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Effects of mindfulness interventions on depressive symptoms in adolescents: A meta-analysis

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ABSTRACT

Background: Depression among adolescents is rising globally and is the leading cause of illness and disability among adolescents. While antidepressants and psychotherapy are effective, only about 40% of depressed adolescents receive treatments due to lack of professionals and barriers such as cost and personal obstacles including stigma, lack of motivation, and negative perceptions of treatment. Use of alternative and complementary treatments for depression is growing. One such treatment is mindfulness meditation.
Objective: We examined the effects of mindfulness interventions on depression among adolescents and explored the moderator effects of participants, methods, and intervention characteristics.
Methods: We searched 17 databases from their inception to April 2019 to identify studies written in English. Search terms included depress* AND mindful* OR meditat* AND adolescen* OR student*; 29 studies met inclusion criteria. Two researchers independently coded data from all primary studies. Discrepancies were discussed with a third researcher to reach consensus. Using the random effects model, we computed the effect sizes (ESs) of mindfulness interventions on depression using standardized mean differences (Hedge's g) with 95% confidence intervals (CI). Funnel plot, Q statistics, and I^2 were used to test the heterogeneity across studies. We examined moderators to explore sources of heterogeneity.
Results: Across 29 studies (N=3688), 1839 adolescents participated in mindfulness interventions; 1849 served as controls. Mean ages ranged from 10.2 to 19.5 years. Mindfulness groups showed reduced depression compared to control groups (g=.14, 95%CI[.01−.28], p<.042). Funded studies showed greater improvement in depression (g=.34, 95%CI[.09−.58], p<.008) compared to unfunded (g=.05, 95%CI[−.12−.22], p<.554). Interestingly, while only two research teams studied mindfulness-based cognitive therapy, they showed trends toward improvement (p=0.09) in depression (g=.76, 95%CI[.18−1.34], p<.010, s=2) compared to adapted mindfulness interventions (g=.13, 95%CI[−.04−.30], p<.140, s=16) or mindfulness-based stress reduction (g=.07, 95%CI[−.16−.29], p<.559, s=11). Mindfulness interventions with individual counseling tended (p=0.09) to improve depression (g=.46, 95%CI[.07−.85], p<.021, s=3) more than without (g=.10, 95%CI[−.04−.24], p<.168, s=26). Depression improved more when follow-up measures occurred further from the intervention (*Slope*=.002, τ^2=.74, $Q_{between}$=4.10, p=.043, s=29). No quality indicators moderated the ES of mindfulness interventions on depression.
Conclusion: Mindfulness interventions are mildly effective interventions to reduce depressive symptoms among adolescents. Clinicians trained in mindfulness interventions might encourage mindfulness meditation as adjunctive/alternative treatment for adolescents with mild or moderate depressive symptoms as well as for at-risk adolescents to prevent depression. Funding, type of mindfulness interventions, individual counseling, and time to follow up were moderators of the effects of mindfulness interventions on depression in adolescents.

What is already known about the topic?

- Depression is a leading cause of illness and disability in adolescents.
- Antidepressants and psychotherapeutic interventions are effective treatments for depression, but approximately 60% of depressed adolescents do not receive treatments due to a lack of mental professionals and barriers.
- Alternative and complementary treatments, such as mindfulness interventions, are growing.

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- Researchers have meta-analyzed the effects of mindfulness interventions on depression in the adult population, but no prior researchers meta-analyzed the effects of mindfulness interventions on depression in adolescents.

What this paper adds

- Mindfulness interventions had a small effect on improving depressive symptoms in adolescents.
- Moderators of the effects of mindfulness interventions on depression included funding, type of mindfulness intervention, mindfulness interventions combined with individual counseling, and time to follow up.

1. Introduction

Depression is a global mental health illness and the 4th leading cause of illness and disability among adolescents aged 15–19 years and 15th for those aged 10–14 years (Bernaras et al., 2019; Twenge et al., 2019; World Health Organization [WHO], 2020a). Among adolescents, females disproportionately report more depressive symptoms than males. Interestingly, females have the peak velocity of depressive symptoms (the age at which depressive symptoms increases most rapidly) at approximately 13.5 years compared to males at 16 years (Kwong et al., 2019). Although the WHO does not regularly assess the prevalence of depression in adolescents (WHO, 2020a, 2020b), the global prevalence rate of depression varies, for example, 6% in Greece (Magklara et al., 2015), 8% in England (Sadler et al.), 13% in Thailand (Wichaidit et al., 2019), 14% in Korea (Yun et al., 2019), 37% in Bangladesh (Anjuma et al., 2019), and 40% in North India (Singh et al., 2017). Approximately 3.2 million (13.3%) adolescents in the United States had at least one major depressive episode and 71% of those had depression with severe impairment (National Institute of Mental Health [NIMH], 2019). Adolescents exhibit depressive symptoms which result in negative consequences across numerous domains of psychosocial functioning such as school/occupational performance, interpersonal functioning, and quality of life in adulthood (Clayborne et al., 2019). In addition, untreated depression in adolescents may extend to major depressive disorders in young adulthood (Mullen, 2018). Unfortunately, adolescents with depression attempt suicide in adulthood (Risk ratio=8.41, 95% [3.04, 23.27], Geoffroy et al., 2020), and about 8% of adolescents with major depressive disorders have completed suicide by young adulthood (Mullen, 2018).

Treatment options for depression in adolescents varies by severity. In fact, mild to moderate depression may be managed with psychosocial treatments (e.g., psychotherapy, interpersonal therapy, and supportive therapy) and more severe depression may require anti-depressants (Viswanathan et al., 2020). Although anti-depressants and psychotherapy are effective treatments, especially when combined, only about 40% of depressed adolescents receive treatments (Mullen, 2018; NIMH, 2017, 2019). Moreover, approximately 70% of adolescents who have recovered after treatment often have recurrence within 2 years (Mullen, 2018). Furthermore, several barriers such as cost of treatments, lack of mental health professionals, and personal obstacles including stigma, lack of motivation for change, and negative perception of treatment play important roles in the access of those treatments (Erawan, 2015; Lenz et al., 2015; WHO, 2013). Thus, alternative and complementary treatments, such as mindfulness meditation, to improve depression in adolescents are growing.

Based on the philosophical view of the Buddhist teaching, mindfulness is defined as the intentional and non-judgmental awareness of thoughts, feelings, and sensations that specifically occur in the present moment (Kabat-Zinn, 2003). Mindfulness training is intended to train individuals to become more aware of their internal events (e.g., thoughts, feelings, emotions, and bodily sensations) and to change the ways in which they relate to these thoughts without judgment (Perry-Parrish et al., 2016). Mindfulness practice can be done as daily meditation practice in both formal and informal settings, in any position (e.g., sitting, walking, and eating), and via group or individually. Additionally, mindfulness meditation can be guided with or without an instructor. Researchers have shown that mindfulness meditation is an effective intervention for improving psychological outcomes—such as depression, anxiety, and stress—because it tends to decrease the habitual tendency to emotionally react to and ruminate about transitory thoughts (Lynch et al., 2018; Song and Lindquist, 2015; Vignaud et al., 2018). Additionally, it encourages individuals to become more aware of their internal experience and to change the ways in which they relate to negative thoughts and emotions (Cladder-Micus et al., 2018; MacKenzie and Kocovski, 2016).

There are two principal interventions used to operationalize mindfulness as a healthcare intervention including mindfulness-based stress reduction and mindfulness-based cognitive therapy. Mindfulness-based stress reduction was developed by John Kabat-Zinn and focuses on the practice and refinement of mindfulness techniques, especially formal meditation (e.g., body scan, sitting meditation, and mindful movement such as yoga and tai chi). Mindfulness-based stress reduction is primarily performed for the relief of suffering such as stress and pain (Kabat-Zinn, 2003), but some researchers use this intervention with adolescents with depression and anxiety (Freedenberg et al., 2017; Freedenberg et al., 2015). Mindfulness-based stress reduction encourages participants to practice through relaxed movement in order to increase mindfulness and/or decrease the negative repetitive thoughts and to specifically manage their problems with the effective strategies (Johnson et al., 2016).

Mindfulness-based cognitive therapy integrates aspects of mindfulness with cognitive behavioral therapy. Most researchers use mindfulness-based cognitive therapy for individuals at risk of depressive relapse because mindfulness-based cognitive therapy encourages depressed patients to observe and identify their thoughts and emotions at the present moment without judgment, then encourages them to understand how the thoughts and emotions are related to their emotion-related problems (Crane et al., 2014). Mindfulness-based cognitive therapy encourages individuals to become more reasonable and flexible and engage in positive thoughts to decrease depressive symptoms.

Besides these two principal mindfulness interventions, some researchers integrate a mindfulness aspect as the main component into their psychosocial interventions to decrease depressive symptoms. Thus we refer to this as adapted mindfulness interventions (Andreotti et al., 2017; Nguyen-Feng et al., 2017). Therefore, all three types of mindfulness interventions above can be subsumed under the more general label of mindfulness interventions.

Several meta-analysis researchers studied the effects of mindfulness interventions on depressive symptoms including mindfulness-based stress reduction, mindfulness-based cognitive therapy, and adapted mindfulness interventions. They found that mindfulness interventions were effective for decreasing depressive symptoms but most researchers focused on adult populations (Mesmer-Magnus et al., 2017; Zhang et al., 2015). Few researchers meta-analyzed the effects of mindfulness interventions on psychological outcomes in children and adolescents. Zenner et al. (2014) meta-analyzed the effects of school-based mindfulness interventions and reported that mindfulness interventions significantly improved children's cognitive capacities of attending and learning, but they did not report on depression. Zoogman et al. (2014) meta-analyzed the effects of mindfulness interventions in young people and showed that

mindfulness interventions were helpful in treating youth with current psychopathological symptoms, but they included only two primary studies measuring depression as an outcome. Likewise, Kallapiran et al. (2015) meta-analyzed the effects of mindfulness interventions in children and adolescents and reported that mindfulness interventions were more effective for decreasing stress, anxiety, and depression than control groups in the nonclinical samples. The two meta-analytic research teams above (Kallapiran et al., 2015; Zoogman et al., 2014) included only two primary studies with depression as an outcome. Their meta-analyses were small and addressed depression as one part of the psychological score, making it difficult to determine the effectiveness of mindfulness interventions for improving depression in adolescents. Also, Kallapiran et al. (2015) and Zoogman et al. (2014) were unable to explore the influence of moderators on the effects of mindfulness interventions on depression due to the small number of primary studies (s=2) measuring depression as an outcome. Moderator analyses compares subgroups to examine the sources of heterogeneity, factors that influence the effects of mindfulness interventions on depression. Importantly, no researchers meta-analyzed the effects of mindfulness interventions on depressive symptoms in adolescents. Therefore, the purpose of this meta-analysis was to examine the effects of mindfulness interventions on depressive symptoms in adolescents who were between 10 and 19 years of age. In addition, we explored participants, methods, and intervention characteristics as moderators of the effects of mindfulness interventions on depressive symptoms among adolescents.

2. Methods

2.1. Search strategy

We searched 17 electronic databases from their inception up to April 2019 for studies which were written in English. Databases included journal databases, international trial registry and conferences for unpublished papers, the grey literature, and specific electronic journal search. Journal databases included Education Resources Information Center (ERIC; 1966+), CINAHL (1937+), PubMed (1809+), Scopus (1788+), Ovid PsycINFO (1967+), Ovid Medline (1946+). We searched the international trial registries and conference proceedings for unpublished studies to minimize the risk of publication bias via ClinicalTrials.gov (2000+), Open Directory of Open Access Repositories (Open DOAR; 1985+), Google Scholar, and Bielefeld Academic Search Engine (BASE; 2004+). We also searched the grey literature and did electronic searches of specific journals including Cochrane Library (1995+), ProQuest Dissertation & Theses (1996+), Open Grey (Mid 2011+), Journal Mindfulness-Springer link (2010+), the American Journal of Psychiatry (1844+), Science Direct (1880+), and American Psychological Association (1982+). Also, we performed ancestry searches from reference lists of all relevant papers, previous reviews, and meta-analyses.

After consultations with a medical librarian, we used the following search terms: mindful* OR meditat* AND adolescent* OR student* AND depress*. Truncating these terms with an asterisk allowed for plural and singular results and other terms relating to them. To broaden the search, we exploded the subject headings. Subject headings were the words or short phases that were added to the records of every item in the databases. Exploding included our selected subject headings and the narrower terms below the headings. Thus, exploding with subject heading helped retrieve a greater number of relevant results. See Supplemental Table 1 for the complete search strategy.

2.2. Inclusion/exclusion criteria

We included primary studies if they evaluated 1) mindfulness interventions, including mindfulness-based stress reduction, mindfulness-based cognitive therapy, or adapted mindfulness interventions; 2) aimed at reducing depression in adolescents in which depression was measured as an quantitative outcome; 3) with participants between 10 and 19.5 years of age (WHO, 2019); and 4) compared to a control group including usual care, waitlist control, or attention-control that was not related to mindfulness. We did not include studies where researchers used active comparison groups, such as comparison groups who received antidepressants, psychotherapy, cognitive behavioral therapy, supportive therapy, or exercise/relaxation interventions. Comparing mindfulness interventions to an active comparison group would result is mitigated effects and cloud the effect of mindfulness interventions on depression. To increase the ability of generalize our results, we included all experimental study designs including randomized control trials and quasi-experimental. To minimize publication bias, conference papers and unpublished dissertations were included (Greco et al., 2013).

When primary researchers did not report sufficient data for the computation of effect size, we emailed the corresponding authors to request more information. If the corresponding author did not response after two inquiry emails, we excluded that the study (Chen et al., 2013; Zeidan et al., 2010). We also excluded studies with less than 4 participants per group. Such decisions on inclusion and exclusion were based on consensus between the researchers (CR and SP), with disagreements resolved by discussion with the third researcher (JKS).

Our initial search returned 4273 studies, which reduced to 1952 studies when duplicates were removed. To these, we added three ancestry studies. After screening the titles and abstracts, removing studies that did not meet inclusion criteria brought the number of studies down to 57. Of these, 28 were excluded because they were systematic reviews and meta-analyses (s=16), not written in English (s=7), qualitative studies (s=2), commentaries (s=2) or case study designs (s=1). The dissertations we found in the grey literature pointed us to the published counterpart. Thus, the final 29 studies that met our inclusion criteria and were included in this meta-analysis were all published and depicted in the reference list with asterisks. See Fig. 1 for the PRISMA diagram.

2.3. Data extraction and coding

After reviewing all 29 primary studies, two researchers further revised the codebooks after pilot testing with five studies. The codebook contained five categories including source information; method, intervention, and participant characteristics; and outcome information. Source information included publication status, year, funding, and country where the study was conducted. Method characteristics, which included quality indicators, consisted of settings, sample sampling, assignment into groups, concealment allocation, data collection masked, intention-to-treat, fidelity, *a priori* of power, comparisons of the participants' characteristics at baseline, and attrition. Participant characteristics included number of participants, mean age, gender, racial/ethnic, and clinical health status (e.g., major depressive disorder, anxiety disorder, learning disorder, substance use disorder, etc.). Intervention characteristics included interventionist training, interventionist status, type of mindfulness interventions, length of mindfulness interventions in weeks, number of structured/unstructured mindfulness sessions per week, duration of structured/unstructured mindfulness interventions in minutes per session, components of mindfulness interventions—guided, music, exercise/relaxation, health education, group discussion, individual counseling, and home assignment.

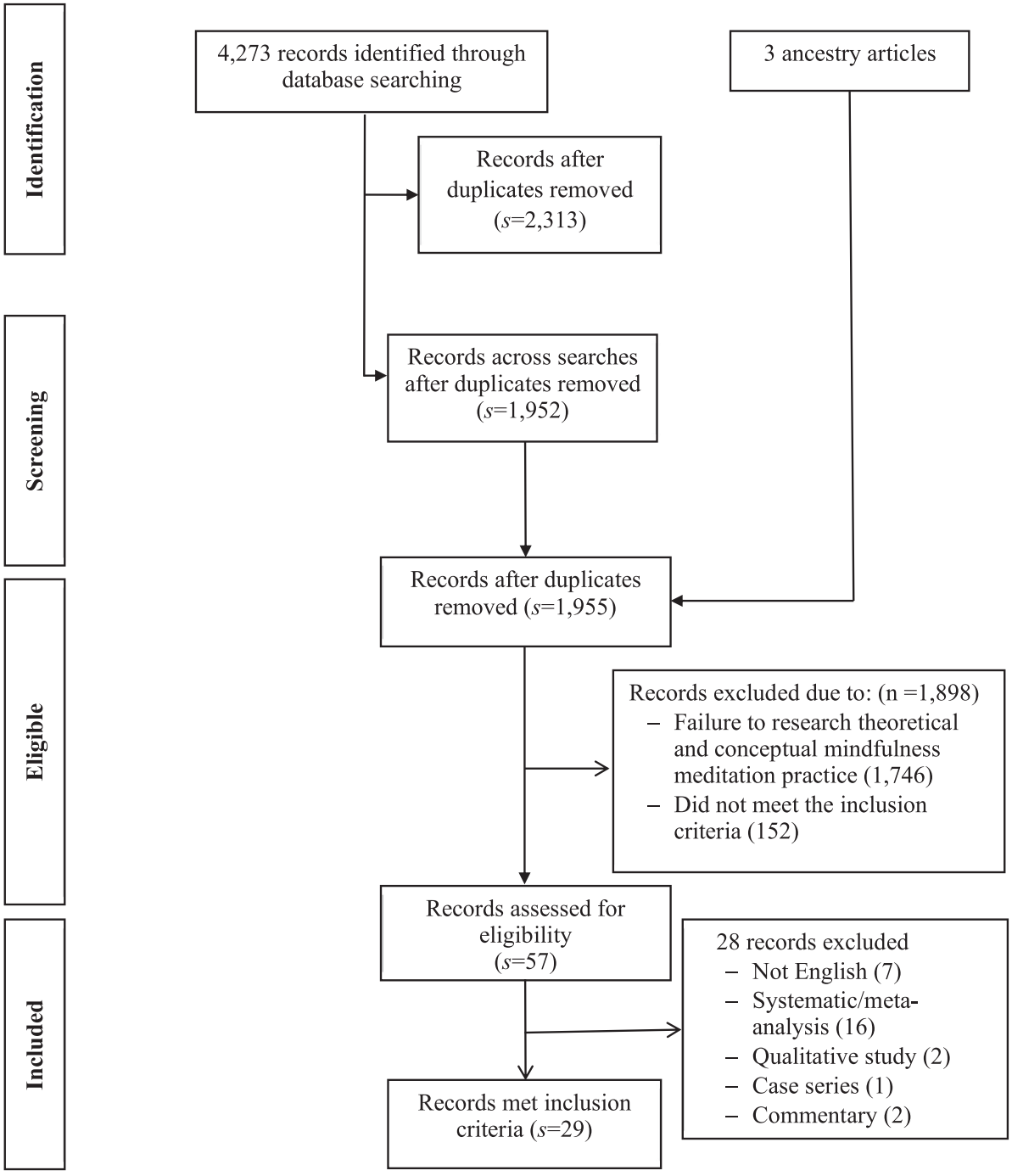

Fig. 1. PRISMA flow diagram.

Finally, outcome characteristics included baseline and follow-up means and standard deviations (SDs) of depression scores.

When research teams published multiple studies with the same participants and depression scores were reported, we coded only one study so we would not duplicate participants and artificially inflate our sample size. When primary studies had more than two groups, we compared mindfulness groups with like comparison groups without mindfulness interventions to examine the effects of only mindfulness interventions, the main objective of this meta-analysis. Two researchers (CR & SP) independently coded all primary studies. Any discrepancies between coders were discussed with the third supervisor researcher (JKS) to reach consensus. Data were double entered into RedCap and compared for errors. Once data entry errors were corrected, data were downloaded into SPSS and Comprehensive Meta-Analysis (CMA) version 3.0 for analysis.

2.4. Statistical analyses

All study characteristics were examined using descriptive statistics. Importantly, because depression was measured multiple ways across the primary studies (as many as 13 different scales), we computed standardized mean differences between the post-mindfulness interventions and control groups as Hedges' *g* to represent the effect size. Using raw mean differences is an option

only when the same measure is used across all studies or when the measure is meaningful. Standardizing the mean differences in each study allows comparisons across measures and therefore studies (Borenstein et al., 2017; Borenstein et al., 2009; Cooper, 2017).

In our initial analysis, we focused on posttest scores across groups. To further understand the effects of mindfulness interventions, we examined pretest/posttest effect sizes within groups. Significant improvements in the control groups would have suggested that depression had improved spontaneously (Borenstein et al., 2009; Cuijpers et al., 2017). Although pre- and post-intervention depression scores are often correlated in single-group design studies, few researchers report correlations between pre- and post-measures. Thus, we estimated a strong positive correlation (r=.8) to be conservative, then re-analyzed with no correlation (r=.0) using within-group analyses (Conn et al., 2009).

To minimize bias due to the small number of primary studies, we used Hedges' g with 95% confidence intervals (Borenstein et al., 2009; Lakens, 2013). Because we assumed a normal distribution of effect sizes across primary studies that are heterogeneous with regard to characteristics of participants, methods, interventions, and outcomes, we used a random-effects model (Borenstein et al., 2009). To compute random-effects summary effect size, Comprehensive Meta-Analysis weights each study by the inverse of the within- and between-studies variance to estimate the mean of the distribution of true effects (Borenstein et al., 2009). We examined heterogeneity across studies by inspecting the funnel plot and calculating the Q statistic (total dispersion, weighted sum of squares), Tau^2 (the variance of the effect size parameters across the population of studies, the variance of the true effect sizes), and I^2 (percentage of variability reflecting real effect size differences). A significant Q indicates heterogeneity across studies. The benchmarks for I^2 are set at 25%, 50%, and 75% as low, moderate, and high heterogeneity across studies, respectively. If an I^2 value is near 100%, it means most of the observed variance is true variation (Borenstein et al., 2009).

When heterogeneity existed, we conducted subgroup analyses to explore moderators that might be sources of heterogeneity. Moderators included source, methods (including quality indicators), participants, and intervention characteristics. To test categorical moderators, we used a meta-analysis analog of ANOVA. For continuous moderators, we used the meta-regression, an analog of regression analysis (Hedges and Pigott, 2004). To examine the effects of quality indicators, variables in method characteristics were tested as moderators (Borenstein et al., 2009).

2.5. Assessment of methodological quality

One important component of meta-analysis is the quality assessment of primary studies. Low quality studies can distort the summary effect estimate. For this meta-analysis, we examined the extent to which effect sizes were influenced by methods reflecting quality (Conn and Rantz, 2003; Thabane et al., 2013). Multiple variables including assignment into groups, masked data collection, *a priori* power analysis, fidelity, comparison of participants' characteristic at baseline, and intention-to-treat were used as quality indicators of methodological strength. These variables were analyzed as dichotomous moderators; attrition was analyzed as a continuous moderator. See Supplementary Table 2 for the quality indicators for each study.

2.6. Risk of publication bias

Using the funnel plot, Begg and Mazumdar rank correlation test, and Egger's bias value, we estimated publication bias. Data points forming a symmetrical funnel-shaped distribution represent the absence of publication bias. The Begg and Mazudar test computes the rank order correlation (Kendall's τ) between the standard treatment effect and variances (standard error, which is primarily affected by sample size). If this test shows significant results (p<.05; one-tailed), it suggests publication bias. A one-tailed significance within the Egger regression test also suggests publication bias (Cooper, 2017; Cooper et al., 2009).

3. Results

3.1. Characteristics of the studies

Overall, the 29 primary studies (s=29) provided 29 comparisons (k=29) between mindfulness and control groups. Twenty of 29 studies were funded. Sixteen studies were conducted in North American including the United States (s=13) and Canada (s=3). Five studies in Asia including Hong Kong (s=2), China (s=1), Iran (s=1), Philippine (s=1). Five studies in Europe including Belgium (s=2), the United Kingdom (s=1), Spain (s=1), and France (s=1); three studies were conducted in Australia (s=3). A total of 3,688 participants were included: 1,839 for the intervention group and 1,849 for the control group. Sample mean age ranged from 10.2 to 19.5 years; with a total mean age (±SD) across studies of 14.9±2.8 years (s=24). The mean age across studies of mindfulness group was 15.5±2.9 years (s=16) and was 15.4±2.9 years for control groups (s=15). Interventions included mindfulness-based stress reduction (s=11), mindfulness-based cognitive therapy (s=2), and adapted mindfulness intervention (s=16). Most of the interventionists were from psychology (s=13) or members of the educational facility where the study was conducted (s=11); three were general health practitioners and one was a nurse. Twenty-three research teams reported that their interventionists were trained. See Table 1 for descriptive statistics across characteristics. Across the 13 self-reported depression scales used, high scores indicated high levels of depression. Reliabilities ranged from .75 to .96. See Supplementary Table 3 for a complete description of the studies.

3.2. Effect size of mindfulness interventions

The overall effect size for the comparison of the mindfulness intervention groups with their control groups was .14 (95%CIs [.01-.28], p = .042) with significant heterogeneity (Q = 96.9, p < .001; I^2= 71.1). Fig. 2 displays the forest plot, each square reflects the direction and magnitude of the effect; the size of the square reflects the weight assigned to the study (Borenstein et al., 2009). While the effect sizes showed that mindfulness interventions tended to improve depressive symptoms compared to control groups, only 10 comparisons showed a significant effect size. Additionally, single group pre-post comparisons showed significant effects within mindfulness intervention groups when samples were correlated .8 (g=.27, 95%CI[.11-.42], p<.001, I^2=95%) as well as not correlated (g=.25, 95%CI[.08-.42], p=.004, I^2=79%), but were not significant within control groups' resulting in .04 (95%CI[-.10-.18], p=.554, I^2=95%) for correlated samples and .04 (95%CI[-.12-.19], p=.648, I^2=74%) for uncorrelated samples. Thus, these pre-post findings support that the improvement within mindfulness intervention groups were likely not due to spontaneous recovery.

3.3. Publication bias

The funnel plot was visually slightly asymmetrical, suggesting the possibility of publication bias (See supplemental material Fig. 1.) The Begg and Mazumdar rank correlation test resulted in a Kendall's tau was −.049 (p=.707) which reflects a low potential for publication bias (Begg and Mazumdar, 1994). Egger's regression intercept resulted in an intercept of −.427 (95%CI[−1.97-1.12], t(18)=.56, p=.287). These results do not support publication bias.

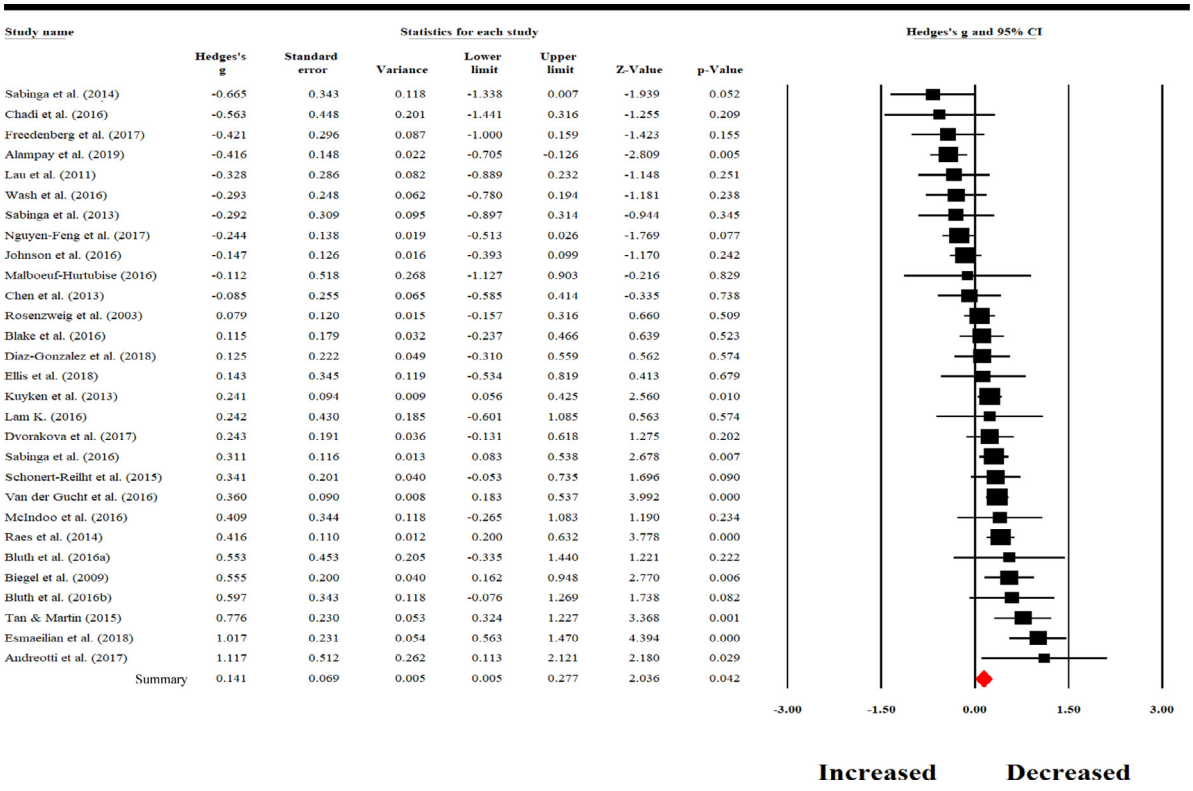

Fig. 2. Forest plot of the effects of mindfulness interventions on depression compared to control groups (Alampay et al., 2019; Chadi et al., 2018; Díaz-González et al., 2018; Ellis et al., 2019; Lau and Hue, 2011; Rosenzweig et al., 2003; Schonert-Reichl et al., 2015; Sibinga et al., 2013, 2014; Tan and Martin, 2015; Biegel et al., 2009; Blake et al., 2016; Bluth et al., 2016; Bluth et al., 2016; Dvorakova et al., 2017).

3.4. Exploratory moderator analyses

Because we found moderate heterogeneity across studies (I^2=71.1), we conducted subgroup analyses. There were four moderators that influenced effect size. Studies with funding tended towards significance (p=.061) and had a greater effect (g=.34, 95%CI[−.12−.22], p=.008) than studies without funding (g=.05, 95%CI[−.12−.22], p=.554). Also while nonsignificant (p=.090), mindfulness-based cognitive therapy tended to have a greater effect on depression (g=.76, 95%CI[.18−1.34], p=.010) than adapted mindfulness interventions (g=.13, 95%CI[−.04−.30], p=.140) and mindfulness-based stress reduction (g=.07, 95%CI[−.16−.29], p=.559). Interestingly, mindfulness interventions combined with individual counseling tended (p=.088) to have a greater effect on depression (g=.46, 95%CI[.07−.85], p=.021) than without (g=.10, 95%CI[−.04, .24], p=.168). Finally, because only one research team studied adolescents diagnosed with major depressive disorders (McIndoo et al., 2016), we did not conduct moderator analysis. Conducting a subgroup analysis with a small number of primary studies in each subgroup might produce a false negative due to inadequate statistical power (Dijkman et al., 2009; Fan et al., 2019). However, such analyses might generate ideas for future research.

Table 1
Characteristics of primary studies.

Characteristics	*s*	Min	Q1	Mdn.	Q3	Max	Mean	SD
Mean age (years)	24	10.2	12.8	15.2	16.7	19.5	14.9	2.8
Total Sample size at analysis	29	13.0	34.0	80.0	198.0	498.0	127.2	134.3
– MM group	29	7.0	18.0	41.0	96.0	248.0	63.4	67.1
Control group	29	6.0	15.5	37.0	102.5	250.0	63.8	67.7
% Female	27	0.0	53.1	59.4	75.0	100.0	63.2	21.1
% White	12	0.0	6.8	51.1	81.5	85.9	48.0	34.1
% African American	12	2.9	4.8	8.3	91.7	100.0	36.8	43.0
% Asian	9	0.0	0.0	5.9	15.2	25.7	7.6	9.4
Weeks of structured MM	29	1.0	6.0	8.0	9.0	12.0	7.6	2.6
Days across intervention (length)	29	7.0	35.5	49.0	56.0	77.0	46.6	17.2
Structured MM session/week	28	1.0	1.0	1.0	1.0	7.0	1.4	1.6
Structured MM min./session	25	8.0	50.0	90.0	95.0	120.0	78.8	28.9
Unstructured MM sessions/week	18	0.0	0.0	6.5	7.0	21.0	5.1	5.1
Unstructured MM min./session	11	0.0	13.0	15.0	20.0	28.0	15.7	8.7
Dose (length x duration)	25	210	3150	4067	4900	6930	3824	1742
Days after intervention measured	29	0.0	0.0	0.0	69.0	183.0	34.1	54.0
% Attrition, MM group	26	0.0	0.0	9.8	19.6	32.0	10.5	9.9
% Attrition, Control group	27	0.0	1.7	11.8	19.5	46.7	12.7	12.0

s=number of studies providing data, Min=minimum, Q1=first quartile, Mdn=median, Q3=third quartile, Max=maximum, MM=mindfulness meditation

With regards to age, we first examined age using meta-regression (See Table 3). Then, following the work of others, we categorized age into early (10–14 yrs.), middle (15–17 yrs), and late (>17 yrs). Providing mindfulness interventions in mid adolescence tended to make greater improvement on depression (g=.31, 95%CI[.06−.55], p=.014) than providing mindfulness interventions in early adolescence (g=.06, 95%CI[−.13−.25], p=.538) and late adolescence (g=.08, 95%CI[−.25−.38], p=.679), but not a significant difference (p=.260). Because mindfulness interventions had greater effects during mid-adolescence, we examined the quadratic effect of age on the effects of mindfulness interventions on depression (Borenstein et al., 2017). Once again, we found no significant relationship between age and effect size based on a curve-linear meta-regression model (*slope*=.001, $Q_{between}$=.04, p=.918). Furthermore, we examined the two (early and late) age categories used by United Nations Children's Fund [UNICEF] (2017). Again, we found no differences across categories (p=.274, see Table 2). Finally, the longer the time between the intervention initiation and the post-intervention depression measurement, the greater the improvement in depression (*slope*=.001, τ^2=.074, $Q_{between}$=4.10, p=.043). See Table 2 and Table 3.

4. Discussion

This is the first systematic review and meta-analysis to summarize primary studies on the effect of mindfulness interventions on depression in adolescents between 10 and 19 years of age. We located 29 studies and found a small yet significant effect size of g=.14 (95%CI [.01-0.28], p=.042). We cannot compare our findings to those of previous meta-analyses because prior meta-analyses were not specific to adolescents in this age group (Dunning et al., 2019; Kallapiran et al., 2015), did not measure depression separately but combined depression with other psychological outcomes (Carsley et al., 2018; Felver et al., 2015; Montgomery et al., 2013; Zenner et al., 2014), or did not examine the moderator effects of participants, methods, and intervention characteristics (Dunning et al., 2019; Kallapiran et al., 2015). Thus, this meta-analysis is novel in that it evaluates the effects of mindfulness interventions on depression in adolescents and provides moderator analyses that suggest future research directions.

Across all 29 studies, only one research team reported studying adolescents who were diagnosed with major depressive disorders (McIndoo et al., 2016). Importantly, evidence shows that elevated levels of depressive symptoms within adolescents were associated with a greater risk for depression in later life (Ellis et al., 2017; Kwong et al., 2019). Thus, providing mindfulness interventions for adolescents with even mild depression might be an effective intervention to reduce the likelihood of depression later. In addition, health policymakers might encourage or support health providers, school nurses, and community stakeholders to use mindfulness interventions as an alternative/adjunctive intervention to decrease the severity of depressive symptoms and to prevent major depressive disorders in adolescents. Future researchers might examine the use of mindfulness interventions as an adjunctive intervention in adolescents diagnosed with major depression.

4.1. Moderator effects

Funded studies showed a greater improvement in depression (g=.34, 95%CI[−.12−.22], p=.008, s=20) than unfunded studies (g=.05, 95%CI[−.12−.22], p=.554, s=9). While this finding only tended toward significance, it warrants consideration. One possible explanation might be that funded research teams could afford higher methodological quality and larger sample sizes (Hansen et al., 2019). In our meta-analysis, the funded studies had a mean sample size of 138 (SD=152) while the unfunded studies had a mean of 110 (SD=88) participants. In Comprehensive Meta-Analysis, studies with greater precision receives greater weights and because precision is mainly driven by sample size (Borenstein et al., 2009), the funded studies may have had greater precision overall.

Mindfulness-based cognitive therapy tended (p=.090) to show a greater improvement in depression (g=.76, 95%CI[.18−1.34], p=.010) than adapted mindfulness interventions (g=.13, 95%CI[−.04−.30], p=.140) and mindfulness-based stress reduction (g=.07, 95%CI[−.16−.29], p=.559). One explanation might be that mindfulness-based cognitive therapy is based on cognitive behavioral therapy and mindfulness. Cognitive behavioral therapy was developed based on the cognitive model which posits that emotions and behaviors are influenced by perceptions of situations. Thus, mindfulness-based cognitive therapy might be more beneficial in dealing with depression than other types of mindfulness interventions because it incorporates cognitive behavioral therapy, a treatment with evidence supporting its usefulness with depression. In cognitive behavioral therapy, therapists encourage participants to explore the association between thoughts, emotions, and behaviors and help them develop more adaptive cognitions and behaviors (Fenn & Byrne, 2014; Oud et al., 2019; Rush and Beck, 1978). In fact, several meta-analysis researchers reported that cognitive behavioral therapy is effective for improving depression (Keles and Idsoe, 2018; Oud et al., 2019; Rith-Najarian et al., 2019; Ssegonja et al., 2019). Thus, mindfulness-based cognitive therapy specifically encourages adolescents to understand the connection between negative thoughts, moods, and behaviors in relation to depression. Then, participants are encouraged to disengage their automatic negative/ruminative thoughts related to depression (Oud et al., 2019). In contrast, mindfulness-based stress reduction and other mindfulness-based interventions focused on refinement of mindfulness techniques through relaxation techniques and using coping strategies to manage stressors related to depression (Kabat-Zinn, 2003). However, because only two research teams conducted mindfulness-based cognitive therapy on depression in adolescents (Ames et al., 2014; Deplus et al., 2016), interpretation should be done with caution.

Mindfulness interventions combined with individual counseling showed greater (but non-significant, p=0.09) improvement in depression (g=.46, 95%CI[.07−.85], p=.021) than mindfulness interventions without (g=.10, 95%CI[−.04, .24], p=.168). One possible reason might be that there is a considerable discrepancy between the number of primary studies in each group; only three research teams reported individual counseling (s=3). Thus, this difference needs additional research. In addition, individual counseling is different than talking with friends/relatives because therapists use the psychotherapeutic relationship. Therapists allow individuals to explore their feelings, beliefs, thoughts, and behaviors and encourage individuals to identify aspects of their lives that they would like to change. Therapists may help individuals build confidence in the management of their depression (Barkham et al., 2017; Cocey, 2012). Thus, mindfulness interventions combined with individual counseling may provide greater benefits than either mindfulness intervention or counseling separately providing a fertile ground for future research.

Researchers who measured depressive symptoms at longer follow-up time periods showed greater reduction in depression than researchers who measured depressive symptoms immediately after the intervention (*slope*=.001, τ^2=.074, $Q_{between}$=4.10, p=.043, s=29). Similarly, Basso et al. (2019) found that eight weeks, not four weeks, of mindfulness practice enhanced attention, decreased negative mood, and improve affective states. One possible reason might be that mindfulness interventions involve cognitive training

Table 2
Categorical moderator results for depression comparing MM versus control groups.

Moderator	*k*	ES	SE	Var.	95%CI	Z	*p*(Z)	Q_{bet}	$p(Q_{bet})$
Study characteristics									
Funding								3.50	.061
Funded	20	0.34	0.13	0.02	0.09, 0.58	2.67	.008		
Unfunded	9	0.05	0.09	0.01	−0.12, 0.22	0.59	.554		
Country								2.87	.413
North America	16	0.07	0.10	0.01	−0.13, 0.26	0.70	.497		
Asia	5	0.05	0.17	0.03	−0.28, 0.39	0.31	.753		
Europe	5	0.35	0.15	0.02	0.06, 0.65	2.33	.020		
Australia	3	0.20	0.19	0.04	-0.18, 0.58	1.02	.307		
Participants characteristics									
Mean Age (AMCHP, 2013)								2.67	.260
Early (10-14 yrs.)	11	0.06	0.10	0.01	-0.13, 0.25	0.62	0.538		
Middle (15-17 yrs.)	8	0.31	0.12	0.02	0.06, 0.55	2.46	0.014		
Late (>17 yrs.)	5	0.08	0.16	0.03	-0.25, 0.38	0.41	0.679		
Mean Age (UNICEFs, 2017)								1.20	.274
Early (10–14 yrs.)	11	0.06	0.10	0.01	-0.13, 0.25	0.61	0.545		
Late (15–19 yrs.)	13	0.21	0.10	0.01	0.02, 0.41	2.14	0.033		
Method characteristics									
Assignment into groups								1.62	.468
Random individuals	19	0.15	0.10	0.01	−0.04, 0.33	1.54	.123		
Random cluster	5	0.26	0.15	0.02	−0.03, 0.54	1.75	.079		
Non-random	5	−0.03	0.17	0.03	−0.34, 0.30	−0.16	.871		
Control group								2.30	.130
Usual/waitlist/different by MM only	22	0.20	0.08	0.01	0.05, 0.36	2.55	.011		
Attention-control	7	−0.04	0.14	0.02	−0.30, 0.23	−0.27	.788		
Conceal allocation								1.19	.276
No	22	0.18	0.08	0.01	0.03, 0.34	2.32	.020		
Yes	7	−0.00	0.15	0.02	−0.29, 0.29	−0.00	.998		
Blinded data collection								0.03	.859
No	22	0.15	0.08	0.01	−0.01, 0.30	1.87	.061		
Yes	7	0.12	0.15	0.02	−0.18, 0.41	0.78	.438		
Intention-to-treat								0.42	.516
No	15	0.11	0.10	0.01	−0.09, 0.30	1.06	.290		
Yes	13	0.20	0.11	0.01	−0.01, 0.41	1.86	.063		
A priori power analysis								0.55	.457
No	4	0.01	0.21	0.04	−0.41, 0.42	0.03	.978		
Yes	5	0.20	0.16	0.03	−0.12, 0.53	1.25	.213		
Baseline characteristics equal across groups								1.44	.231
No	8	0.29	0.14	0.02	0.01, 0.58	2.05	.041		
Yes	19	0.09	0.09	0.01	−0.08, 0.27	1.03	.304		
Fidelity								0.01	.913
No	18	0.15	0.09	0.01	−0.03, 0.32	1.66	.099		
Yes	11	0.13	0.12	0.02	−0.11, 0.37	1.07	.284		
Intervention characteristics									
Setting								0.10	.941
Clinic/Health/Hospital	8	0.08	0.15	0.02	−0.21, 0.38	0.57	.572		
Education institution	20	0.14	0.08	0.01	−0.02, 0.30	1.76	.079		
Type of MMIs								4.82	.090
MBSR	11	0.07	0.12	0.01	−0.16, 0.29	0.59	.559		
MBCT	2	0.76	0.30	0.09	0.18, 1.34	2.58	.010		
Adapted MMIs	16	0.13	0.09	0.01	−0.04, 0.30	1.47	.140		
Guided meditation								1.91	.168
No/NR	8	0.29	0.13	0.02	0.04, 0.53	2.29	.022		
Yes	21	0.08	0.08	0.01	−0.08, 0.24	1.01	.312		
Group discussion								1.21	.272
No/NR	15	0.08	0.09	0.01	−0.10, 0.25	0.84	.400		
Yes	14	0.23	0.10	0.01	0.02, 0.43	2.19	.028		
Home assignment								0.02	.877
No/NR	7	0.12	0.15	0.02	−0.18, 0.42	0.77	.439		
Yes	22	0.15	0.08	0.01	−0.01, 0.31	1.81	.071		
Individual counseling								2.92	.088
No/NR	26	0.10	0.07	0.01	−0.04, 0.24	1.38	.168		
Yes	3	0.46	0.20	0.04	0.07, 0.85	2.31	.021		
Psychoeducation								0.01	.915
No/NR	4	0.16	0.19	0.04	−0.21, 0.53	0.85	.398		
Yes	25	0.14	0.08	0.01	−0.01, 0.29	1.82	.071		
Music								0.00	.975
No/NR	27	0.14	0.07	0.01	0.00, 0.28	1.97	.049		
Yes	2	0.13	0.31	0.10	−0.48, 0.75	0.42	.675		
Outcome measure									
Days after intervention measured								5.05	.025
Immediate post-MM	17	0.00	0.09	0.01	−0.18, 0.18	0.04	.962		
Delayed follow-up	12	0.31	0.10	0.01	0.11, 0.51	3.07	.002		

(*Continued on next page*)

Table 2 (*Continued*).

Moderator	*k*	ES	SE	Var.	95%CI	Z	*p*(Z)	Q_{bet}	$p(Q_{bet})$
Days after intervention measured								5.12	.077
Immediate post-MM	17	0.00	0.09	0.01	−0.18, 0.19	0.03	.975		
3 mo. follow-up	10	0.29	0.12	0.01	0.06, 0.52	2.45	.014		
>3 mo. follow-up	2	0.39	0.21	0.05	−0.03, 0.80	1.82	.068		

k=number of comparisons, Q=heterogeneity statistics, SE=standard error, MBSR=mindfulness-based stress reduction, MBCT=mindfulness-based cognitive therapy, Adapted MMIs=Adapted mindfulness interventions, Var.=variance, NR=not reported

Table 3
Continuous moderators of the effects of mindfulness meditation on depression.

Moderator	*k*	Slope	SE	Tau^2	Q_{model}	*p*
Study characteristic						
Publication year	29	−0.001	0.02	0.089	0.00	.096
Sample characteristic						
Age (mean)	24	−0.005	0.03	0.072	0.03	.873
%female	27	0.000	0.00	0.096	0.01	.936
%White	12	−0.000	0.00	0.091	0.00	.983
%African American	12	−0.003	0.00	0.061	1.66	.198
%Asian	9	0.009	0.01	0.097	0.41	.523
Method characteristic						
%Attrition	27	0.011	0.01	0.082	2.34	.126
Reliability of depressive instruments	16	−1.550	1.68	0.094	0.85	.356
Intervention characteristics						
Intervention length (total days)	29	0.006	0.00	0.075	2.15	.143
Structured MM sessions per week	28	0.028	0.05	0.079	0.26	.611
Duration of structured MM min./session	25	−0.000	0.00	0.091	0.02	.890
Dose (Length x Duration)	25	0.000	0.00	0.078	1.30	.254
Unstructured MM session per week	18	0.004	0.02	0.088	0.04	.840
Duration of unstructured MM min./session	11	0.006	0.01	0.116	0.16	.692
Days After intervention measured	29	0.002	0.00	0.074	4.10	.043

k=number of comparisons, Q=heterogeneity statistics

skills, paying attention to the present moment with non-judgment (Zeidan et al., 2010) and learning how to think more positively and flexibly. Thus, depressed adolescents need to understand the relationships between their thoughts, emotions, and behaviors and how to decrease their ruminative thoughts to manage their depression, skills that can take some time to develop, especially for those who are depressed. However, this assumes that depressed adolescents stay focused on practicing the skills that decrease their repetitive thoughts. Another possible reason for positive effects long term might be that adolescents with mild depressive symptoms had a spontaneous recovery (Kiviruusu et al., 2020). If this were the case, we would expect the control groups to have had a similar spontaneous recovery which was not evident in our single-group analyses. Future researchers might further explore the effects of mindfulness interventions on depression long term.

Although mindfulness interventions were created based on Buddhist teaching which is mainly found in eastern countries, they have been growing in popularity in the west over the past 40 years. However, our findings showed that the countries where the studies were conducted did not make a difference in effect size ($Q_{between}$=2.87, *p*=.413). One possible reason might be that nowadays, mindfulness meditation has become popular and widely considered to be an optional alternative and complementary treatment in many fields in western cultures (e.g., medicine, psychology, education, public health). Also, it is a universal practice, not restricted to religion (Kabat-Zinn, 2003). Additionally, many research teams (*s*=16) integrated the mindfulness aspect into their interventions in novel ways, such as using smart phones and mobile mindfulness applications or online mindfulness interventions appropriate for depressed adolescents.

Kwong et al. (2019) showed that depressive symptoms gradually increased in early adolescence, then increased at peak velocity in middle adolescence, and plateaued and started to decrease in late adolescence. Because the related factors, causes, and symptoms of depression as well as developmental domains (physical, cognitive, social, emotional) in each stage of adolescence (early, middle and late adolescence) were different (National Academies of Sciences Engineering and Medicine, 2019), we explored age as a categorical moderator. We found that providing mindfulness interventions in mid adolescence tended to improve depression to a greater extent than mindfulness interventions in early or late adolescence, but these differences were not significant (*p*=.260, See Table 2). One possible reason for these finding might be the difference in neurocognitive maturity at each stage of adolescence (McKeering and Hwang, 2019). The period of mid adolescence is claimed to be the "*window of opportunity*" because of the heightened brain plasticity, that is, middle adolescents have more receptivity for learning new skills (social, emotional, and motivational learning) than early adolescence and later in life. Therefore, this is a golden period for mindfulness practice (Dunning et al., 2019; Johnson et al., 2017). Middle adolescents might learn how to manage depressive symptoms more effectively than early adolescence and late adolescence (Dunning et al., 2019). This prompted us to examine age as a quadratic moderator. Again, we did not find age to be a significant moderator of the effects of mindfulness interventions on depression (*slope*=.001, τ^2=.07, $Q_{between}$=.04, *p*=.917). However, our lack of significant findings might be influenced by the small number of primary studies in the moderator analysis; only five research teams studied mindfulness interventions in late adolescents. Thus, further study is needed across the adolescent age groups.

Researchers have suggested for mindfulness interventions to be a universal school-based program to prevent depression in adolescents (Calear, 2012; Joshi et al., 2019). We found that providing mindfulness interventions in school/educational settings (*g*=.14, 95%CI[−.02, .30], *p*=.079) tended to have greater effects on de-

pression than mindfulness interventions in clinical/health/hospital settings (g=.08, 95%CI[−.21, .38], p=.572). However, these differences across settings were not significant (p=.941). Further research is needed to explore these differences.

Parsons et al. (2017) claimed that self-reported home mindfulness practice was associated with positive outcomes, (r=.26, 95%CI[.19−.34], Z=6.74, p<.0001). However, mindfulness interventions with home assignments did not show strong moderated effects in our meta-analysis. One possible reason might be that the strategies used to determine how adolescents practice mindfulness at home were diverse. Some researchers provided daily diaries (Ames et al., 2014), workbook/sheets (Raes et al., 2014), tracking logs (Walsh et al., 2016), and mobile phone records (Tan and Martin, 2012) for their adolescents to record at home. With so many diverse recording strategies, only one research team used each method limiting our use of these strategies as a moderator for subgroup analysis. In addition, several researchers did not provide details about how they monitored participants' home practice (Johnson et al., 2016; Kuyken et al., 2013; Malboeuf-Hurtubise et al., 2016; McIndoo et al., 2016; Nguyen-Feng et al., 2017; Van der Gucht et al., 2017). Moreover, some research teams pointed out that it was difficult to follow-up with depressed adolescents for many reasons. Some depressed adolescents became bored or uncomfortable, forgot, or were impatient because mindfulness practice took too long (Ames et al., 2014; Andreotti et al., 2017). Some adolescents needed their parents to remind them about mindfulness practice (Andreotti et al., 2017). Thus, further study is needed to explore the effects of home practice and monitoring strategies on adolescents with depression.

Finally, no quality indicators had moderator effects on mindfulness interventions on depressive symptoms in depressed adolescents (See Table 2). One possible reason might be that most researchers did not report many quality indicators. For instance, 9 of 29 primary researchers reported that they estimated the sample size (*a priori* power analysis) before conducting the study and only 5 of those research teams met their sample size (see Table 2). Conducting moderator analyses with a small number of primary studies in each level of subgroup analyses increases the risk of the false negative effect sizes and can generate misleading recommendations about the directions for the further research (Borenstein et al., 2009; Deeks et al., 2019). Thus, primary researchers should report the methodological quality indicators they used of their studies. Also, further study is needed to explore the subgroup analysis with a greater number of primary studies.

4.2. Strengths and limitations

One of the strengths of the current meta-analysis was that it specifically focused on depression in adolescents and not only randomized controlled designs. Including primary studies with quasi-experimental designs gives us an idea of the effects of mindfulness interventions on depression in more realistic situations and allows us to generalize to typical situations. In addition, this meta-analysis fills an important gap and provides evidence of the effect of mindfulness interventions on depression among adolescents. However, there were limitations in our study. First, this meta-analysis was limited to reports written in English, excluding several potentially pertinent studies. Excluding non-English reports may induce language bias and reduce the precision of summary treatment effect estimates (Haidich, 2010; Jüni et al., 2002). Second, there were small numbers of primary studies in some subgroup analyses to explore moderators. Thus, parameter estimation is likely poor, rendering conclusions that are uncertain. For instance, only two research teams evaluated the effects of mindfulness-based cognitive therapy on depression in adolescents (Esmaeilian et al., 2018; Lam, 2016). However, our findings highlight future research ideas.

4.3. Implications and recommendations

Depression is generally classified in three severity levels of symptoms: mild, moderate, and severe. Most participants in our meta-analysis were adolescents with mild or moderate depressive symptoms (non-clinical samples). Mindfulness interventions might be less effective in adolescents with severe depression or adolescents with major depressive disorders, especially during the acute phase. Thus, nurses and health care providers trained in mindfulness interventions might use them as an adjunctive or alternative complementary treatment to improve depressive symptoms in adolescents with mild and moderate depressive symptoms. In addition, mindfulness interventions may be used to prevent major depressive disorders in adolescents and a greater risk for depression in later life (Ford et al., 2020). Further research is needed to examine the effects of mindfulness interventions in adolescents with severe depression or major depressive disorders. Moreover, reports in languages other than English should be examined. Also, most researchers measured depression immediately post-intervention, thus, exploring the long-term effects of mindfulness interventions on depression is needed.

5. Conclusion

This meta-analysis is important as it revealed evidence from both randomized and non-randomized trials regarding the effectiveness of mindfulness interventions specifically target to adolescents with depressive symptoms. Overall, mindfulness interventions are effective interventions to reduce mild to moderate depressive symptoms in adolescents who were between 10 and 19 years of age. Funding, type of mindfulness interventions, individual counseling, and follow-up time frames after the intervention, were potential moderators affecting effect size. Further study is needed to examine the long-term effect of mindfulness interventions on depressive symptoms as well as to investigate the effects of mindfulness interventions among adolescents with major depressive disorders. Nurses and health care providers trained in mindfulness interventions might consider using them as adjunctive/alternative treatment to decrease depressive symptoms in adolescents. School nurses might also teach high-risk adolescents to practice mindfulness to prevent depression.

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Conflict of interest

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Ethical Approval

A meta-analysis was not subject to ethical review.

Supplementary material

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* = *included primary study*

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