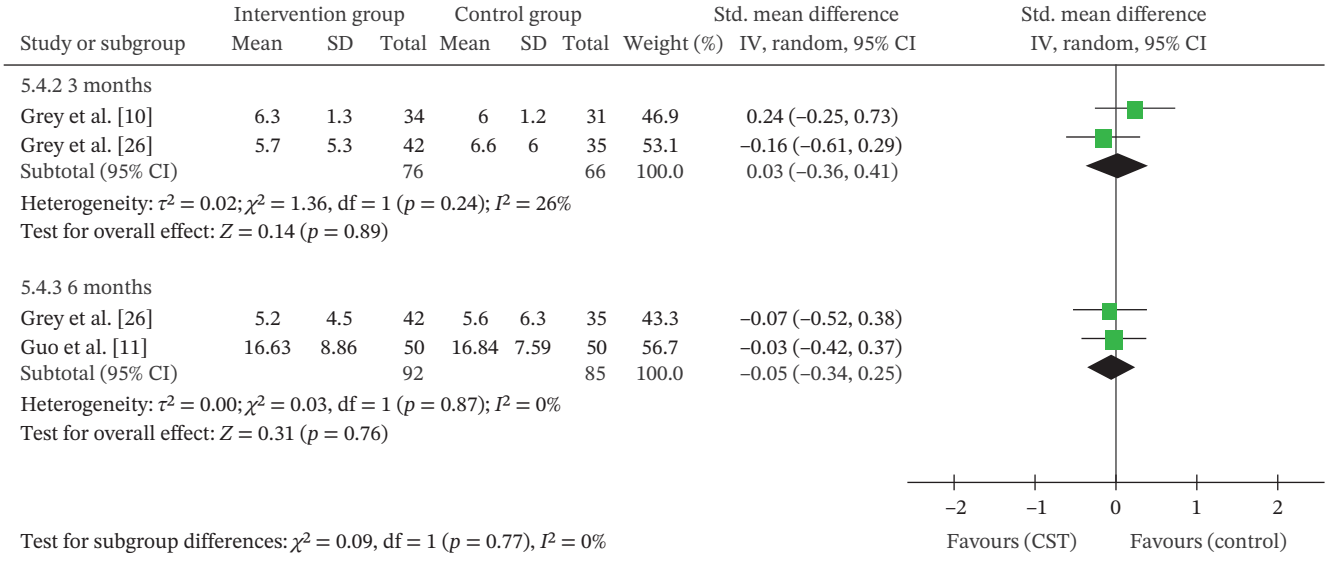
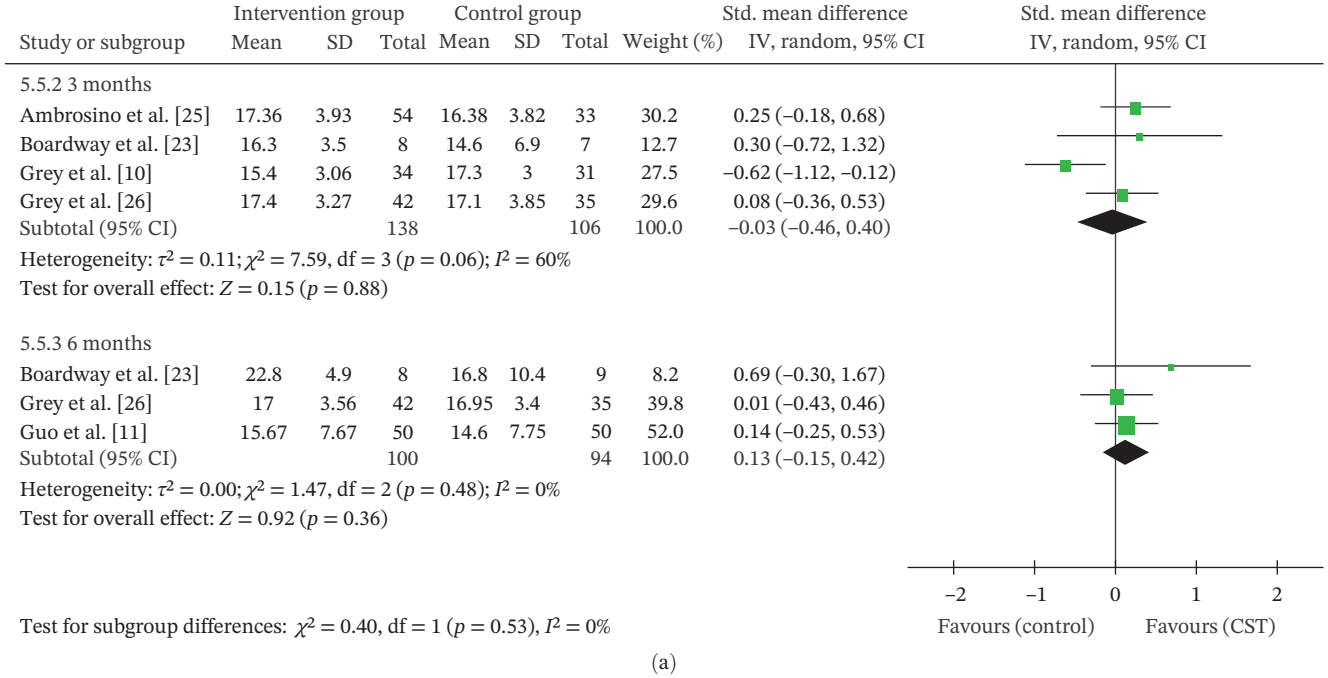



**FIGURE 7** | Effect of CST on depressive symptoms.

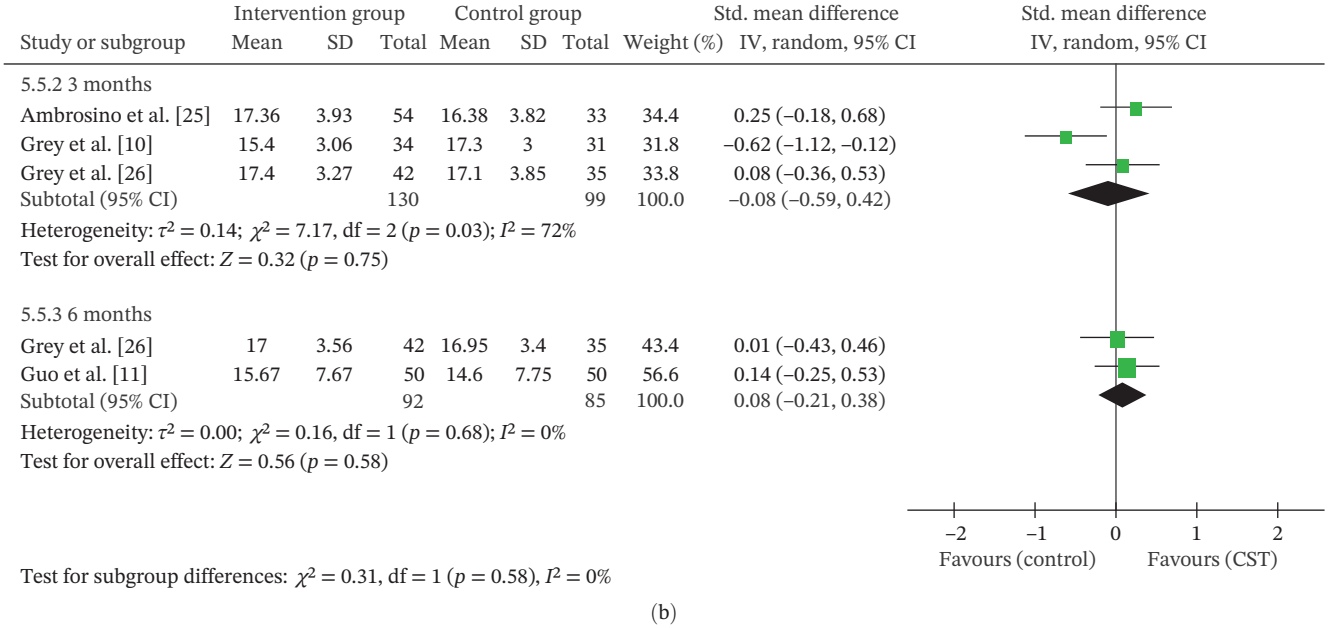
preventing diabetes-related complications. Additionally, psychosocial benefits emerge progressively over time, as demonstrated by significant improvements in self-efficacy and quality of life over 12 months. However, no significant improvements were observed in stress, depressive symptoms, or coping across all time points, indicating areas where CST may have limited impact.

Although the CST intervention demonstrated statistically significant improvements in HbA1c levels over 3, 6, and 12 months, only the 6- and 12-month outcomes met the clinically meaningful threshold (MD ≥ 0.5) [32]. The delayed attainment of clinical significance may suggest that the full metabolic benefits of CST require at least 6 months to manifest. The delayed clinical significance indicates that CST's metabolic effects develop progressively, highlighting the need for long-term intervention to attain meaningful glycemic improvements. Furthermore, the effect size over 6 months remained robust and clinically significant after excluding extreme outliers, indicating that improvements are not driven by individual anomalies but reflect the consistent therapeutic impact of CST.

Our study reveals that CST can improve the quality of life for youth with T1DM over 12 months. This finding aligns with prior evidence from Swedish adult T1DM populations utilizing




(a)




(b)

**FIGURE 8** | (a) Effect of CST on coping, (b) Effect of CST on coping: sensitivity analysis excluding outlier.

Acceptance and Commitment Therapy [33]. Quality of life is a critical outcome for youth with T1DM [34] and is influenced by sociodemographic variables (e.g., gender, age, and family income) [35], psychological issues [36], and self-efficacy [37]. Our findings suggest that CST helps youth develop greater confidence and competence in managing diabetes-related challenges, thereby improving their quality of life [38]. Notably, self-efficacy was the only psychosocial variable that showed significant improvement over 12 months, consistent with CST's theoretical focus on increasing self-efficacy [39].

However, these improvements in glycemic control and quality of life occurred without concurrent changes in coping, stress, or depressive symptoms, which are factors previously identified by Whittemore et al. [34] as potential mediators between CST and HbA1c or quality of life. The lack of observed mediation effects may stem from the fact that eight of the 10 included studies calculated the sample size based solely on primary outcomes (HbA1c or quality of life), rather than these secondary outcomes. Consequently, these studies may have been underpowered to detect significant changes in these secondary outcomes, potentially explaining the null findings. Additionally, the predominance of "insulin-centric" care models in most diabetic centers may explain the limited number of robust studies on nonpharmacological therapies like CST. This gap highlights the

importance of developing comprehensive treatment strategies that address not only glycemic control but also psychosocial outcomes and self-management skills.

Specifically, two studies examined CST's effectiveness for diabetes self-management [11, 12], with only one reporting statistically significant improvements [11]. One study reported statistically significant relief in anxiety following CST (Edrki et al., 2018). Our study did not conduct the quantitative synthesis on anxiety and diabetes self-management because only one or two studies reported the data. Nevertheless, these findings suggest potential benefits of CST on diabetes self-management and anxiety that warrant dedicated investigation in larger-scale studies.

### 4.1 | Strengths and Limitations

This study has several strengths. First, it provides a systematic synthesis of RCTs that evaluated CST specifically tailored to youth with T1DM. Second, it provides a comprehensive summary of the effectiveness of CST on glycemic control, psychosocial variables, and diabetes self-management. Finally, we performed subgroup analyses to examine the effectiveness of CST over 3, 6, and 12 months, allowing us to explore temporal dynamics and benefits at different time points.

However, limitations warrant consideration when interpreting the results. First, these results should be interpreted with caution, as the conclusions are derived from 10 included studies with a pooled sample size of 1029 participants. Furthermore, the outcomes for glycemic control and psychosocial variables were assessed through subgroup analyses based on follow-up time points (3, 6, and 12 months), which may reduce statistical power. Second, due to insufficient data, some relevant variables, such as anxiety and diabetes self-management, were not included in the meta-analysis. Third, this review did not evaluate intervention costs as an outcome variable. The exclusion of cost-effectiveness analyses may limit the applicability of our findings to real-world healthcare settings, where resource allocation and economic feasibility are critical factors in policy implementation.

### 4.2 | Implications

Our study has several important implications. First, the comprehensive findings from our meta-analysis suggest that CST may serve as a feasible adjunct to standard diabetes care for youth with T1DM, though larger implementation studies are needed to confirm real-world effectiveness. Second, further well-designed RCTs are needed to assess the long-term effectiveness of CST on depressive symptoms, anxiety, coping, and diabetes self-management. Third, future studies should consider both primary and secondary outcomes when calculating sample sizes to ensure adequate statistical power. Finally, future cost-effectiveness analyses should be conducted to assess whether the incremental costs of extending the intervention outweigh the potential savings from preventing long-term complications.

## 5 | Conclusion

The findings of this meta-analysis suggest that CST interventions may improve glycemic control and quality of life in youth with T1DM, with benefits sustained for up to 12 months. Based on the current evidence, integrating CST into standard pediatric diabetes care could be considered, though further validation in larger and more diverse populations is needed. To better establish the therapeutic role of CST, well-designed RCTs are required to evaluate its effects on anxiety and diabetes self-management.

**Funding**

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**Conflicts of Interest**

The authors declare no conflicts of interest.

**Data Availability Statement**

The data that support the fundings of this study are available from the corresponding author upon reasonable request.

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section. (*Supporting Information*)

File 1: Full search strategy.