**Meditation-based therapies for Attention-Deficit/Hyperactivity Disorder in children, adolescents, and adults: a systematic review and meta-analysis**

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**ABSTRACT**

**BACKGROUND:** The efficacy of meditation-based therapies for ADHD across the lifespan remains uncertain. **OBJECTIVE:** To conduct a systematic review and meta-analysis of randomised controlled trials (RCTs) assessing the efficacy of meditation-based therapies for ADHD core symptoms and associated neuropsychological dysfunctions in children/adolescents or adults with ADHD. **METHODS:** We searched Pubmed, PsycInfo, Embase+Embase Classic, Ovid Medline, and Web of Knowledge with no language, date, or type of document restriction, up to May 5th, 2018. Random-effects model was used. Heterogeneity was assessed with Cochran's Q and I2 statistics. Publication (small studies) bias was assessed with funnel plots and the Egger’s test. Studies were evaluated with the Cochrane risk of bias (RoB) tool. Analyses were conducted using *Comprehensive Meta-Analysis.* **FINDINGS:** 13 RCTs (7 in children/adolescents, n=270 and 6 in adults, n=339) were retained. Meditation-based therapies were significantly more efficacious than the control conditions in decreasing the severity of ADHD core symptoms (inattention+hyperactivity/impulsivity: children/adolescents: Hedge’s g = 0.44, 95% CI: - 0.69 to - 0.19, I2: 0%; adults: -0.66, -1.21 to -0.11, I2: 81.81%). No significant effects were found on neuropsychological measures of inattention and inhibition in children/adolescents. In adults, significant effects were detected on working memory and inhibition, although these results were based on a small number of studies (n=3). 57% and 43% of the studies in children/adolescents were rated at overall unclear and high risk of bias, respectively. In adults, 17% and 83% of the studies were deemed at overall unclear and high risk of bias, respectively. No evidence of publication bias was found. **CONCLUSIONS:** Despite statistically significant effects on ADHD combined core symptoms, due to paucity of RCTs, heterogeneity across studies, and lack of studies at low risk of bias, there is insufficient methodologically sound evidence to support meditation-based therapies for ADHD.

**Summary box**

What is already known about this subject?

* Meditation-based therapies aim to develop attention and emotion regulation to strengthen awareness, presence, and a more integrated sense of self
* Meditation-based therapies have been proposed as a treatment for ADHD
* Evidence on the efficacy of meditation-based therapies for ADHD is uncertain

What are the new findings?

* A meta-analysis of 13 randomised controlled trials on meditation-based therapies showed statistically significant effects on combined ADHD symptoms, both in children and in adults
* No significant effects were found on neuropsychological measures of inattention and inhibition in children/adolescents.
* In adults, significant effects were detected on working memory and inhibition, although these results were based on a small number of studies (n=3)
* No study was rated at overall low risk of bias

How might it impact on clinical practice in the foreseeable future?

* Due to lack of solid evidence, currently, meditation-based therapies cannot be recommended for ADHD

**BACKGROUND**

With a worldwide estimated prevalence around 5%,1 Attention Deficit/Hyperactivity Disorder (ADHD) is the most common neurodevelopmental disorder in childhood. ADHD is defined by a pervasive, persistent, and impairing pattern of inattention and/or hyperactivity/impulsivity.2 Impairing symptoms of ADHD persist into adulthood in about 65% of cases, with a pooled prevalence of adulthood ADHD around 2.5%.3, 4

Available treatments for individuals with ADHD include pharmacological and non- pharmacological options.3, 5ADHD medications have been found to be highly efficacious in randomised controlled trials (RCTs), at least in the short term.6 However, due to concerns around their possible adverse effects as well as inconclusive evidence of persistent long-term positive effects,7, 8 there is a need for additional effective and safe non-pharmacological treatments for ADHD.

Meditation-based interventions have been increasingly investigated, over the past years, as a possible therapeutic option for ADHD. These therapies, that include mindfulness and yoga, have been defined as interventions that aim to develop attention and emotion regulation to strengthen awareness, presence, and a more integrated sense of self. 9

An early Cochrane systematic review and meta-analysis published in 2010 aimed to assess the efficacy of meditation therapies for ADHD based on RCTs conducted in children or adolescents.9 However, only one of the four studies retained in the systematic review provided data for the meta-analysis, which prevented the authors from drawing any firm conclusion on the efficacy of meditation-based therapies for ADHD. A more recent meta-analysis concluded that mindfulness is effective, with a moderate effect size, both for inattentive (d = - 0.66) and hyperactive-impulsive symptoms (d= - 0.53). 10 However, this meta-analysis pooled randomised and non-randomised studies, which decreases the confidence in the results. Finally, a recent systematic review focused on randomised as well as non-randomised studies in children with ADHD, 11 although a quantitative synthesis via meta-analysis was beyond the scope of this review.

Therefore, there is a need for an updated quantitative evidence synthesis of the efficacy of meditation-based therapies for ADHD based on RCTs across the lifespan.

**OBJECTIVE**

To fill this gap, we conducted a systematic review and meta-analysis of RCTs assessing the efficacy of meditation-based therapies on ADHD core symptoms, as well as associated neuropsychological dysfunctions, in children/adolescents and adults. Given the exploratory nature of the meta-analysis, no *a priori* hypotheses were formulated.

**METHODS**

We followed the recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. 12 The protocol of this systematic review was registered in PROSPERO (CRD42018096156).

**Type of studies**

We included RCTs, regardless of the levels of blinding. Both parallel and cross-over designs were eligible. For cross-over studies, we used pre cross-over data. If these were not available, due to concerns about possible carry-over effects, we removed the study in a sensitivity analysis.

**Type of participants**

We included studies with participants of any age (children, adolescents, or adults) with either an ADHD diagnosis (or equivalent) based on any *Diagnostic and Statistical Manual of Mental Disorders* (DSM) or *International Classification of Diseases* (ICD) edition or with scores above a cut point on any validated ADHD scale. Psychiatric comorbidities in part of the study participants or all of them were not exclusionary.

**Type of interventions**

Any meditation-based intervention, including the following: mindfulness, vipassana, zen, yoga, yogic, pranayama, sudarshan, qi-gong, qigong, chi kung, kundalini, chundosunbup, eiki, tai chi, mantra, kirtane, samantha, kriya, "loving kindness", "self compassion", Dharan, Vajrayana, samadi, zaizen, Patanjali, dhyani, acceptance and commitment therapy.

**Type of control condition**

Eligible control conditions included: no treatment; waiting list; psychoeducation without any structured psychotherapy, training without a structured psychotherapy, any other activity not classified as a structured psychotherapy, or treatment as usual. Treatment as usual was accepted even when including a pharmacological intervention, if the medication was not an entry criteria or it was delivered within the trial design.

**Outcomes**

The primary outcome was represented by combined scores of ADHD core symptoms (i.e., inattention plus hyperactivity/impulsivity) on any validated ADHD scale. When inattention and hyperactivity/impulsivity scores were reported separately, they were pooled to obtain the overall effect size for the study; if only inattention or only hyperactivity/impulsivity were reported, we used what available for the primary outcome. In terms of source of the reporting, we explored the feasibility of conducting separate meta-analyses by source (e.g., one meta-analysis for scores reported by investigators, one for parents, one for teachers, one for self-reported). However, this turned out to be not possible due to paucity of data. As such, as per protocol, the following hierarchy was followed in the choice of the outcome for the meta-analysis: investigator-rated, teacher-rated, parent-rated, and self-reported.

Secondary outcomes included: 1) inattention and hyperactivity/impulsivity, separately (using the same hierarchy as above for the choice of the rater); 2) neuropsychological measures (any) of inhibition; 3) neuropsychological measures (any) of working memory; 4) neuropsychological measures (any) of inattention.

**Search strategy/syntax**

The following electronic databases were searched (last search: May 5th, 2018), with no language/date/type of document restrictions: Pubmed (Medline), OVID databases (PsycInfo, EMBASE+EMBASE classic, OVID Medline), and WEB OF KNOWLEDGE Databases (Web of science (science citation index expanded), Biological abstracts, Biosis, Food science and technology abstracts). Search terms/syntax in Pubmed were as follows: (meditation OR mindful OR mindfulness OR mindfulness-based OR vipassana OR zen OR yoga OR yogic OR pranayama OR sudarshan OR qi-gong OR qigong OR chi kung OR kundalini OR chundosunbup OR reiki OR tai chi OR mantra OR kirtane OR samantha OR kriya OR "loving kindness" OR "self compassion" OR "self-compassion" OR dharan OR vajrayana OR samadi OR zaizen OR patanjali OR MSC OR MBCT OR MBSR OR dhyani OR "acceptance and commitment therapy" OR acceptance commitment therapy) AND (ADHD OR attention deficit OR attention-deficit OR hyperkinetic syndrome OR hyperkinetic disorder) AND (randomly OR randomized OR randomised). Additional details on the search strategy/syntax, including search terms for each database, are reported in the Supplemental Material 1. Additionally, references of included studies were hand-searched to find any potential pertinent study detected with the electronic search.

**Screening and data extraction**

*Screening*

The eligibility process was conducted in two separate stages:

1. Two authors (JZ, AD) independently screened title and abstracts of all non-duplicated papers and excluded those not pertinent. A final list was agreed with discrepancies resolved by consensus between the two authors. When consensus was not reached, a third, senior author (SC) acted as arbitrator. If any doubt about inclusion existed, the article proceed to the next stage.

2. The full-text version of the articles passing stage 1 screening was downloaded and assessed for eligibility by two authors (JZ, AD), independently. Discrepancies were resolved by consensus between the two authors and, if needed, a third senior author (SC) acted as arbitrator.

Where required, the corresponding authors of screened studies were contacted to inquire on study eligibility.

*Data extraction*

Two researchers (JZ, AD) performed independently data extraction; any discrepancies were resolved by consensus between the two authors.

The following data were extracted:

1. Publication detail: year and language of publication, country where the study was

conducted; 2. Setting (clinical vs. population-based study); 3. Study participants details: number, mean age (SD), gender distribution, SES and ethnicity of participants; method to establish the ADHD diagnosis; medication status; 4. Outcome: mean and SD for each of the above mentioned outcomes.

**Risk of bias assessment**

The risk of bias of each study retained for the meta-analysis was independently assessed by two authors (JZ, AD) using the Cochrane Risk of Bias (RoB).13 RoB domains included: selection bias (random sequence generation, allocation concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and other bias. Any disagreement was resolved through consensus. As in Cortese et al.,14 the overall rating of risk of bias for each study was the lowest rating for any of the criteria (e.g., if any item was scored high risk of bias, the study was considered at high risk of bias; if all the items were scores at low risk, the study was deemed at overall low risk).

**Statistical analysis**

Analyses were performed with Comprehensive Meta-Analysis, CMA (http:// [www.meta-analysis.com/index.php)](http://www.meta-analysis.com/index.php%29), using the option “Comparison of two groups, continuous, unmatched groups, pre and post data, means, SD, pre and post N, Pre/Post correlation, standardized by post score SD. Of note, since CMA requires the pre/post correlation but this was not reported in any of the studies included in our meta-analysis, we checked if the results varied according to different values of pre/post correlation. Since our results did not change at all when varying the pre/post correlation from 0 to 0.9, we could run the analyses even though individual papers did not report the pre/post correlation. Given the inherent heterogeneity of studies, random-effect model was used. We used the I-squared index to assess the heterogeneity of effect sizes. We used the appropriate CMA function to combine outcomes from the same subjects to pool hyperactivity/impulsive and inattentive scores when they were reported separately (<https://www.meta-analysis.com/downloads/Multiple%20outcomes.pdf>). Heterogeneity was assessed and measured with Cochran's Q and I2 statistics, which estimates the percentage of variation among effect sizes that can be attributed to heterogeneity. 15 I2 > 0 indicates that the degree of heterogeneity is greater than would be expected by chance. We used Egger’s test and funnel plots to estimate publication biases.16

**FINDINGS**

From a pool of 142 non-duplicate potentially relevant references, a total of 13 studies (reported 17 references), 7 in children/adolescents 17-23 and 6 in adults,24-29 were retained in the meta-analysis. A detailed description of selection process is shown in Figure 1, reporting the PRISMA flow diagram. Reasons for the exclusion of studies assessed in full-text length are listed in Supplemental Material 2. A list of included studies is provided in Supplemental Material 3. Table 1 reports the main characteristics of the included studies. Two studies, both in children/adolescents, were cross-over, the rest were parallel. In terms of type of intervention, in children/adolescents, four were on mindfulness (two including a family component) and three on yoga, whilst in adults, two were on mindfulness, two on mindfulness-based cognitive therapy, one on dialectical therapy including meditation-based elements, and one on cognitive behavioral therapy including meditation-based elements.

 The average duration was 8 weeks. Overall, the retained studies included 609 participants (270 children/adolescents, 339 adults). As for the risk of bias (see Supplemental Material 4), in children/adolescents, 57% of the studies were at overall unclear risk of bias and 43% at overall high risk of bias, whilst in adults, 17% of the studies were at overall unclear risk of bias and 83% at overall high risk of bias.

Table 2 summarises the results of all the analyses, reported in more detail in the Supplemental Material 5. In addition to the planned sensitivity analysis removing the cross-sectional study by Jensen et al.,22 (for which no pre-cross over data were available) in children/adolescents, we conducted a post hoc sensitivity analysis removing two studies, both in adults, (Fleming et al. 26 and Pettersson et al. 29) where the active interventions were not exclusively meditation-based therapies. More specifically, in the study by Fleming et al. 26, the intervention was dialectical behavior therapy (DBT) group skills training adapted for college students with ADHD (including a component of meditation-based therapy) and in the study by Petterson et al. 29 the intervention consisted of (a) Behavior analysis, (b) Mindfulness and acceptance, (c) Time management, (d) Gauging attention span, (e) Reducing distractors, (f) Organization and planning, (g) Problem solving, (h) Behavior activation, (i) Cognitive restructuring, and (j) Anger control training. Furthermore, we conducted another sensitivity analysis removing the study by Gershy et al.,17 in children/adolescents, because its outcome was based on the Child Behavior Checklist (CBCL) externalizing scale, which includes ADHD but also other non-ADHD externalizing symptoms. Finally, we conducted *post hoc* analyses according to the type of control condition. Indeed, we deemed that there were enough studies (children: n=2; adults, n=4) to conduct sub-group analyses restricted to studies using waiting list, while there were not enough studies (i.e., 1 study per type of control condition) to run separate meta-analyses for the other individual control conditions.

*Children/adolescents*

The result relative to the primary outcome (combined ADHD core symptoms) showed that, when pooling the retained studies, meditation-based therapies were significantly more efficacious than the control conditions, with a moderate effect size (Hedge’s g = 0.44, 95% CI: - 0.69 to - 0.19), with no evidence of true heterogeneity (I2: 0%) (Figure 2). We also found evidence of larger effects on inattentive symptoms (-0.52, -0.81 to -0.23, I2: 0%), compared to hyperactive-impulsive symptoms (-0.40, -0.68 to -0.12, I2: 0%). Results relative to the effects of meditation-based therapies on ADHD core symptoms were generally robust to the sensitivity analyses that we conducted. In contrast to the effect on ADHD core symptoms, no significant effects were found on neuropsychological measures of inhibition (-0.35, -0.91 to 0.21) or inattention (-0.35, -0.86 to 0.17), with evidence of heterogeneity for both (I2: 61.85% and 59.26%, respectively).

*Adults*

We found a significant effect on the combined measure of inattention/hyperactivity (-0.66, -1.21 to -0.11, with evidence of heterogeneity, I2: 81.81%), which disappeared in the sensitivity analysis removing the two studies 26,29 with interventions not exclusively focused on meditation-based elements. When considering effects on inattention and hyperactivity/impulsivity separately, results were significant for inattention (-0.81, -1.55 to -0.08) but not for hyperactivity/impulsivity (-0.70, -1.48 to 0.09), with evidence of heterogeneity for both (I2: 88.31% and 88.65%, respectively). As for the neuropsychological measures, effects of meditation-based therapies on inhibition (-0.54, -0.84 to -0.24, I2: 0%) and working memory (-0.42, -0.73 to -0.11, I2: 0%), but not on inattention (-0.63, -1.41 to 0.14. 58.39%), were significant, although analyses on inhibition and working memory were based, each, on three studies only.

As expected, limiting the analyses to studies including a wait list control increased the effect size (see Table 2 and Supplemental Material 5), both in children/adolescents and in adults.

As reported in the Supplemental material 6 (funnel plots) and Table 2 (Egger’s test), there was no evidence of publication (small studies) bias in any of the analyses, both in children/adolescents and in adults.

**DISCUSSION**

To our knowledge, this is the largest systematic review and meta-analysis of RCTs assessing the efficacy of meditation-based interventions for ADHD core symptoms and neuropsychological dysfunctions associated with ADHD. Due to the increasing number of relevant publications in the field over the past years, we were able to retrieve a higher number of RCTs in relation to previous systematic reviews/meta-analyses in the field. 9-11

When considering our primary outcome (i.e., combined symptoms of ADHD), meditation-based therapies were significantly more efficacious then the control conditions, both in children/adolescents and adults, with moderate mean effect size (higher in adults compared to children/adolescents). In terms of effects on neuropsychological measures, whilst we found significant effects on inhibition and working memory, but not inattention, in adults, no significant effects were detected on inhibition and inattention in children.

Significant effects of meditation-based therapies on ADHD core symptoms would be plausible considering that a common feature of these interventions is to address attention process as well as self-control and emotional regulation, which are deficient in a sizable portion of individuals with ADHD.30 However, our results should be considered very cautiously due to a number of methodologically and clinically relevant issues in the retained studies.

First, whilst we restricted the meta-analysis to RCTs, all the studies were either single blind or failed to clearly report the level of blinding. This raises the concern of possible expectancy effects, which are a well-known issue particularly with RCTs of non-pharmacological interventions and may introduce potential important bias. 31 In a series of meta-analyses aimed to assess the efficacy of other non-pharmacological interventions for ADHD (namely, behavioural therapy, diet interventions, cognitive training and neurofeedback), the European ADHD Guidelines Group (EAGG) addressed this issue conducting separating analyses based on the type of rater, defined as *most-proximal* (i.e., rater involved in the delivery of the intervention, usually not blinded) and *probably blinded* (defined as such after consensus of the EAGG members, when trials did not clearly report that the rater was blind). 5, 32-34 The EAGG found significant effects considering *most proximal* ratings across the majority of the interventions, but these significant effects were generally not replicated when relying on *probably blinded* ratings. Unfortunately, due to paucity/inconsistency in data reporting, we were not able to adopt here the same approach used by the EAGG.

Second, beyond the issue of blinding, none of the retained studies was rated at overall low risk of bias, due to a number of concerns with the majority of the items of the RoB, including not only performance bias (blinding of participants and personnel) and detection bias (blinding of outcome assessment), but also selection bias (random sequence generation and allocation concealment), and attrition bias (incomplete outcome data). Furthermore, the lack of protocol for the majority of the retained studies prevented us from ruling out possible reporting bias (selective reporting) and calls for a more complete and transparent reporting in the field.

Third, the type of control condition varied across the retained studies, encompassing self-guided skills handouts, nonviolent resistance parent training, psychoeducation, waiting list, among others. It is possible that the type of control impacts on the magnitude of the effects. Due to paucity of data, we did not deem informative to conduct separate subgroup analyses according to the type of intervention. Of note, the significant effects of mediation-based therapies on ADHD combined symptoms disappeared in a sensitivity analysis removing two studies 26,29 with interventions not exclusively focused on meditation-based elements. On the one hand, this casts doubt on the actual effects of meditation-based therapies *per se* on ADHD; on the other hand, it suggests that interventions combining different approaches (e.g., cognitive behavioral therapy plus meditation therapy) may be more efficacious then single-modality interventions.

Fourth, in the majority of the retained studies, participants were treated with medications, so that it not possible to disentangle to which extent the observed effects were due to meditation-based therapies or were accounted for by the interaction of meditation base therapies and pharmacological treatment.

Fifth, the heterogeneity across studies in adults and in the analyses relative to neuropsychological measures in children, reflected in values of I2 > 0 in the majority of the analyses, indicated true heterogeneity, rather than variability due to chance, which urges caution in generalizing our results to the entire ADHD population.

An additional concern in relation to meta-analysis of studies in adults is the lack of significant results when considering, specifically, hyperactive/impulsive symptoms as an outcome, in contrast to the positive (albeit marginally) effect of meditation-based therapies on inattentive symptoms. This points to possible specific effects of meditation-based therapies on specific subdomains of ADHD, which should be further explored in future research.

The lack of effects on neuropsychological measures in children/adolescents is in contrast with what observed with cognitive training. In a meta-analysis of cognitive training for children with ADHD, Cortese et al. 32 found significant effects on working memory (verbal and visual), but not on ADHD core symptoms rated by probably blinded observers. This led these authors to conclude that deficits in executive functions are unlikely to mediate the pathway between etiological factors and phenotypic behavior of ADHD. On the same ground, given our negative finding on neuropsychological measures, it is even more unlikely that the effects of meditation-based therapies on ADHD core symptoms, if any, are driven by improvement in executive dysfunctions, at least in children/adolescents. Whilst the effects on neuropsychological measures of inhibition and working memory were significant in adults, we would urge caution in the interpretation of these results since they were based on three studies only.

In addition to including a larger number of participants and rigorously blinded raters, future RCTs aimed to assess the effects of meditation-based therapies for ADHD will need to adopt a standard definition of control condition and, possibly, include medication-naïve participants.

As noted by Evans et al.,11 an important aspect that needs to be clarified by further research is to which extent including parents in the therapeutic programme enhances the effects of the treatment. Since only two studies, among the ones retained in our meta-analysis, included a parental component in the treatment programme, we were unable to address this clinically relevant question. Future research will also need to establish the optimal frequency/intensity and duration of the treatment programme, as well as the requirements, in terms of training of the therapist, that are likely to lead to effective interventions. Whilst the majority of the available RCTs of meditation-based therapies for ADHD focused on ADHD core symptoms or neuropsychological dysfunctions, other important outcomes, such as quality of life, or comorbid disorders, should be included in future trials. Finally, it will be important to establish to which extent meditation-based therapies can be considered a stand-alone intervention for ADHD, or, rather, they can enhance the effects of other interventions (pharmacological or non-pharmacological), on ADHD core symptoms or associated impairment.

**CLINICAL IMPLICATIONS**

Currently, there is insufficient methodologically sound evidence to support the recommendation of meditation-based therapies as an intervention aimed to target ADHD core symptoms or related neuropsychological dysfunctions in children/adolescents or adults with ADHD. Pending replication of good efficacy of meditation-based therapies in additional well conducted RCTs, clear standards for the training of therapists will need to be considered before implementing such therapies in routine care for children, adolescents and adults with ADHD.

**Table 1. Descriptive table of the studies included in the meta-analysis.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **First author (year)** | ***N*** | **Type of meditation** | **Type of control** | **Study design** | **Blinding** | **Length of the study (weeks)** | **Age range** | **Meditation\_Mean age (SD)** | **Control\_Mean age (SD)** | **% of subjects treated with medication** |
| Studies in children/adolescents |
| Gershy (2017) | 57 | Mindfulness and nonviolent resistance parent training | Nonviolent resistance parent training | Parallel | NS | 0 | 6-15 | - | - | Not reported |
| Haffner (2006) | 20 | Yoga | Conventional motor exercise | Cross-over | NS | 8 | 8-11 | 9.78 (0.83) | 9.36 (0.81) | Meditation = 55.56Control = 27.27 |
| Jensen (2004) | 14 | Yoga | Cooperative activities | Cross-over | NS | 20 | 8-13 |  |  | Total = 85.71  |
| Kiani (2017) | 30 | Mindfulness meditation training | Waiting list | Parallel | NS | 8 | 13-15 | 13.17 (0.35) | 13.42 (0.73) | Meditation = 0Control = 0 |
| Kim (2014) | 20 | Yoga | Waiting list | Parallel | NS | 4 | 7-17 | 12.90 (1.79) | 13.00 (48) | Not reported |
| Lo (2017) | 100 | Family-based mindfulness intervention | Waiting list | Parallel | NS | 6 | 5-7 | 6.24 (0.87) | 5.92 (0.70) | Not reported |
| Sidhu (2015) | 29 | Mindfulness training | Puzzle/Lego wood block stacking games | Parallel | NS | 4 | 8-12 | 10.20 (1.37) | 10.71 (1.44) | Meditation = 26.7; Control = 21.4 |
| Studies in adults |
| Fleming (2015) | 33 | Dialectical behavior therapy | Self-guided skills handouts | Parallel | Single blind | 8 | 18-24 | 21.20 (1.67) | 21.50 (1.12) | Meditation = 70.6Control = 81.2 |
| Gu (2018) | 54 | MBCT | Waiting list | Parallel | Single blind | 6 | 19-24 | 20.21 (1.03) | 20.38 (1.02) | Meditation = 71.43Control = 76.92 |
| Hoxhaj (2018) | 81a | Mindfulness training | Psychoeducation | Parallel | Single blind | 8 | - | 40.51 (9.48) | 38.50 (11.83) | Meditation = 0Control = 0 |
| Janssen (2018) | 120b | MBCT | Waiting list | Parallel | Single blind | 8 | - | 39.7 (11.1) | 39.0 (10.1) | Meditation = 60Control = 48 |
| Mitchell (2017) | 20 | Group-based mindfulness treatment | Waiting list | Parallel | Open label | 8 | - | 40.55 (6.83) | 36.22 (6.92) | Meditation = 54.5Control = 55.6 |
| Pettersson (2017) | 31 | Internet-based cognitive behavioral therapy, self-format (S) | Waiting list | Parallel | Single blind | 10 | - | 38.92 (8.50) | 33.78 (10.07) | Meditation = 53.8Control = 50.0 |
| MBCT = mindfulness-based cognitive therapy; NS = not specified.aData on working memory come from Bachmann 2018 on 40 subjects only.bData on inhibition and working memory refer to 103 subjects only from Hepark 2015 (see Supplemental Material 3). |

**Table 2. Summary of the results of the meta-analysis.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of analysis** | **N Studies** | **N Subjects** | **Hedge 'g** | **Lower****limit** | **Upper****limit** | **P** | **Heterogeneity** |  | **Egger's Testpublication Bias** |
| **Q** | **df** | **p** | **I2** |  | **t** | **p** |
| **Children/adolescents** |
|  ADHD symptoms COMBINED OR inattention OR hyperactivity/ impulsivity  | 6 | 240 | -0.44 | -0.69 | -0.19 | 0.001 | 4.17 | 5 | 0.525 | 0.00 |  | 0.48 | 0.654 |
|  ADHD symptoms COMBINED OR inattention OR hyperactivity/ impulsivity (removing Jensen 2004) | 5 | 226 | -0.46 | -0.72 | -0.20 | 0.001 | 3.94 | 4 | 0.414 | 0.00 |  | 0.73 | 0.518 |
| ADHD symptoms COMBINED OR inattention OR hyperactivity/ impulsivity (removing Gershy 2017) | 5 | 183 | -0.54 | -0.83 | -0.26 | <0.001 | 2.05 | 4 | 0.726 | 0.00 |  | 0.29 | 0.788 |
|  Inattention  | 5 | 183 | -0.52 | -0.81 | -0.23 | <0.001 | 2.60 | 4 | 0.626 | 0.00 |  | 0.25 | 0.818 |
|   Inattention (removing Jensen 2004) | 4 | 169 | -0.57 | -0.88 | -0.27 | <0.001 | 1.62 | 3 | 0.654 | 0.00 |  | 0.95 | 0.442 |
|  Hyperactivity/impulsivity  | 4 | 191 | -0.40 | -0.68 | -0.12 | 0.006 | 1.95 | 3 | 0.582 | 0.00 |  | 0.20 | 0.857 |
|  Hyperactivity/impulsivity (removing Jensen 2004) | 3 | 177 | -0.39 | -0.69 | -0.10 | 0.010 | 1.07 | 2 | 0.378 | 0.00 |  | 0.14 | 0.909 |
|  Hyperactivity/impulsivity (removing Gershy 2017) | 3 | 134 | -0.52 | -0.85 | -0.18 | 0.002 | 0.19 | 2 | 0.906 | 0.00 |  | 0.38 | 0.767 |
|  Neuropsychological measures of inhibition  | 3 | 159 | -0.35 | -0.91 | 0.21 | 0.223 | 5.24 | 2 | 0.073 | 61.85 |  | 0.87 | 0.545 |
|  Neuropsychological measures of inattention  | 4 | 179 | -0.35 | -0.86 | 0.17 | 0.189 | 7.36 | 3 | 0.061 | 59.26 |  | 1.83 | 0.208 |
|  ADHD symptoms COMBINED OR inattention OR hyperactivity/ impulsivity (studies with waiting list control only ) | 2 | 120 | -0.62 | -0.98 | -0.25 | 0.001 | 0.91 | 1 | 0.339 | 0.00 |  | - | - |
| **Adults** |
| ADHD symptoms COMBINED OR inattention OR hyperactivity/ impulsivity  | 6 | 339 | -0.66 | -1.21 | -0.11 | 0.018 | 27.48 | 5 | <0.001 | 81.81 |  | 2.12 | 0.101 |
| ADHD symptoms COMBINED OR inattention OR hyperactivity/ impulsivity (removing Fleming 2015 and Petterson 2017) | 4 | 275 | -0.72 | -1.50 | 0.07 | 0.073 | 26.38 | 3 | <0.001 | 88.63 |  | 1.73 | 0.224 |
| Inattention  | 5 | 308 | -0.81 | -1.55 | -0.08 | 0.030 | 34.23 | 4 | <0.001 | 88.31 |  | 2.03 | 0.134 |
| Inattention (removing Fleming 2015) | 4 | 275 | -0.93 | -1.84 | -0.02 | 0.046 | 34.23 | 3 | <0.001 | 91.23 |  | 2.05 | 0.175 |
| Hyperactivity/impulsivity  | 4 | 275 | -0.70 | -1.48 | 0.09 | 0.081 | 26.44 | 3 | <0.001 | 88.65 |  | 2.00 | 0.182 |
| Neuropsychological measures of inhibition  | 3 | 174 | -0.54 | -0.84 | -0.24 | <0.001 | 1.17 | 2 | 0.557 | 0.00 |  | 0.74 | 0.593 |
| Neuropsychological measures of inattention  | 2 | 74 | -0.63 | -1.41 | 0.14 | 0.110 | 2.40 | 1 | 0.121 | 58.39 |  | - | - |
| Neuropsychological measures of working memory  | 3 | 160 | -0.42 | -0.73 | -0.11 | 0.008 | 1.56 | 2 | 0.458 | 0.00 |  | 0.22 | 0.857 |
| ADHD symptoms COMBINED OR inattention OR hyperactivity/ impulsivity (studies with waiting list control only) | 4 | 225 | -0.98 | -1.68 | -0.28 | 0.006 | 15.24 | 3 | 0.002 | 80.31 |  | 2.61 | 0.120 |

**FIGURES CAPTIONS**

Figure 1. PRISMA flow chart

Figure 2. Forest plots for the primary outcome (ADHD core symptoms, combined)

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