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Assessing the impact of mindfulness programs on attention-deficit/ hyperactivity disorder in children and adolescents: a systematic review

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Abstract

Background Attention Deficit Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental disorder which poses challenges for the individuals with the disorder and their families. While stimulant medications are effective, a comprehensive approach, including psychosocial and behavioral interventions, is recommended. There is a growing body of research exploring the potential benefits of mindfulness-based interventions for children with ADHD. Our study aims to assess the effectiveness of mindfulness interventions in reducing ADHD symptoms in children and adolescents through a systematic review of relevant studies.

Methods Following PRISMA guidelines, our systematic review searched PubMed, Cochrane library, Psycinfo, and Scopus from January 2000 to August 2022. We included studies focusing on mindfulness for pediatric ADHD, comprising various study designs with a minimum 8-week duration. Descriptive statistics summarized results, while risk of bias was assessed using Cochrane RoB and ROBANS tools. The quality of RCTs was further evaluated using the Correlation of Quality Measures tool.

Results In the initial search, 450 records were identified, and after removing duplicates, 339 underwent screening. Forty-one studies underwent full text assessment for eligibility, with 11 studies meeting inclusion criteria, including seven RCTs, two Quasi RCTs, and three cohort studies. These studies, conducted in five countries, involved participants aged 7 to 18 years. Six studies showed improvement in hyperactivity/inattentive symptoms, and five studies showed improvement in impulsivity.

Conclusions This systematic review demonstrates the potential benefits of mindfulness programs on ADHD symptoms in children and adolescents. This study emphasizes the need for high-quality research to explore mindfulness-based interventions for ADHD management in younger populations.

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Keywords Mindfulness, ADHD, Symptomatology, Attention, Hyperactivity

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Introduction

Attention-deficit/ hyperactivity disorder (ADHD) is a neurobiological disorder that is behaviorally defined [1]. It is one of the most prevalent neurodevelopmental disorders and most widely researched field in children [2]. The ADHD worldwide pooled prevalence in children aged 18 and under is estimated at 5.29% [2]. The etiology of ADHD is complex, involving genetic and environmental risk factors [3], therefore, the assessment of ADHD is multimodal including fulfilling the DSM 5 diagnostic criteria, identifying the risk factors and family history.

ADHD is characterized by persistent patterns of inattention, hyperactivity, and impulsivity which can significantly impact many aspects of behavior and performance and interfere with one's daily functioning [4]. ADHD has significant societal and family burdens, particularly affecting parents [5]. Additionally, challenging behaviors exhibited by children diagnosed with ADHD can result in increased hostility and defiance directed towards their parents, subsequently contributing to elevated levels of parental stress [5]. To date, stimulants are the most effective psychopharmacological treatments available for ADHD [6]. However, it is recommended that drug treatment should always be part of a comprehensive plan that includes psychosocial and behavioral interventions. ADHD is a complex disorder that varies in onset, severity, and response to treatment among diverse populations. This emphasizes on the need for considering psychosocial interventions as tools for early intervention, hence the need for research on existing non-pharamacological solutions for ADHD management. There is an increasing evidence base to support the potential benefits of mindfulness-based interventions in the management of ADHD [7].

In a meta-analytic review of 472 adults, mindfulness training showed significant positive effects on ADHD symptoms [8]. However, two other reviews focusing on children and adolescents diagnosed with ADHD revealed mixed results. One of the reviews was a meta-analysis of 11 studies with 295 participants. It evaluated mindfulness effects on ADHD symptoms, internalizing and externalizing symptoms, and parental stress [1, 7]. The other review was a systematic review of 12 studies with 388 participants, and it found limited evidence due to poor study quality.

To further understand the effect of mindfulness training among children and adolescents, our study aimed to analyze studies of adequate duration of the mindful intervention. Furthermore, it aimed to assess other potential contributing factors that may influence the effect of the mindfulness intervention. For instance, ADHD subtype, presence of comorbidities, duration of the mindfulness intervention, providing training to parents, and presence of other treatment interventions.

Using a systematic review design, this study aims to focus on studies that assessed mindfulness as an intervention to treat ADHD among patients under 19 years of age, with or without comparable control groups, to understand its effects on ADHD symptom-reduction in this population.

Methods

This systematic review was done following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement [9] and registered with PROSPERO (CRD42024520800; https://www.crd.york.ac.uk/PROSPERO accessed 21 March 2024).

Search selection

We performed a systematic search using a search strategy in four different databases, including PubMed, Cochrane library, PsycINFO, and Scopus starting from January 2000 through August of 2022. We used a combination of keywords and medical subject headings (MESH) related to attention deficit disorder with hyperactivity OR "ADHD" AND Mindfulness-based interventions OR MBT OR attention training OR mindfulness-based cognitive therapy OR MBCT OR mindfulness-based interventions (Supplementary Table S1 shows the search strategy for the study).

Six authors (M.A.S., F.A.N., B.A., E.K., S.S., and N.E.A.) were involved in the inclusion of studies. We used Rayyan software (https://rayyan.ai/) to remove the duplicates. Subsequently, the authors did the title and abstract screening followed by full-text screening with the same software. Only studies that satisfied our inclusion criteria were included finally. Conflicts in between two authors during the inclusion phase were solved through discussion or later by an additional third author (J.J.) if consensus was not reached.

Inclusion and exclusion criteria were established to ensure the selection of studies relevant to the review objectives. Studies were included if they focused on children and adolescents under the age of 19 diagnosed with ADHD, as per standardized diagnostic criteria (e.g., DSM-5 or ICD-10). Eligible studies investigated mindfulness-based interventions, including but not limited to Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT), with a minimum intervention duration of 8 weeks.

This duration is consistent with existing literature, where many studies have utilized 8-week interventions, providing a robust framework for comparison and benchmarking results. An 8-week duration is also developmentally appropriate, as it allows for meaningful

changes in children's behavior and skills without causing fatigue or disengagement. Additionally, this timeframe is practically feasible, aligning well with school terms and extracurricular schedules, ensuring smooth integration into children's routines. The core program is designed to be adaptable, allowing for adjustments based on individual needs and contexts, as detailed in the methodology section.

The interventions could be delivered individually or in groups, with or without parental involvement. Both randomized controlled trials (RCTs) and non-randomized studies (e.g., cohort, case-control, or cross-sectional designs) were included, provided they assessed ADHD symptoms or related outcomes such as sleep quality, anxiety, or executive functioning. Only studies published in peer-reviewed journals from January 2000 to August 2022 were considered. Studies were excluded if they focused on individuals aged 19 and above, used case series or case report designs, involved animal models, or were published before 2000. Non-mindfulness interventions and those lacking sufficient details on intervention structure or duration were also excluded. To ensure methodological rigor, studies with significant methodological flaws, such as incomplete data reporting or lack of ADHD-specific outcomes, were excluded.

Data collection process

Six authors (M.A.S., F.A.N., B.A., E.K., S.S., and N.E.A.) were responsible for data extraction from all the included studies into a pre-piloted data extraction form in Microsoft Excel. A sixth author (J.J.) independently assessed the extraction data for validation. The data extraction process focused on obtaining comprehensive details about the included studies to ensure a robust analysis. General information such as the author, title, DOI, URL, and year of publication was recorded for all studies. Key study characteristics, including the study design, location, study period, total number of children receiving mindfulness training, age range, mean age, and gender ratio, were extracted. Participant characteristics encompassed the method of ADHD diagnosis, ADHD subtypes, comorbidities, and details of the mindfulness training, including its duration, type, and setting (e.g., with or without parental involvement). The nature of the intervention was documented to determine alignment with established protocols, such as Mindfulness-Based Stress Reduction (MBSR) or Mindfulness-Based Cognitive Therapy (MBCT), as well as therapies that incorporated mindfulness principles but deviated from these standard frameworks. Outcomes of interest were primarily ADHD symptoms and sleep quality, along with secondary measures such as anxiety, depression symptoms, challenging behaviors, conduct problems, executive function, sleep quality, and parental stress. This structured approach ensured that the extracted data provided a nuanced understanding of the interventions and their contexts.

Synthesis of results

We employed descriptive statistics to derive various summary measures from the gathered data. Continuous data points were represented as either median with interquartile range (IQR) or mean with standard deviation (+/- SD). Categorical variables were expressed as percentages, while outcomes were presented as counts and their corresponding percentages.

Study risk of bias assessment

Study quality was evaluated using the quality assessment tools. The Cochrane risk-of-bias (RoB) assessment tool version 1 was used for randomized trials [10] and for Randomized Controlled Trials (RCTs) included in this systematic review, and the Risk-of-bias Assessment Tool for Non-randomized Studies (ROBANS) [11] was used for non-randomized studies. These instruments were created to evaluate the internal validity of a trial, the extent to which the reported effects can strictly be attributed to the intervention applied, and the potential flaws in methodology or implementation.

Types of bias and the domains that are assessed by the RoB assessment tool version 1 included Selection (Sequence generation; Allocation concealment), Performance (Blinding of participants and research personnel; Other potential threats to validity), Detection (Blinding Of Outcome Assessments, Other Potential Threats To Validity), Attrition (Incomplete Outcome Data) and Reporting (Selective Outcome reporting).

Types of bias and the domains that are assessed by the ROBANS tool included several items to evaluate bias for non-randomized studies namely Selection Bias (selection of participants; confounding variables), Performance Bias (Measurement of exposure or intervention), Detection Bias (blinding of outcome assessments), Attrition Bias (incomplete outcome data), and Reporting bias (selective outcome reporting).

Six independent investigators (M.A.S., F.A.N., B.A., E.K., S.S., and N.E.A.) utilized The RoB assessment tool to evaluate the methodological quality of RCTs Two authors independently assessed the risk of bias of each study included in this systematic review. A final third author (J.J.) decided on any disagreements which were discussed with all the authors, and the decision was made via a consensus. Non-randomized studies underwent methodological quality assessment in a similar fashion using the RoBANS tool.

Furthermore, the Correlation of Quality measures with estimates of treatment effects in meta-analyses of

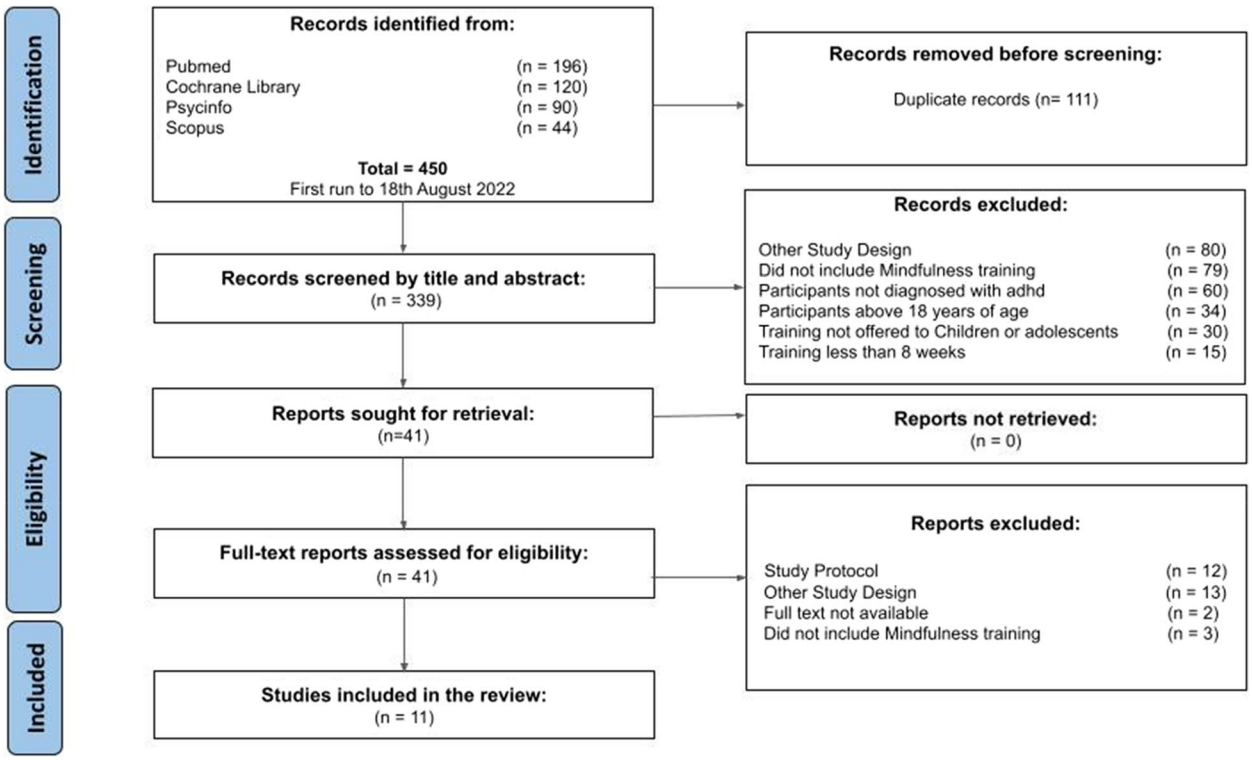

Fig. 1 PRISMA flowchart outlining the study search

randomized controlled trials tool [12] was employed to assess the quality of the included RCTs.

Results

Study selection

After identifying a total of 450 records from selected databases during the initial search, 111 were removed as duplicates and 339 were included to undergo title and abstract screening. Finally, forty-one were chosen for full text screening but only 11 met the inclusion criteria out of which seven were RCTs [13–19], two were of a Quasi RCT design [20, 21] and two were cohort studies [22, 23]. Figure 1 shows the PRISMA diagram for our study selection process.

Study characteristics

The included studies were conducted across 5 countries: including Canada, Italy, Netherlands, United States and Spain. Across the studies, the overall age of participants ranged from 7 to 18 years old. Seven studies included only children [14–16, 19, 21–23], and four studies included both children and adolescents [13, 17, 18, 20]. Five studies [15, 17, 18, 20, 21] included the participation of parents. The sample size ranged from 5 to 55 participants, with a total of 234 participating children and adolescents in all the included studies. In respect of the study design, seven studies were randomized controlled trials (RCTs), two cohort studies, and two pre/post design. The main characteristics of the included studies are summarized in Table 1 and the outcome measurement tools used in studies are summarized in supplementary table S2.

Mindfulness interventions

The majority of the MBT interventions used were based on the Mindfulness Based Stress Reduction protocol (MBSR) and the Mindfulness-Based Cognitive Therapy (MBCT), one study used Mindful Movement Treatment, based largely in Tai Chi practice, and one used Mindfulness Martial Arts (MMA) which is described as a manualized group treatment program that incorporates elements of mindfulness meditation, cognitive behavioral therapy (CBT), behavior modification and mixed martial arts. The predominant (10/11) intervention period was 8 weeks, and one was 20 weeks long. The frequency of sessions were mostly once per week, two studies had three sessions per week and one was twice per week. The duration of the sessions ranged from 30 min up to 90 min.

Effect of MBT interventions on ADHD

Each study tailored the scales used to assess the changes in ADHD symptoms based on their parameters of focus.

Table 1 Main characteristics of the included studies in the systematic review

Author and Year	Country	Sample and Age	Study Design	Type of Intervention	Control Group	Duration and Frequency	Outcomes and Tests	Main results
[Bergsma et al. 2012] [20]	Netherlands	10 (11–15 year)	non-controlled pre-post-follow-up design	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	No Control Group	Once per week for 8 weeks	**Primary outcome**: ADHD symptoms (attention) were assessed on the Youth Self Report (YSR), the Child Behavior Checklist (CBCL), and the Teacher Report Form (TRF).	Neither adolescents, fathers, nor mothers reported a change in their self-rated mindful awareness and attention after training, or at 8-week follow-up. Adolescents also did not report a significant change in mindful awareness at 16-week follow-up. A borderline significant reduction in attention problems was reported after training by fathers ($p = .09$). Adolescents, mothers reported no significant reduction. At 8-week fathers as well as adolescents reported a reduction in attention problems, but mothers did not. At 16-week follow-up, adolescents reported no significant reduction in attention problems.
[Clark et al. 2020] [22]	USA	29 (8–12 year)	non randomised, non-controlled pre-post-follow-up design	Tai Chi based Mindful Movement Treatment	No Control Group	Twice per week for 8 weeks	**Primary outcome**: ADHD symptoms were assessed using Conners 3 (Inattentive Type, Hyperactive/Impulsive Type, Executive Function, ODD, and Emotional Lability). **Secondary outcome**: ADHD severity on Clinical Global Impression-Severity (CGI-S).	Significant reduction in Conners inattentive ($p < .001$), hyperactive/impulsive ($p = .01$), executive function ($p < .001$), ODD ($p = .001$) following treatment. Significant decrease in symptom severity following treatment in CGI-S ($p = .01$).

Table 1 (continued)

Author and Year	Country	Sample and Age	Study Design	Type of Intervention	Control Group	Duration and Frequency	Outcomes and Tests	Main results
[Haydicky et al. 2012] [13]	Canada	14 (12–18 year)	quasi-experimental investigation	Mindfulness Martial Arts (MMA)	Each phase of the study included an MMA (mindfulness meditation training) group for adolescents with learning disabilities and co-occurring difficulties and a WL (Waitlist) control group, allowing for comparisons between the two conditions over a period of 2.5 years	Weekly 1.5 h sessions for 20 weeks	**Primary outcome**: ADHD symptoms (Hyperactivity/Impulsivity, Inattention) were assessed on CBCL, BRIEF and YSR subscales. **Secondary outcome**: Anxiety was assessed on YSR.	*Hyperactive/Impulsive Symptoms*: No significant ANCOVA results were found on any other CBCL, BRIEF or YSR subscales. *Inattentive Symptoms*: The ANCOVA results for CBCL social problems were significant. No significant ANCOVA results were found on any other CBCL, BRIEF or YSR subscales. *Anxiety Symptoms*: The ANCOVA for DSM anxiety problems on the YSR was significant.

Table 1 (continued)

Author and Year	Country	Sample and Age	Study Design	Type of Intervention	Control Group	Duration and Frequency	Outcomes and Tests	Main results
[Huguet et al. 2017] [23]	Spain	5 (7–12 year)	pilot investigation	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	No Control Group	Once per week for 8 weeks	**Primary outcome**: screen of ADHD symptoms (inattention, hyperactivity/impulsivity) were analysed through ADHD Rating-Scale-IV. **Secondary outcomes**: Conners Rating Scale (parent version), Screen for Child Anxiety Related Emotional Disorder - SCARED scale, Stroop-word card (cognitive flexibility, automatic response inhibition, attentional capacity), Wechsler Intelligence Scale for Children-WISC-IV (cognitive task performance) and CPT-3 (inattentiveness, sustained attention, vigilance and impulsivity)	Significant reduction of total ADHD symptoms evaluated on the ADHD Rating Scale-IV ($p = .042$) and Conners Rating Scale parents version ($p = .042$). On anxiety symptoms, referred by parents, statistically significant improvements were found in total scores in the SCARED scale ($p = .042$). Regarding cognitive task performance, significant improvements were found for measures that involve Stroop colour-word card ($p = .043$) and processing speed (coding subtest WISC and Stroop colour card), respectively ($p = .043$; $p = .042$). No significant difference was observed on the results of CPT-3.
[Huguet et al. 2019] [14]	Spain	34 (7–12 year)	randomized controlled trial	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	Control group received standard treatment without mindfulness intervention	Once per week for 8 weeks	**Primary outcome**: ADHD symptoms (inattention) was assessed on Child Behaviour Checklist (CBCL). **Secondary outcome**: Emotion self-regulation was assessed in the CBCL	No significant difference in attention problems scale in the Child Behavior Checklist (CBCL). But improved emotion self-regulation in the Child Behavior Checklist (CBCL)

Table 1 (continued)

Author and Year	Country	Sample and Age	Study Design	Type of Intervention	Control Group	Duration and Frequency	Outcomes and Tests	Main results
[Muratori et al. 2021] [15]	Italy	23 (8–12 year)	randomized controlled trial	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	control group in the study received standard treatment without any mindfulness intervention	Once per week for 8 weeks	**Primary outcome**: ADHD symptoms assessed through Strengths and Difficulties Questionnaire (SDQ) (hyperactivity, conduct behavioural problems), Avoidance and Fusion Questionnaire for Youth (AFQ) score. **Secondary outcomes**: Modified Overt Aggression Scale (MOAS), accuracy scores using Bells Test, Matching Familiar Figures test Mindfulness Measure (MF-20), and Child and Adolescent Mindfulness Measure (CAMM).	Scores in SDQ–Hyperactivity ($p = .000$) and AFQ ($p = .009$) decreased across time only in the experimental group. At the same time, the accuracy scores of the Bells Test increased across time in the experimental group ($p = .000$), whereas accuracy scores remain unchanged in the control group. No intervention effects were found for MOAS scores, SDQ–conduct problems, CAMM scores, and performances in the MF-20 test.
[Oord et al. 2012] [21]	Netherlands	18 (8–12 year)	quasi-experimental pilot study	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	Waitlist control group, families in the waitlist group had to wait at least 6 weeks before starting treatment and received assessments during this waiting period to control for the effects of time and repeated assessments. None of the families in the waitlist group received any treatment during this time	Once per week for 8 weeks	**Primary outcome**: ADHD symptoms (inattention, hyperactivity/impulsivity) measured on Disruptive Behavior Disorder Rating Scale (DBDRS), and ADHD Rating Scale (ARS). **Secondary outcomes**: Mindfulness Attention and Awareness Scale (MAAS), Parenting Stress Index (PI), and Parenting Scale (PS).	Significant reduction of inattention (ES = 0.80, large Effect Size) and hyperactivity/impulsivity symptoms of the child (ES = 0.56, medium ES) on the parent-rated DBDRS. There was a significant reduction of the parental inattention and hyperactivity/impulsivity symptoms on the ARS, with small effect sizes (ES = 0.36 and 0.48 respectively). Parents showed significantly more mindful awareness on the MAAS (ES = 0.28, small ES).

Table 1 (continued)

Author and Year	Country	Sample and Age	Study Design	Type of Intervention	Control Group	Duration and Frequency	Outcomes and Tests	Main results
[Santonastaso et al. 2020] [16]	Italy	15 (7–11 year)	randomized controlled trial	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	The control group is an active control condition known as the Emotional Education Program (EEP), which shares several elements with the MOM program but is not related to mindfulness practice	Twice per week for 8 weeks	**Primary outcomes**: ADHD symptoms were measured using CPRS - R: L **Secondary outcomes**: impulsivity and restlessness using the CGI restless-impulsive scale.	clinical significant improvement on ADHD symptoms based on parent rate T-scores declining on several CPRS-R: L subscales. Significant decrease in the CGI restless-impulsive scale and CGI total subscale and significant mean improvement in all neuropsychological measures and executive function deficits

Table 1 (continued)

Author and Year	Country	Sample and Age	Study Design	Type of Intervention	Control Group	Duration and Frequency	Outcomes and Tests	Main results
[Siebelink et al. 2022] [17]	Netherlands	55 (8–16 year)	randomized controlled trial	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	The control group consists of families receiving care as usual (CAU) without the mindfulness-based intervention	Once per week 90 min sessions for 8 weeks	**Primary outcomes**: ADHD Symptoms evaluated with the parent rated Behaviour Rating Inventory of Executive Function (BRIEF) and the Conners' Parent Rating Scale (CPRS), Conner's Teacher ating Scale (CTRS) and the Strengths and Weaknesses of ADHD symptoms and Normal behaviour scale (SWAN) rated by both teachers and parents	Study showed a non significant trend of decreased hyperactivity/inattentiveness and restlessness/impulsivity symptoms and better self-control at post-treatment than those in the care-as-usual (CAU) group, but not statistically significant (ITT: d = 0.27, $p = .18$; PP: d = 0.33, $p = .11$).
[Valero et al. 2022] [18]	Spain	15 (9–14 year)	randomized controlled trial	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	The control group is a wait-list control group, which means that participants in this group did not receive the intervention during the study period but were invited to participate after the study concluded	Once per week for 8 weeks	**Primary Outcomes**: ADHD symptoms were assessed with a post test evaluation and Conners parent rated scale (CPRS) **Secondary Outcomes**: Perantal stress was measured with the Parental Stress Index (PSI)	No significant difference in inattention and hyperactivity/impulsivity on the post-test however it did have a significant decrease in inattention symptoms ($p = .0324$) and executive functions ($p = .02$) on the parent rated Conners Rating scale during the 6 months follow up. It also reported a significant decrease in parental stress (post test, $p = .038$) as well as a statistically significant differences at follow up for externalizing problems on Conners (LD $p = .013$), aggression ($p = .045$) and peer relations ($p = .30$).

Table 1 (continued)

Author and Year	Country	Sample and Age	Study Design	Type of Intervention	Control Group	Duration and Frequency	Outcomes and Tests	Main results
[Zaccari et al. 2022] [19]	Italy	16 (7–11 year)	Pilot randomized controlled trial	Mindfulness-based cognitive therapy (MBCT) and Mindfulness-based stress reduction training (MBSR)	The control group is the Active Control Condition group (ACC G), which participated in an eight-week emotional awareness and recognition program instead of mindfulness training	Twice per week for 8 weeks	**Primary Outcome**: ADHD symptoms assesed with the Child Behavior Checklist for Ages 6–18 (CBCL 6–18) **Secondary Outcome**: CGI Restless-Impulsive subscale of CPRS-R: L, Sleep quality assesed Sleep Disturbance Scale for Children (SDSC) and actigraphy	A Group effect was found, with lower scores for MOM (Mindfulness-oriented meditation) than Active Control Condition Group. A subscale effect was also found with lower scores on Attention Deficit/Hyperactivity Problems subscale of CBCL 6–18 than on Attention Problems subscale of CBCL 6–18 ($p = .023$) and than on CGI Restless-Impulsive subscale of CPRS-R: L ($p = .001$). Results showed that the number of children in MOM G having, on average, clinical scores was significantly smaller than those of ACC G in: Attention Problems subscale of CBCL 6–18 (RD = −0.53, 95% CI: 0–0.86, −0.19; $p = .0089$), CGI Restless-Impulsive subscale of CPRS-R: L (RD = −0.46, 95% CI: −0.81,−0.12; $p = .0221$), and CGI Total of CPRS-R: L (RD = −0.6, 95% CI: −0.92, −0.27; $p = .0031$). Positive effect on subjective measures of sleep quality (i.e. parental questionnaire, SDSC) but not on objective ones (i.e. actigraphy)

Abbreviation: *MOM* Mindfulness oriented meditation, *EEP* Emotion Education Program, *ACC* Active control condition, *ANCOVA* Analysis of Covariance, *RCT* Randomized control trial, *CPRS* Conners parent rated scale, *CBCL* Child Behaviour checklist, *YSR scales* Behaviour rating inventory of executive functioning, youth self report, *CPT-3* Conners continous performance test 3rd edition

Huguet et al. 2017 used the Conners parent rated scale (CPRS) to assess ADHD symptoms, SCARED scale to assess anxiety symptoms, Stroop color and ward cards and coding subtest WISC to assess cognitive flexibility, automatous response inhibition and attention capacity [23]. Digit span and arithmetic subsets of WISC- IV were used to measure working memory, and CPT-III was used for the four measurements of inattentiveness, sustained attention, and impulsivity [23]. Santonastaso et al. 2020 assessed impulsivity and restlessness using the CGI restless-impulsive scale, and ADHD symptoms were measured using CPRS [16]. CPT-II, stroop color word test, MASC was used in assessing anxiety, CDI for depression and PSI-SF was used to assess parental stress [16]. Huguet et al. 2019 used CBCl, WISC-IV, ADHD Rating Scale ARS and SCQ [14]. In Clark et al. 2020 subsets of Conners 3 were used to assess inattention, hyperactivity, impulsivity, executive functions, ODD and emotional lability, and the Clinical Global Impression-Severity CGI-S was also used to assess ADHD symptom severity [22]. Muratori et al. 2021 focused on the use of the Strength and Difficulties Questionnaire SDQ-Hyperactivity subscale, Avoidance and fusion questionnaire for youth AFQ scores and the Child and Adolescent Mindfulness Measure CAMM scores [15]. Van der Oord et al. 2012 utilized the Disruptive Behavior Disorder Rating scale, DBDRS, Parental Scale Index PSI, the ADHD Rating Scale ARS [21]. Van de Weijer-Bergsma et al. 2012 used the Youth Self Report YSR, CBCL, the Teacher report Form TRF, Behavior Rating Inventory of Executive Function BRIEF, PSI, Subjective Happiness scale SHS, Flinders Fatigue Scale FFS was also used to assess insomnia associated daytime fatigue [20]. Siebelink et al. 2022 used BRIEF, CPRS, CTRA and the Strength and Weaknesses of ADHD symptom and Normal behavior SWAN scales [17]. Valero et al. 2022 [18] used CPRS, PSI, and WISC-IV assessments [18]. Zaccari et al. 2022 focused on the use of CBCL 6–18 to assess ADHD symptoms [19]. Haydicky et al. 2012 used CBCL, BRIEF and YSR assessments [13].

Overall, the studies showed improvement in the hyperactivity/ inattentive symptoms [15, 16, 19, 21–23] as well as reported decrease in oppositional defiant and conduct problems [13], impulsivity [16, 19, 21–23], improvement of executive function [18, 22], and self-control [14, 17].

A cohort study of 5 children diagnosed with ADHD revealed reductions in all core symptoms of ADHD (inattention, hyperactivity, impulsivity) according to the parents version of Conners Rating Scale ($p = .04$) [23]. Furthermore, this study revealed improvements in anxiety symptoms according to the SCARED scale. This was statistically significant for the scales completed by parents ($p = .04$), however, was not statistically significant for the scales completed by children ($p = .68$) [23].

Four RCTs [15, 16, 19, 21] showed a significant decrease in core ADHD symptoms. The RCTs also reported other significant measured outcomes. Santonastaso et al. 2020, reported a significant decrease in the CGI restless-impulsive scale and CGI total subscale and significant mean improvement in all neuropsychological measures and executive function deficits [16]. Zaccari et al. 2022 showed improvement in sleep quality on parental questionnaires [19]. Muratori et al. 2021, reported an improvement in visual motor processing speed, visual perception and focused attention as well as a significant improvement in cognitive flexibility measured on the Bells Test - Accuracy score ($p = .002$) [15].

The four other RCTs [13, 14, 17, 18] showed no significant difference in total ADHD symptoms but significant improvement in other outcomes; Siebelink et al. 2022 showed a trend of decreased hyperactivity/inattentiveness and restlessness/impulsivity symptoms and better self-control at post-treatment than those in the care-as-usual (CAU) group, but not statistically significant (ITT: $d = 0.27$, $p = .18$; PP: $d = 0.33$, $p = .11$) [17]. Haydicky et al. 2012, reported significant improvement in oppositional defiant problems and conduct problems [13]. Huguet et al. 2019, showed no significant difference in attention problems scale in the Child Behavior Checklist (CBCL) but improved emotion self-regulation in the Child Behavior Checklist (CBCL) ($p = .032$) [14]. Valero et al. 2022 [18]showed no significant difference in inattention and hyperactivity/impulsivity on the post-test, however, it did have a significant decrease in inattention symptoms ($p = .0324$) and executive functions ($p = .02$) on the parent rated Conners Rating scale during the 6 months follow up [18]. It also reported a significant decrease in parental stress (post test, $p = .038$) as well as a statistically significant differences at follow up for externalizing problems on Conners (LD $p = .013$), aggression ($p = .045$) and peer relations ($p = .30$) [18].

Two cohort studies [22, 23] showed significant reduction in hyperactivity/inattentive symptoms and impulsivity. Clark et al. 2020, a cohort of 29 children showed decreased core symptoms according to the Conners 3 subscales; Conners inattentive ($p < .001$), hyperactive/impulsive ($p = .01$), executive function ($p < .001$), ODD ($p = .001$) [22]. Huguet et al., 2017, a cohort study of 5 children revealed reductions in all core symptoms of ADHD (inattention, hyperactivity, impulsivity) according to the parents version of Conners Rating Scale ($p = .04$) [23]. Other significant measured outcomes include a reduction in anxiety symptoms according to the SCARED scale. This was statistically significant for the scales completed by parents ($p = .04$), however, was

not statistically significant for the scales completed by children ($p=.68$) [23]. Furthermore the study reported significant improvements in measures that involve cognitive flexibility, automatic response inhibition, attentional capacity (Stroop colour-word card) ($p=.043$) and processing speed (coding subtest WISC and Stroop colour card), respectively ($p=.043$; $p=.042$) [23].

One pre/post design study [20] showed no significant decrease in ADHD symptoms, it also reported decreased parental stress in fathers but no significant improvement in mothers. The study explored potential factors influencing the results, including the incorporation of parents, intervention duration, intervention type, and participants' ADHD subtypes [20].

Regarding the involvement of parents, 5 out of the 11 studies included them in the intervention [15, 17, 18, 20, 21]. Among these, two studies Muratori et al. 2021 and van der Oord et al. 2012 demonstrated significant findings, however, there was no observed significant difference in study results due to parent involvement [15, 21].

Examining the intervention duration aspect, seven out of eleven articles [14, 15, 17, 18, 20, 21, 23] implemented a once-per-week schedule, with three of them yielding significant findings [15, 21, 23]. Haydicky et al. 2012 adopted a 1.5-hour per session for 20 weeks approach but did not show a significant reduction [13]. Notably, all three studies employing a twice-per-week duration demonstrated a significant reduction in ADHD [16, 18, 22]. However, due to the limited number of studies with this frequency, the significance of this factor cannot be conclusively determined.

Concerning the relationship between the type of intervention and outcomes, nine out of eleven articles employed Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT)-based Mindfulness-Based Interventions (MBI) [14–21, 23]. Among these, five articles demonstrated a significant reduction in ADHD symptoms [15, 16, 19, 21, 23]. Tai Chi movement was utilized in a single study [22], resulting in a significant reduction of ADHD symptoms. In contrast, Haydicky et al. 2012 employed Mixed Martial Arts (MMA) during their study, with no significant impact observed on the outcome [13]. Due to the uneven distribution of studies across different interventions, no definitive comparative conclusion can be drawn regarding the effectiveness of one type of intervention over others.

As far as the medications are concerned, out of the 6 articles that showed significant difference in outcome, 2 of them had participants on ADHD medications [21, 22]. Conversely, out of the five articles showing no significant difference in ADHD symptom domains, four included participants on ADHD medications [13, 17, 18, 20].

When examining the connection between the ADHD subtypes and comorbidities on the outcome, it was noted that all studies incorporated participants, with the majority having a combined ADHD type followed by the inattentive type. Since there is no significant disparity in the ratio of ADHD subtypes across the studies, we are unable to identify any correlation with the available data. Regarding comorbidities, all studies included a majority of participants with various pre-existing disorders such as anxiety, emotional dysregulation, dyslexia, and Oppositional Defiant Disorder (ODD). Therefore, we cannot draw a conclusive correlation between comorbidities and the outcome.

Risk of bias and quality assessment in studies

The RoB assessment tool [9] used to assess risk of bias for randomized trials included in this systematic review indicated only one study [13] had an issue with random sequence generation and allocation concealment which may have led to selection bias. A high risk for performance bias in terms of blinding of participants and research personnel was noted in two studies [15, 17]. Five out of the seven studies [13, 15, 17–19] had a high risk of detection bias due to issues in the blinding of outcome assessments. One study [19] had incomplete outcome data indicative of attrition bias. No study was found to have issues in reporting bias (Selective Outcome reporting) (See Figs. 2 and 3).

The ROBANS tool [11] used to evaluate risk of bias for non-randomized studies showed all four studies [20–23] had a risk for selection bias with problems noted surrounding sequence generation and confounding variables. All four studies also had a high risk for performance bias in terms of the measurement of exposure or interventions. These studies also were found to be at risk for detection bias with issues in blinding of outcome assessments. None of the studies had incomplete outcome data and therefore there are no issues in attrition bias. One study [23] was selective in outcome reporting and thus at high risk for reporting bias. (See Figs. 4 and 5).

Table 2 shows the assessment of quality of included RCTs in this review as measured by the Correlation of Quality measures with estimates of treatment effects in meta-analyses of randomized controlled trials tool [12].

Discussion

Our systematic review consisting of 11 studies with a total number of 234 patients, sheds light on the potential benefits of mindfulness programs on the core symptoms of ADHD. Six studies revealed overall improvement in hyperactivity/ inattentive symptoms [15, 16, 19, 21–23] and five studies revealed improvement in impulsivity [16, 19, 21–23]. Mindfulness-based interventions (MBIs)

have recently garnered attention for the potential role they can play in improving the symptoms of ADHD. This proposed treatment modality is particularly appealing to a special population such as children and adolescents. It can probably contribute to additional benefits associated with psychostimulant medication treatment of ADHD.

Several characteristics of the mindfulness programs were noted to have an impact on outcomes, potentially yielding a greater effect size. For instance, the studies highlighting parental involvement tended to report larger effect sizes, suggesting a positive correlation [18, 21]. Similarly, more intensive interventions yielded greater reductions in ADHD symptoms, supporting the hypothesis that these factors contribute significantly to the efficacy of mindfulness programs [16, 19, 22]. However, it's important to note that the limited number of studies impacts our ability to draw definitive conclusions, and further studies are needed to support these observed relations.

However, it is essential to critically evaluate the findings in light of existing literature. Moreover, recent evidence from the My Resilience in Adolescence (MYRIAD) Trial highlights the importance of considering adverse effects and subgroup differences in mindfulness interventions, particularly within school settings [24]. Prior systematic reviews have suggested small effects of school-based mindfulness training (SBMT) on mental health outcomes and well-being, but evidence is limited by small sample sizes, short follow-up periods, and heterogeneity in outcomes and target populations [24].

Contrary to earlier findings, the MYRIAD Trial found no superiority of universal SBMT over standard social-emotional education, raising questions about subgroup benefits and implementation factors [25]. Specifically, concerns have been raised regarding potential iatrogenic effects in individuals with mental health difficulties [25]. In line with these considerations, our review underscores the importance of exploring potential moderators and implementation factors of mindfulness interventions. Furthermore, it highlights the importance of understanding the complexities surrounding ADHD treatment to provide comprehensive care.

Understanding the complexities surrounding ADHD treatment necessitates a comprehensive approach that integrates various modalities. While mindfulness interventions may offer supplementary benefits, it is essential to acknowledge the extensive evidence supporting pharmacological interventions, such as stimulant medications. There are few studies revealing potential tolerance to stimulant medications and authors of a literature review recommended more studies in this area [26]. However, a meta-analysis of 87 randomized controlled trials of medication treatment duration ranging from 3 to 28 weeks did not illustrate tolerance to medication treatment [27]. In addition to evidence supporting medication management of ADHD, there is also extensive evidence supporting recommending various psychosocial interventions, including behavior management interventions, training interventions and cognitive behavioral therapy [28].

Furthermore, parental perceptions of ADHD pharmacotherapy is variable, with some parents expressing reservations regarding the use of medications. This is due to multiple factors such as information seen in the lay press, concerns about substance dependence and doubts regarding the need for medication [8]. In view of such perceptions, MBIs can be a potential treatment modality clinicians may consider amongst the various treatment options available, particularly when discussing a suitable plan of care with parents who may have reservations regarding pharmacological treatment.

To discuss the possible benefits of MBIs in the treatment of ADHD, we must first address factors that can influence the outcomes of these interventions. This research sheds light on a few such factors including intervention type, intervention duration and frequency, participants' ADHD subtypes, concurrent medication use, and the involvement of parents and their supportive role.

As for the types of intervention used, the majority of the studies utilized Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT). The benefits of mindfulness practices have been explored across different populations, ranging from patients with various chronic clinical conditions to healthy individuals seeking support in improving their daily coping skills. Overall, the data suggests that mindfulness training is a useful tool that improves coping abilities, particularly in cases of distress and disability [29]. In our review of the available data, positive effects were observed in five out of nine studies, but the distribution of positive outcomes across different interventions was uneven. Some unique programs such as the Tai Chi movement showed promise, whereas Mixed Martial Arts (MMA) did not yield significant results [13, 22].

However, for such MBIs which were less represented in our study, more data is required with larger sample sizes before any clear conclusions can be drawn. Some studies have attempted to compare the efficacy of MBIs versus other treatment modalities such as comparing the effects of Computerized Progressive Attention Training (CPAT) vs. MBSR in adults with ADHD compared to a passive group [30]. Other studies have tried to compare the benefits of psychosocial treatment modalities versus medications, which found that while psychosocial treatments were helpful, they did not provide any additive benefit to stimulant medications [31]. While some

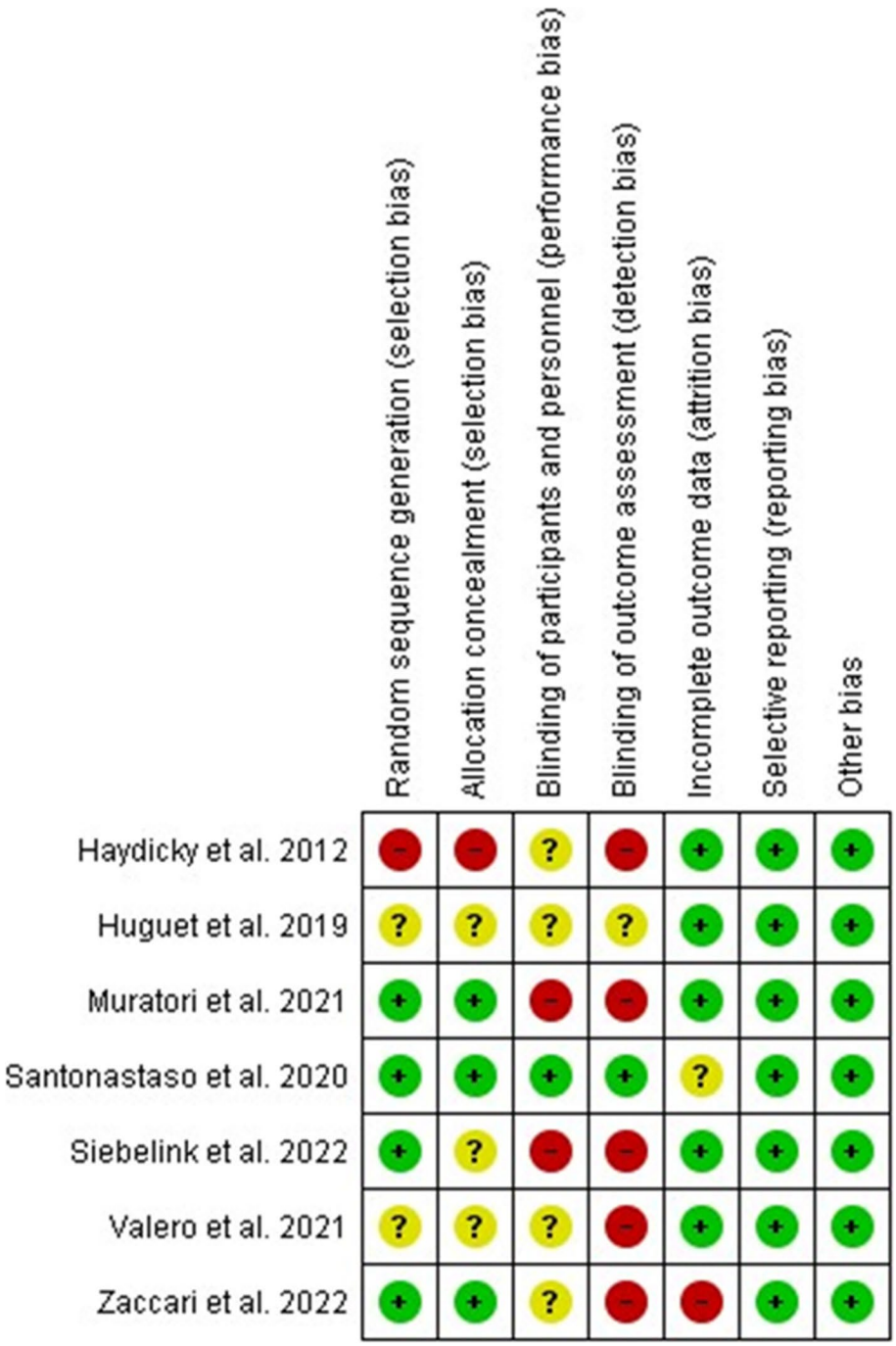

Fig. 2 Risk of bias summary of included RCTs based on the Cochrane risk-of-bias (RoB) assessment tool version 1

studies have evaluated various MBI alongside each other [32], they have not attempted to make direct comparisons between the different types and to compare their degree of efficacy.

More heterogeneous studies with various MBI types that are equally represented would allow for more room to draw conclusions about the unique benefits of each intervention type, and comparisons in the efficacy of one type of intervention over another.

Intervention duration and frequency are other factors that must be addressed when reviewing the study results. All the studies included had a minimum of 8 weeks of intervention. A mindfulness program of adequate duration is likely crucial in order to ensure the benefits of the

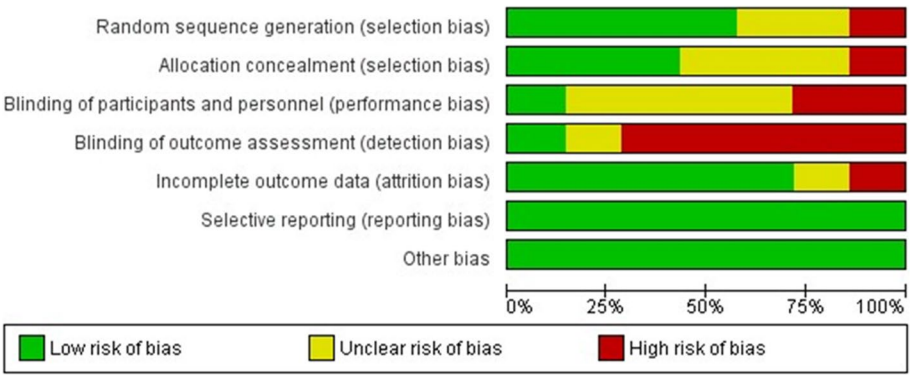

Fig. 3 Risk of bias graph of included RCTs based on the Cochrane risk-of-bias (RoB) assessment tool version 1

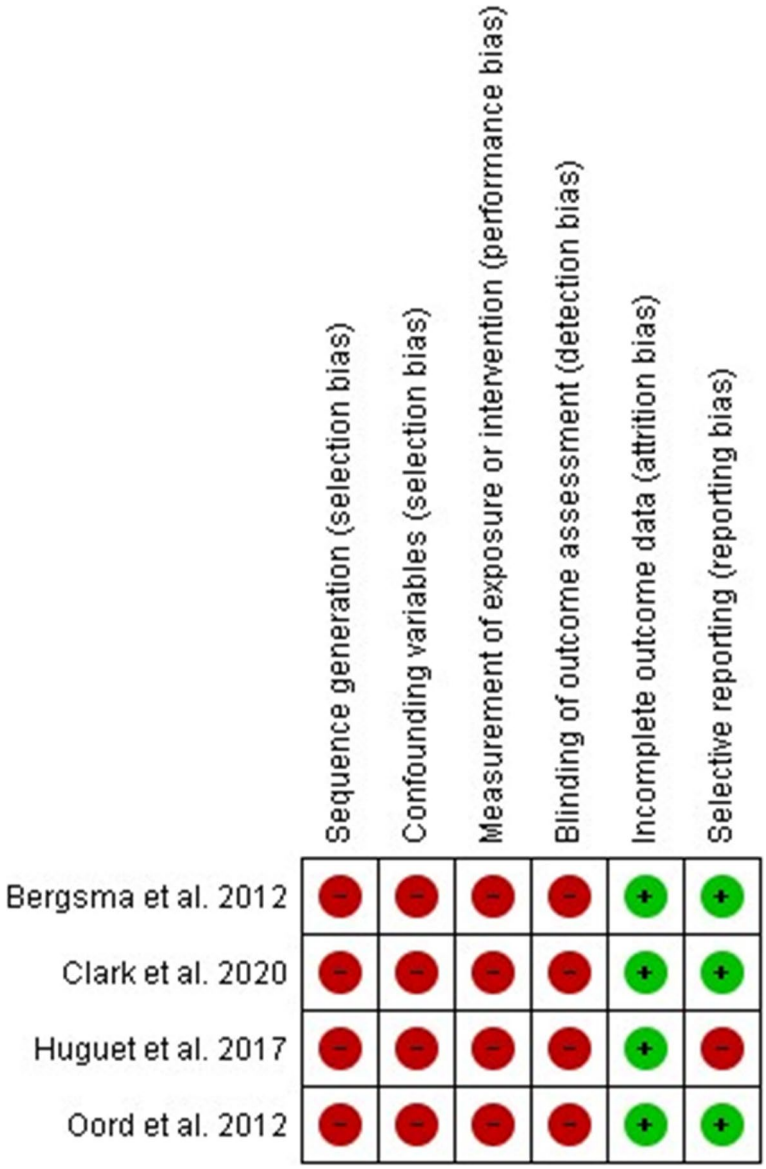

Fig. 4 Risk of bias summary of included non-Randomised studies based Risk-of-bias Assessment Tool for Non-randomized Studies (ROBANS)

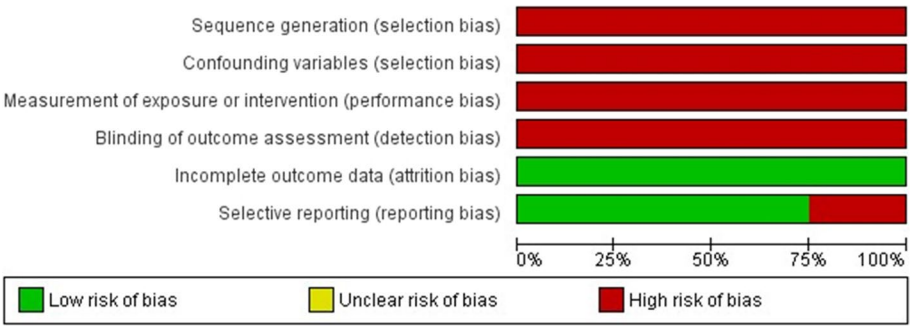

Fig. 5 Risk of bias graph of included non-Randomised studies based Risk-of-bias Assessment Tool for Non-randomized Studies (ROBANS)

intervention, for instance the effects of mindfulness on awareness and attention. The frequency of the interventions varied across studies, with a range of once-per-week to twice-per-week schedules. Notably, all studies employing a twice-per-week duration reported significant reductions in ADHD symptoms [16, 19, 22]. However, due to the limited number of studies with this frequency, further research is needed to clearly determine the impact of intervention frequency on outcomes.

The distribution of ADHD subtypes and comorbidities across studies did not seem to have an association with intervention outcomes. The studies reviewed here include participants who had a combined ADHD subtype, and various comorbidities. Therefore, the impact of ADHD subtypes and comorbidities on the effectiveness of MBIs remains inconclusive based on the available data. Consistent with previous reports it is still unclear which ADHD subtypes would benefit more from MBIs [33].

The relationship between medication use and intervention outcomes is an intriguing subject. Out of the six studies which reported significant impact of MBIs on ADHD symptomatology, only two included participants already receiving pharmacological treatment [21, 22]. One explanation for this phenomenon could be that participants receiving medications have already displayed significant change from their baseline upon initiating medications, and therefore any further changes with adjunctive MBIs only displayed incremental differences in comparison as symptoms were already significantly improved prior to introducing MBIs. This observation was also noted in a different study where it was noted that psychosocial treatment modalities did not provide any additional benefits to patients who were already receiving methylphenidate medication [31]. Further investigation into the interplay between mindfulness interventions and ADHD medications is necessary to help formulate new approaches to management and treatment of ADHD.

Lastly, when discussing the role of MBIs in a younger population, we cannot overlook the importance of parental involvement and its influence on the efficacy of MBIs. While this may be less relevant in a more independent adult population, children and adolescents are often shaped by the environments they are exposed to [34]. Family dynamics [35], adequate parental psychoeducation [36] and parental involvement [37] are some points of interest when addressing this subject.

As for the findings in this review, two out of the five studies involving parents in the mindfulness training program showed improvement in ADHD symptoms, Consequently, the conclusions that can be drawn are limited [18, 21]. Across these studies, there were several reported benefits for both children with ADHD and their parents who underwent mindfulness treatments. For the children and adolescents, the studies reported improvement in hyperactive symptoms and inattentiveness [15, 17, 18], as well as executive functions [18]. As for parental outcomes, different studies reported improvement across several domains such as improvement in parental hyperactivity and inattentiveness symptoms, reactivity, parental stress levels and parenting styles.

It is difficult to judge fairly whether the reported improvements would remain consistent across the board as the different studies each assessed unique components. The findings reported were not consistent across all studies as there were variances in the reported degree of benefit in each domain, with some studies reporting an absence of any significant improvement.

Comparing these results to existing studies in the literature which applied MBIs to other populations such as children with developmental delays [38] as well as those with normal development [39], there was overall a significant improvement in stress levels and greater life satisfaction for the parents.

In a metanalytic systematic review of MBI for adults and children with ADHD, the pooled effect size of MBIs among adults was greater for inattention (g = −0.69, 95% CI = −1.13 to −0.25, $p = .006$) compared to their effect on hyperactivity/impulsivity symptoms (g = −0.46, 95% CI

Table 2 Quality assessment of included RCT studies

Author	Haydicky et al. 2012 [13]	Huguet et al. 2019 [14]	Muratori et al. 2021 [15]	Santonastaso et al. 2022 [19]	Siebelink et al. 2022 [17]	Valero et al. 2022 [18]	Zaccari et al. 2022 [19]
Study Question well defined in introduction/methods	adequate	adequate	adequate	adequate	adequate	adequate	adequate
Study Question well defined anywhere in article	adequate	adequate	adequate	adequate	adequate	adequate	adequate
Placebo Control	not described (no placebo)	Mindfulness vs. Control	Mindfulness vs. wait list control	MOM vs. EEP	adequate	not described (no placebo)	MOM vs. ACC
Appropriate outcome studied	yes	adequate	adequate	adequate	adequate	yes	adequate
Multicenter study	single center	single center	single center	single center	single center	multicenter (two associations)	single center
Study Country	Canada	Spain	Italy	Italy	Netherlands	Spain	Italy
Adequate selection criteria	adequate	adequate	adequate	adequate	adequate	adequate	adequate
Randomization methods described	not described (wait list design was used instead of random assignment)	unclear	randomized	randomized	randomized	not described	randomized
Central randomization site	not described	unclear	local	local	not described	not described	local
Allocation concealment	not described	unclear	adequate (computer generated)	adequate	not described	not described	adequate (computer-generated random number sequence)
Patients blinded	no	unclear	unclear	adequate	no	no	unclear
Caregivers blinded	no	unclear	unclear	unclear	no	no	no
Outcome assessors blinded	not described (Reports from teachers blind to the treatment condition)	unclear	unclear	adequate	yes	not described	yes
Data analysts blinded	not described	unclear	unclear	adequate	not described	not described	not described
Double blinded	no	unclear	unclear	adequate	no	no	no
Valid statistical methods	yes	adequate	adequate	adequate	yes	yes	yes
Statistician author or acknowledged	not described	not described	not described	not desceibed	not described	not described	not described
Intention-to-treat analysis	yes	unclear	unclear	unclear	yes	no	yes

Table 2 (continued)

Author	Haydicky et al. 2012 [13]	Huguet et al. 2019 [14]	Muratori et al. 2021 [15]	Santonastaso et al. 2022 [19]	Siebelink et al. 2022 [17]	Valero et al. 2022 [18]	Zaccari et al. 2022 [19]
Power calculation reported	No	not described	not described	not described	yes	yes	yes
Stopping rules described	not described	unclear	not described	unclear	not described	not described	not described
Baseline characteristic reported	yes	adequate	yes	adequate	yes	yes	yes
Groups similar at baseline	yes (with minimal differences)	adequate	yes	adequate	yes	partially (statistically significant difference in age found between the 2 groups	yes
Confounders accounted for	not described (but ANCOVA used)	unclear	yes	unclear	yes	yes	no (they were excluded from the study)
Dropouts recorded	yes	adequate	yes	adequate	yes	yes	yes
Percentile dropouts	4.6%. withdrew from the research prior to posttesting	3/36 in Control and 2/34 in Minfulness	2/25 in experiment group. 0/25 dropouts from control	1/16 in MOM and 6/16 in EEP	5/55 from intervention and 4/48 from control	1 drop out (0.03%) lost to follow up	1/16 dropout from MOM vs. 6/16 dropouts from ACC
Reason for dropouts given	No	unclear	yes	unclear	yes	yes	not described
Findings support conclusions	Yes	adequate	yes	adequate	yes	yes	yes

= −0.80 to −0.11, $p = .015$) and overall ADHD symptoms (g = −0.52, 95% CI = −0.96 to −0.09, $p = .025$) [40].

While our review provides insights into the potential benefits of MBIs for ADHD, further research is warranted to address existing gaps in the literature, including subgroup differences, adverse effects, and implementation considerations. By critically evaluating the evidence and addressing these challenges, we can better understand the role of MBIs in ADHD management and develop more effective interventions for individuals with ADHD.

Strengths and limitations

In terms of the strengths of this systematic review, the comprehensive search strategy resulted in the identification and inclusion of a diverse range of studies, encompassing various mindfulness interventions and study designs. The inclusion of randomized controlled trials (RCTs), quasi-RCTs, and cohort studies enhanced the breadth of evidence and allowed for a more nuanced understanding of the potential benefits of mindfulness programs for ADHD.

Thoroughly analyzing study characteristics, including participant age and parental involvement, offered a comprehensive view of diverse mindfulness program contexts. A detailed examination of intervention details, such as types, duration, and frequency, enhanced understanding of how these factors may impact outcomes.

The study's emphasis on exploring potential contributing factors, including ADHD subtype, comorbidities, and the presence of other treatment interventions, demonstrated a thorough investigation into the complexities surrounding mindfulness interventions for ADHD.

While the systematic review offered valuable insights, it is essential to acknowledge certain limitations inherent in the included studies. Notably, our review did not conduct a meta-analysis, and the small sample sizes across studies warrant cautious interpretation. A key limitation lies in the heterogeneity of the mindfulness interventions employed across the studies, with variations in protocols, duration, and frequency. This diversity made it challenging to draw definitive conclusions about the most effective mindfulness approach for ADHD.

The reliance on different scales and measures across studies to assess ADHD symptoms introduced variability in outcome assessment, potentially impacting the comparability of results. Moreover, the risk of bias assessment revealed concerns, including issues related to blinding and potential selective outcome reporting, which may influence the validity of the findings. Additionally, the inclusion of participants on ADHD medications in some studies raises questions about the potential confounding effects of concurrent pharmacological treatments.

Although we utilized three of the largest research databases that encompass educational research, a limitation of our review might be the absence of searches conducted in other additional educational databases. However, leveraging these comprehensive databases may help mitigate this limitation to some extent.

Despite these limitations, this systematic review can provide a valuable source of information on the current available evidence regarding the use of mindfulness programs as a potential treatment modality for children and adolescents with ADHD. It can also help shed light on existing gaps in knowledge that may prompt further research.

Conclusion

In conclusion, this systematic review highlights the complex and multidimensional aspects of mindfulness-based interventions and how they can influence treatment outcomes for children and adolescents with ADHD. While certain trends and hypotheses have emerged in relation to the positive impact of mindfulness on the core symptoms of ADHD, the presence of multiple factors influencing study outcomes demands further exploration. Standardizing research protocols, for instance intervention types, and outcome measures, as well as increasing the number of studies with diverse characteristics will allow us to gain a more comprehensive understanding of the potential benefits of mindfulness-based interventions for children and adolescents with ADHD. Such research is of utmost value as it has the potential to change the way we design treatment plans for patients, and it can guide us in designing more individualized plans of care fitting the unique needs of different patients.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

MS and JJ contributed to designing the study. RQ and ST contributed to developing the electronic search strategy and obtaining the articles. MS, FN, BA, EK, SS, NE, and JJ contributed to data extraction and processing. MS, FN, BA, EK, SS, NE, RQ and JJ contributed to writing the original manuscript. All authors revised the paper, and approved the final version.

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Data availability
All data generated or analyzed during this study are included in this published article and its supplementary material.

Declarations

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Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Barranco-Ruiz Y, Esturo Etxabe B, Ramírez-Vélez R, Villa-González E. Interventions based on mind–body therapies for the improvement of Attention-Deficit/Hyperactivity disorder symptoms in Youth: a systematic review. Medicina. 2019;55(7):325. https://doi.org/10.3390/medicina55070325.
2. Polanczyk G, De Lima MS, Horta BL, Biederman J, Rohde LA. The Worldwide Prevalence of ADHD: a systematic review and metaregression analysis. Am J Psychiatry. 2007;164(6):942–8. https://doi.org/10.1176/ajp.2007.164.6.942.
3. Faraone SV, Doyle AE. Genetic influences on attention deficit hyperactivity disorder. Curr Psychiatry Rep. 2000;2(2):143–6.
4. American Psychiatric Association, American Psychiatric Association, editors. Diagnostic and statistical manual of mental disorders: DSM-5. 5th ed. Trevose: American Psychiatric Association; 2013.
5. Deault LC. A systematic review of parenting in relation to the development of comorbidities and functional impairments in children with Attention-Deficit/Hyperactivity disorder (ADHD). Child Psychiatry Hum Dev. 2010;41(2):168–92. https://doi.org/10.1007/s10578-009-0159-4.
6. Curatolo P, D'Agati E, Moavero R. The neurobiological basis of ADHD. Ital J Pediatr. 2010;36(1):79. https://doi.org/10.1186/1824-7288-36-79.
7. Lee YC, Chen CR, Lin KC. Effects of Mindfulness-based interventions in children and adolescents with ADHD: a systematic review and Meta-analysis of Randomized controlled trials. Int J Environ Res Public Health. 2022;19(22):15198. https://doi.org/10.3390/ijerph192215198.
8. Xue J, Zhang Y, Huang Y. A meta-analytic investigation of the impact of mindfulness-based interventions on ADHD symptoms. Medicine. 2019;98(23):e15957. https://doi.org/10.1097/MD.0000000000015957.
9. Deeks JJ, Higgins JP, Altman DG, Group on behalf of the CSM. Analysing data and undertaking meta-analyses. Cochrane Handbook for Systematic Reviews of Interventions. Ltd: Wiley; 2019. pp. 241–84. https://doi.org/10.1002/9781119536604.ch10.
10. Higgins JP, Savović J, Page MJ, Elbers RG, Sterne JA et al. Assessing risk of bias in a randomized trial. In: Higgins JPT, Thomas J, Chandler J, eds. Cochrane Handbook for Systematic Reviews of Interventions. Wiley. 2019:205–228. https://doi.org/10.1002/9781119536604.ch8
11. Kim SY, Park JE, Lee YJ, Seo H-J, Sheen S-S, Hahn S, Jang B-H, Son H-J. Testing a tool for assessing the risk of bias for nonrandomized studies showed moderate reliability and promising validity. J Clin Epidemiol. 2013;66(4):408–14. https://doi.org/10.1016/j.jclinepi.2012.09.016.
12. Balk EM. Correlation of Quality measures with estimates of treatment effect in Meta-analyses of Randomized controlled trials. JAMA. 2002;287(22):2973. https://doi.org/10.1001/jama.287.22.2973.
13. Haydicky J, Wiener J, Badali P, Milligan K, Ducharme JM. Evaluation of a mindfulness-based intervention for adolescents with learning disabilities and co-occurring ADHD and anxiety. Mindfulness. 2012;3(2):151–64. https://doi.org/10.1007/s12671-012-0089-2.
14. Huguet A, Izaguirre Eguren J, Miguel-Ruiz D, Vall Vallés X, Alda JA. Deficient emotional self-regulation in children with attention deficit hyperactivity disorder: mindfulness as a useful treatment modality. J Dev Behav Pediatr. 2019;40(6):425–31. https://doi.org/10.1097/DBP.0000000000000682.
15. Muratori P, Conversano C, Levantini V, et al. Exploring the efficacy of a Mindfulness Program for boys with attention-deficit hyperactivity disorder and oppositional defiant disorder. J Atten Disord. 2021;25(11):1544–53. https://doi.org/10.1177/1087054720915256.
16. Santonastaso O, Zaccari V, Crescentini C, et al. Clinical application of mindfulness-oriented meditation: a preliminary study in children with ADHD. Int J Environ Res Public Health. 2020;17(18):6916. https://doi.org/10.3390/ijerph17186916.
17. Siebelink NM, Bögels SM, Speckens AEM, et al. A randomised controlled trial (MindChamp) of a mindfulness-based intervention for children with ADHD and their parents. J Child Psychol Psychiatry. 2022;63(2):165–77. https://doi.org/10.1111/jcpp.13430.
18. Valero M, Cebolla A, Colomer C. Mindfulness training for children with ADHD and their parents: a Randomized Control Trial. J Atten Disord. 2022;26(5):755–66. https://doi.org/10.1177/10870547211027636.
19. Zaccari V, Santonastaso O, Mandolesi L, et al. Clinical application of mindfulness-oriented meditation in children with ADHD: a preliminary study on sleep and behavioral problems. Psychol Health. 2022;37(5):563–79. https://doi.org/10.1080/08870446.2021.1892110.
20. van de Weijer-Bergsma E, Formsma AR, de Bruin EI, Bögels SM. The effectiveness of mindfulness training on behavioral problems and Attentional Functioning in adolescents with ADHD. J Child Fam Stud. 2012;21(5):775–87. https://doi.org/10.1007/s10826-011-9531-7.
21. van der Oord S, Bögels SM, Peijnenburg D. The effectiveness of Mindfulness Training for Children with ADHD and mindful parenting for their parents. J Child Fam Stud. 2012;21(1):139–47. https://doi.org/10.1007/s10826-011-9457-0.
22. Clark D, Seymour KE, Findling RL, Mostofsky SH. Subtle motor signs as a Biomarker for Mindful Movement Intervention in Children with Attention-Deficit/Hyperactivity disorder. J Dev Behav Pediatr. 2020;41(5):349–58. https://doi.org/10.1097/DBP.0000000000000795.
23. Huguet A, Miguel-Ruiz D, Haro JM, Alda JA. A pilot study of the efficacy of a mindfulness program for children newly diagnosed with attention-deficit hyperactivity disorder: impact on core symptoms and executive functions. Int j Psychol Psychol Ther (Ed Impr). 2017;17:305–16.
24. Kuyken W, Ball S, Crane C, et al. Effectiveness and cost-effectiveness of universal school-based mindfulness training compared with normal school provision in reducing risk of mental health problems and promoting well-being in adolescence: the MYRIAD cluster randomised controlled trial. BMJ Ment Health. 2022;25(3):99–109.
25. Montero-Marin J, Allwood M, Ball S, et al. School-based mindfulness training in early adolescence: what works, for whom and how in the MYRIAD trial? BMJ Ment Health. 2022;25(3):117–24.
26. Handelman K, Sumiya F. Tolerance to stimulant medication for attention deficit hyperactivity disorder: Literature Review and Case Report. Brain Sci. 2022;12(8):959. https://doi.org/10.3390/brainsci12080959.
27. Castells X, Ramon M, Cunill R, Olivé C, Serrano D. Relationship between treatment duration and efficacy of pharmacological treatment for ADHD: a Meta-analysis and Meta-regression of 87 randomized controlled clinical trials. J Atten Disord. 2021;25(10):1352–61. https://doi.org/10.1177/1087054720903372.
28. Shrestha M, Lautenschleger J, Soares N. Non-pharmacologic management of attention-deficit/hyperactivity disorder in children and

adolescents: a review. Transl Pediatr. 2019;9(S1):S114–24. https://doi.org/10.21037/tp.2019.10.01.
29. Grossman P, Niemann L, Schmidt S, Walach H. Mindfulness-based stress reduction and health benefits: a meta-analysis. J Psychosom Res. 2004;57(1):35–43. https://doi.org/10.1016/S0022-3999(03)00573-7.
30. Stern P, Kolodny T, Tsafrir S, Cohen G, Shalev L. Near and Far Transfer Effects of Computerized Progressive Attention Training (CPAT) Versus Mindfulness based stress reduction (MBSR) practice among adults with ADHD. J Atten Disord. 2023;27(7):757–76. https://doi.org/10.1177/10870547231155877.
31. van der Oord S, Prins PJM, Oosterlaan J, Emmelkamp PMG. Efficacy of methylphenidate, psychosocial treatments and their combination in school-aged children with ADHD: a meta-analysis. Clin Psychol Rev. 2008;28(5):783–800. https://doi.org/10.1016/j.cpr.2007.10.007.
32. Chimiklis AL, Dahl V, Spears AP, Goss K, Fogarty K, Chacko A. Yoga, mindfulness, and Meditation Interventions for Youth with ADHD: systematic review and Meta-analysis. J Child Fam Stud. 2018;27(10):3155–68. https://doi.org/10.1007/s10826-018-1148-7.
33. Lee CSC, Ma M-T, Ho H-Y, et al. The effectiveness of mindfulness-based intervention in attention on individuals with ADHD: a systematic review. Hong Kong J Occup Ther. 2017;30(1):33–41. https://doi.org/10.1016/j.hkjot.2017.05.001.
34. Mulligan A, Anney R, Butler L, et al. Home environment: Association with hyperactivity/impulsivity in children with ADHD and their non-ADHD siblings. Child Care Health Dev. 2013;39(2):202–12. https://doi.org/10.1111/j.1365-2214.2011.01345.x.
35. Muñoz-Silva A, Lago-Urbano R, Sanchez-Garcia M. Family Impact and Parenting styles in families of children with ADHD. J Child Fam Stud. 2017;26(10):2810–23. https://doi.org/10.1007/s10826-017-0798-1.
36. Bai G, Wang Y, Yang L, Niu W. Effectiveness of a focused, brief psychoeducation program for parents of ADHD children: improvement of medication adherence and symptoms. Neuropsychiatr Dis Treat. 2015;11:2721–35. https://doi.org/10.2147/NDT.S88625.
37. Rogers MA, Wiener J, Marton I, Tannock R. Supportive and Controlling parental involvement as predictors of children's academic achievement: relations to children's ADHD symptoms and parenting stress. School Ment Health. 2009;1(2):89–102. https://doi.org/10.1007/s12310-009-9010-0.
38. Neece CL. Mindfulness-based stress reduction for parents of Young Children with Developmental Delays: Implications for Parental Mental Health and child behavior problems. J Appl Res Intellect Disabil. 2014;27(2):174–86. https://doi.org/10.1111/jar.12064.
39. Chaplin TM, Turpyn CC, Fischer S, et al. Parenting-focused mindfulness intervention reduces stress and improves parenting in highly stressed mothers of adolescents. Mindfulness. 2021;12(2):450–62. https://doi.org/10.1007/s12671-018-1026-9.
40. Oliva F, Malandrone F, di Girolamo G, Mirabella S, Colombi N, Carletto S, Ostacoli L. The efficacy of mindfulness-based interventions in attention-deficit/hyperactivity disorder beyond core symptoms: a systematic review, meta-analysis, and meta-regression. J Affect Disord. 2021;292:475–86.

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