



Effects of Mindfulness-Based Interventions on Peer Relationships of Children and Adolescents: a Systematic Review and Meta-analysis

Xiaolu Dai¹ · Nan Du¹ · Songyun Shi¹ · Shuang Lu^{1,2}

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Abstract

Objectives Peer relationships play a critical role throughout childhood and adolescence. This meta-analysis systematically reviews the effects of mindfulness-based interventions (MBIs) on peer relationships of children and adolescents.

Methods We identified 21 relevant studies from 12 databases. The overall intervention effect size was estimated with the pooled standardized mean difference using random-effects models. Moderator analyses were performed to explore the variability in intervention effects. Fidelity data were synthesized narratively. Risk of bias and publication bias were also assessed.

Results MBIs showed small positive within-group effects ($g = 0.48$, 95% CI [0.33, 0.62]) and between-group effects ($g = 0.40$, 95% CI [0.18, 0.62]) on peer relationships. The effects of MBIs on peer relationships varied significantly by participant age and facilitator background.

Conclusions MBIs show promising effects in improving peer relationships among children and adolescents. However, considering the limited evidence currently available, more studies are needed to validate the efficacy of the interventions.

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Keywords Mindfulness · Peer relationships · Children · Adolescents · Intervention fidelity · Meta-analysis

Peer relationships can be defined as complex patterns of sequential interactions with same-age mates (Naylor, 2011). Researchers have emphasized the multidimensional nature of peer relationships because it includes both positive and negative features and may occur in dyads or at the group level (Brown & Klute, 2006; Naylor, 2011). Positive peer interactions are linked to a number of variables, including friendship quality, peer attachment, and peer acceptance (Portt et al., 2020). Negative peer interactions include bullying, peer rejection, neglect, and victimization (Gardner & Gerdes, 2015).

Peer relationships in childhood and adolescence are essential to social development, psychological health, and physical health. Peer relationships offer the key context for learning social norms and social skills. During peer

interactions, children acquire skills and experiences that affect their social, emotional, and cognitive functioning (Rubin et al., 2006). Adolescent peer support was found to be a protective factor against poor mental health (Roach, 2018), whereas bullying victimization was reported to have persistent and pervasive impacts on various psychological and school problems, such as depression, anxiety, academic performance, and school engagement (Halliday et al., 2021). In addition, peer victimization in adolescence showed consistent negative associations with immune health from inception to up to 30 years later (Scott & Manczak, 2021). Some adverse effects can persist up to midlife and even later years (Arseneault, 2018).

Mindfulness has been theorized to have positive implications for interpersonal relationships. Researchers have suggested that by cultivating present moment awareness without judgment, mindfulness may contribute to attunement, closeness, and satisfaction in relationships (Brown et al., 2007; Kabat-Zinn, 1993). Specifically, mindfulness may promote a greater ability to identify and communicate emotions and thoughts, to control automatic impulses in challenging interpersonal episodes (Karremans et al., 2017; Wachs & Cordova, 2007), to reflect on how their actions

✉ Shuang Lu
shuanglu@hku.hk

¹ Department of Social Work and Social Administration, The University of Hong Kong, Jockey Club Tower, 5/F, Centennial Campus, Pokfulam, Hong Kong

² Center on Behavioral Health, The University of Hong Kong, 2/F, 5 Sassoon Road, Pokfulam, Hong Kong

affect others (Faraji et al., 2019), to become aware of others' experiences and needs, and to take into account others' perspective (Brown et al., 2007; Van Doesum et al., 2013). These findings suggest there may be multiple pathways by which mindfulness can promote relationship functions, including peer relationships.

Mindfulness-based interventions (MBIs) refer to a range of structured interventions that intentionally cultivate mindfulness through formal and informal meditation practices (Baer, 2003). MBIs have been increasingly used to promote peer relationships among children, which have provided mixed but promising early results. A number of studies have demonstrated the positive effects of MBIs in enhanced social preference (Carro et al., 2020), increased peer acceptance (Schonert-Reichl et al., 2015), and reduced peer problems (Haydicky et al., 2015). However, some other studies did not detect significant effects (e.g., Meadows, 2018). Research to date has not yielded a consistent conclusion on whether MBIs can improve peer relationship outcomes among children and youth.

Moreover, the delivery of MBIs has varied regarding the mindfulness components, the number of sessions, the intervention duration, and other characteristics; it would be highly beneficial to evaluate how potential moderators are likely to affect the interventions. Additionally, a few recent reviews and meta-analyses have highlighted the lack of reporting on the intervention fidelity in MBI studies (Emerson et al., 2020; Feagans Gould et al., 2016; Kechter et al., 2019). Intervention fidelity refers to “the methodological strategies used to monitor and enhance the reliability and validity of behavioral interventions” (Bellg et al., 2004, p. 443) and plays a critical role in intervention research. In light of this, we aimed (a) to review the available evidence of MBIs on peer relationships among children and adolescents and the intervention fidelity addressed across the studies; (b) to assess the effects of MBIs on peer relationships, including positive and negative peer interactions; and (c) to identify differences in the effects of MBIs moderated by the characteristics of the participants, interventions, and studies.

Method

Eligibility Criteria

This review was conducted and reported by following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagnostic test accuracy (PRISMA-DTA) guideline (McInnes et al., 2018). Studies were included in this review if they (a) were empirical studies investigating the effects of MBIs among children or adolescents (aged 18 years and younger); (b) measured an aspect of peer relationships (e.g., peer attachment, peer rejection, peer status, peer acceptance,

peer problems, sociometric status, peer neglect, peer victimization, popularity, social preference, bullying); (c) used a randomized controlled trial (RCT), quasi-experimental design, or single-group pre-posttest design; and (d) were published in English. We only included articles that explicitly mentioned mindfulness practice as a core intervention component, including interventions combining mindfulness with other activities. We excluded interventions that consisted of other contemplative practices without explicit mention of mindfulness practices, such as yoga and tai chi. The outcome measures required at least one aspect of peer interactions that either occurred in dyads (e.g., friendship) or in larger groups (e.g., group acceptance). We excluded studies focused on individual characteristics (e.g., social capabilities) or larger peer groups (e.g., network centrality). If researchers reported the same data in published journal articles and unpublished dissertations, only the published articles were included. Case studies, qualitative studies, review articles, or other studies that did not report treatment efficacy were excluded.

Information Sources

Studies were identified through searches of the following 12 databases: Applied Social Sciences Index & Abstracts (from 1987), APA PsycArticles (from 1894), ERIC (from 1966), Family & Society Studies Worldwide (from 1970), MEDLINE (from 1946), ProQuest Dissertations & Theses databases (from 1743), PsycINFO (from 1806), PubMed (from 1997), Social Work Abstracts (from 1968), Sociological Abstracts (from 1952), Web of Science (from 1990), and Scopus (from 2004).

Search

We performed an initial search of the abovementioned electronic databases up to December 2020, a second-round search in July 2021, and a prepublication search in March 2022. Four sets of keywords were used in combination and adapted according to the requirements of each database: (a) mindfulness (mindful*); (b) peer relationships (“peer relation*” OR “peer problem*” OR “peer rejection” OR “peer acceptance” OR “peer conflict*” OR “peer violence” OR “peer status” OR “sociometric status” OR bully* OR “peer victimi*” OR “peer neglect” OR “peer attachment” OR “peer clique” OR “peer group” OR “peer crowd” OR interpersonal OR friend* OR popularity OR “peer nomination*” OR “social preference” OR sociometry OR “peer interact*”); (c) children or adolescents (child* OR boy* OR girl* OR juvenil* OR minors OR adolesc* OR pre-adolesc* OR pre-adolesc* OR pre-school OR preschool OR student* OR paediatric* OR pediatric* OR pubescen* OR puberty OR school* OR campus OR teen* OR young

OR youth* OR teen OR young people OR minor*); and (d) intervention (random* OR experiment* OR RCT OR intervention OR group OR program* OR training OR therapy OR trial OR treatment OR service* OR prevent* OR evaluat* OR effect* OR practice OR pilot).

Backward searching (reviewing the citations of each article) and forward searching (searching studies that have cited that article) of the included articles were completed. Hand-searching of the key journals *Mindfulness*, *Journal of Child and Family Studies*, and *Journal of Youth and Adolescence* was also carried out. Three experts in the field of mindfulness were consulted for further references to relevant studies.

Study Selection

After duplicates were removed, paired reviewers (XD, ND, and SS) independently screened titles, abstracts, and full texts of articles according to the inclusion and exclusion criteria. Any disagreement was resolved through discussion with the other review author (SL).

Data Collection

Data from the selected studies were extracted by paired researchers (XD, ND, and SS) independently using a standard data coding scheme. Relevant data were extracted from each article under the following domains: publication details (e.g., author or authors, country of study), study characteristics (e.g., study design, control conditions), participant characteristics (e.g., age, gender), target outcomes (e.g., measures, effect size), and data relevant to the intervention details and fidelity. All coding inconsistencies were resolved in consultation with the other review author (SL). We contacted 15 authors for further information, and seven replied with requested information.

Information regarding intervention fidelity in all articles was extracted using a structured intervention fidelity tool for MBIs (Kechter et al., 2019). This checklist covered five components of intervention fidelity: “Design” included any information about the intervention content and dosage and any mention of a program adaptation. “Training” included any information about the facilitators’ credentials and how the facilitators were trained on mindfulness and curriculum content. “Delivery” included any methods of reviewing, evaluating, and supervising to ensure the intervention was delivered as intended. “Receipt” included any information about the participants’ attendance, satisfaction, and comprehension. “Enactment” included any information about the participants performing mindfulness skills in daily life.

Risk of Bias

Paired reviewers (XD, ND, and SS) independently assessed the risk of bias in the included studies. Quality was assessed using the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool (Thomas et al., 2004), which covers six domains: sample selection, study design, identification and treatment of confounders, blinding of outcome assessors and of participants, reliability and validity of data collection methods, and withdrawals and dropouts. Each domain is rated as strong, moderate, or weak. The tool has good construct validity and reliability (Thomas et al., 2004). Paired assessors rated each study and demonstrated an acceptable level of inter-rater agreement (Cohen’s kappa = .79). Any disagreements were resolved through discussion.

Synthesis of Results and Meta-analyses

Our main analysis calculated the overall effect size of MBIs on all peer relationship outcomes. In addition, two independent meta-analyses were performed to estimate the effects of MBIs on negative peer interactions and positive peer interactions. Following Goessl et al.’s (2017) approach, we calculated a primary effect size (using within-group effect sizes) and a secondary effect size (using between-group effect sizes) based on means, standard deviations, and information from significance tests, such as *t*- and *F*-values. For studies that did not report pre–posttest correlations, we assumed $r = 0.5$ in analyses. As a sensitivity test, we also conducted main analyses using $r = 0.7$ and $r = 0.9$ (a range of common correlations in applied settings, as suggested by Estrada et al., 2019).

Because the studies included various interventions and study populations, we used random-effects models, which take such differences across studies into account. A pooled standardized mean difference (i.e., Cohen’s *d*) was calculated based on the pre–post mean differences before and after intervention for single-group studies and the pre–post mean differences of the intervention and control groups for controlled studies. The Cohen’s *d* was then converted to Hedge’s *g*, an effect size indicator that adjusts for small sample estimation bias (Hedges, 1981). Similar to Cohen’s *d*, small, medium, and large effect sizes with Hedges’ *g* are denoted by values of 0.2, 0.5, and 0.8 (Cohen, 1992). Positive within-group effect sizes indicate pre–post improvements in peer relationships (i.e., increased positive interactions and decreased negative interactions in MBI groups). Positive between-group effect sizes indicate greater improvements in MBI groups compared with controls (i.e., greater pre–post increase in positive peer interactions or greater pre–post decrease in negative peer interactions).

We assessed heterogeneity among studies using the prediction interval, which is an index of dispersion that

indicates how widely the true effect size varies (Borenstein, 2019). In addition, the I^2 statistic was used to indicate the ratio of true variation in effect sizes (rather than random error) to the total observed variation (Borenstein et al., 2009). To avoid underestimation of the error in the summary effect, we averaged the effect sizes within a study when peer relationships were measured with multiple tests (Borenstein et al., 2009). We assessed publication bias through a visual inspection of funnel plot asymmetry (Borenstein et al., 2009) and tested possible bias using Egger's test (Egger et al., 1997), rank correlation test (Begg & Mazumdar, 1994), trim and fill analysis (Duval & Tweedie, 2000), classic fail-safe N (Rosenthal, 1979), and Orwin fail-safe N (Orwin, 1983). In addition, we conducted a series of moderator analyses to explain the variability in effect sizes. The studies were grouped by relevant characteristics, such as participant age, gender, type of mindfulness intervention, dosage, facilitator, and study design. The analyses were done in Comprehensive Meta-Analysis software (Version 3.3).

Results

Study Selection

Figure 1 depicts the screening process and search results. Our electronic database search identified 1910 records, and 63 additional articles were identified through other sources. After we removed the duplicates, 1572 potentially eligible studies remained for title and abstract screening. Seventy-five articles were deemed suitable for full-text analysis. Seventeen articles and four theses were ultimately judged eligible for inclusion.

Study and Participant Characteristics

The study characteristics are presented in Table 1. The reviewed articles included eight RCTs, seven quasi-experimental design studies, and six single-group pre–post studies published from 2010 to 2022. Randomization occurred at the classroom or school level in all studies but one, which randomized at the individual level (Valero et al., 2021). Only two studies adopted active control groups, and most studies used wait-list control groups ($k = 10$). The included studies reported on different dimensions of peer relationships. In general, the included studies focused mainly on the effects of MBIs on negative peer interactions ($k = 12$) rather than positive peer interactions ($k = 7$); two studies included both positive and negative peer relationship outcomes.

The 21 studies included 2179 participants, with final sample sizes ranging from 15 (Ahola Kohut et al., 2020) to 319 (Berger et al., 2018) children. Participants covered the entire age span of school-age children and adolescents from 5 to

18 years old, and primary school students were represented most in the included studies ($k = 10$). Among 19 studies that reported child gender information, there was a generally balanced gender representation, with 48.7% female participants on average.

Intervention Characteristics and Fidelity

We summarized how five components of intervention fidelity were reported in the included studies. As shown in Table 2, 21 articles (100%) reported on the study design, 19 (90%) reported on monitoring or improving facilitator training, nine (43%) reported on monitoring or improving delivery of the intervention, nine (43%) reported on monitoring and improving receipt of the intervention, and 15 (71%) reported on monitoring and improving enactment of mindfulness skills. Only two studies (Haydicky et al., 2015; Terjestam et al., 2016) reported all five components. Overall, we found high variation in the way each component was monitored and reported.

Design All studies except two (Haydicky et al., 2015; Valero et al., 2021) reported the implementation context. Among them, 18 studies were conducted in school settings and one study was conducted in a pediatric hospital (Ahola Kohut et al., 2020). Seven participating schools were identified as serving mainly at-risk populations. Most of the programs ($k = 14$) were manualized MBIs and 13 studies also involved other activities. The included programs varied in duration, from 4 weeks (Ricard et al., 2013) to 28 weeks (Carro et al., 2020, 2022), with sessions of 0.5–2 h per week. Fifteen articles included information on program adaptations for specific environments or populations. Over half of the interventions ($k = 13$) were classroom-based programs where the whole class received the intervention in the classroom setting. Others were group-based programs in which students were pulled from class to participate in a group intervention.

Training Nine interventions were conducted by nonteaching personnel (e.g., outside clinicians), four interventions were facilitated by trained schoolteachers, and the other five interventions were delivered by nonteaching personnel together with schoolteachers. As for the facilitators' training, in some studies, the facilitators received formal mindfulness training and practiced mindfulness regularly (e.g., Bokoch & Hass-Cohen, 2020), whereas in others, they received hours of training on the curriculum before the intervention (e.g., Meyer & Eklund, 2020).

Delivery Seven studies provided regular supervisor meetings throughout the program, and one study (Schonert-Reichl et al., 2015) provided teachers with a “booster session” midway through the intervention to support the program's

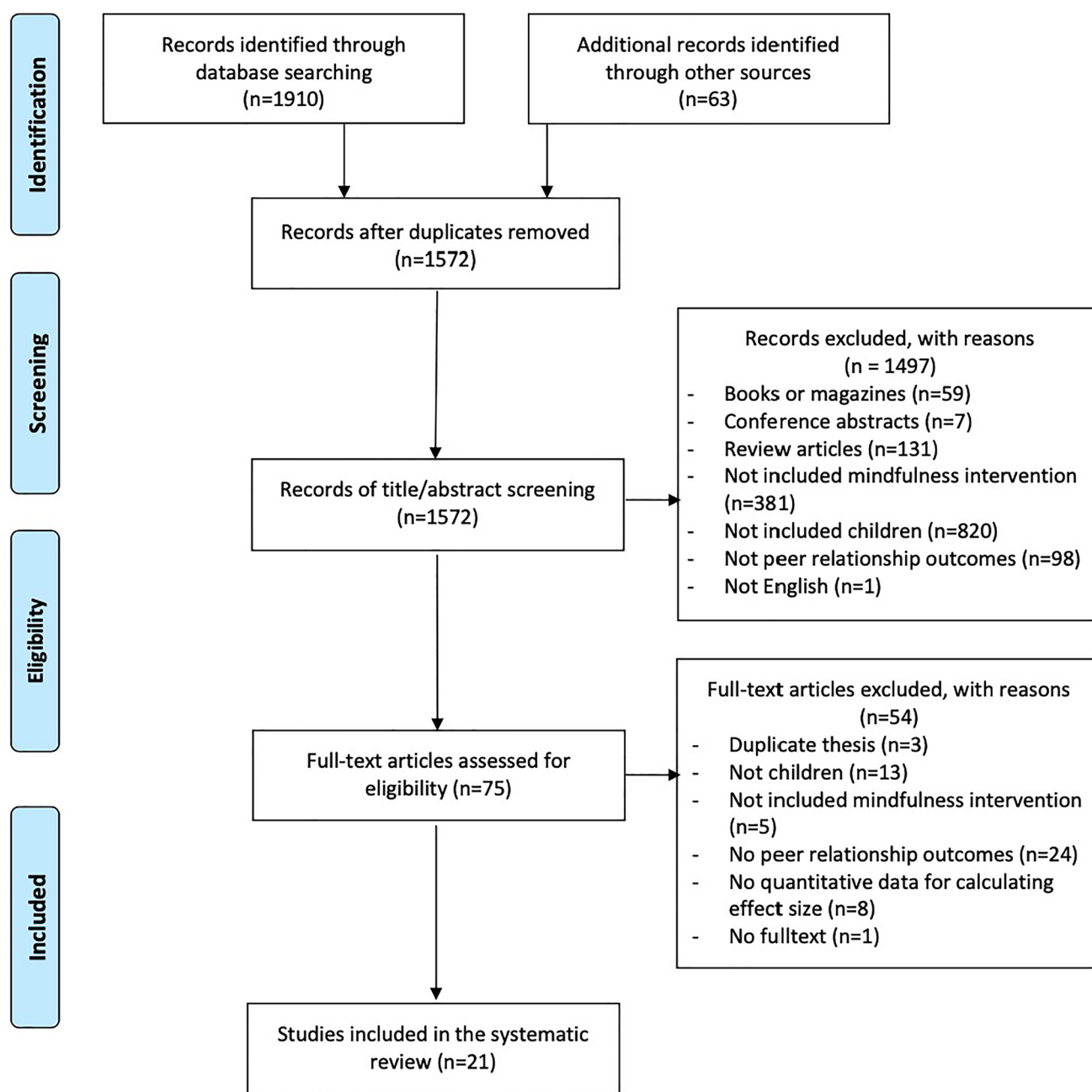


Fig. 1 Screening process of eligible studies

implementation. As for fidelity assessment, only three studies formally assessed implementation fidelity. Two other studies reported that intervention adherence and quality were assessed through informal interviews or observations.

Receipt Regarding participants' attendance, eight articles explicitly reported collecting participant attendance. Another six articles implicitly reported collecting participant attendance in intervention sessions (e.g., children absent for more than four sessions were excluded). In addition, five studies

reported information related to the participants' responsiveness. Feedback forms, focus groups, and individual interviews were conducted to obtain program satisfaction and engagement.

Enactment Only six studies directly measured mindfulness as an outcome variable with validated instruments. Four studies assessed variables closely related to the mindfulness concept, such as experiential avoidance. Eleven of the studies did not report home practice, and the remaining 10

Table 1 Characteristics of participants and studies

References	Samples		Studies					Related outcomes (measures)	
	Total <i>N</i> (treatment <i>N</i> , control <i>N</i>)	Mean age (age range/grade levels)	% girls	Race/ethnicity	Mental/health conditions	Home SES; income/employment/education	Country		Design (type of controls)
Ahola Kohut et al. (2020)	15 (NA)	14.6 (ages 13–17)	44.4%	NR	Inflammatory bowel disease	NR	Canada	Single group (NA)	Friendship quality (PROMIS-P)
Anand and Sharma (2014)	33 (NA)	14.2 (ages 13–15)	45.5%	NR	NR	Middle class population	India	Single group (NA)	Peer difficulties (SSS)
Berger et al. (2018)	319 (173, 146)	9.7 (grades 3–5)	51.5%	100% Israeli–Jewish	NR	Middle class population	Israel	Cluster RCT (WLC)	Readiness for social contact (RSC)
Bokoch and Hass-Cohen (2020)	83 (50, 33)	NR (ages 5–12)	42%	75% Latinx, 15% White, 5% Asian, 5% biracial	Internalizing symptoms, externalizing behaviors, and relational problems	Mostly low-SES population	USA	Quasi (WLC)	Peer difficulties (Conners-3)
Carey (2017)	28 (NA)	NR (ages 7–8)	53.6%	NR	NR	NR	UK	Single group (NA)	Peer difficulties (SDQ)
Carro et al. (2020)	26 (19, 7)	NR (ages 7–8)	NR	NR	NR	Low-SES population	Argentina	Cluster RCT (WLC)	Social integration (SPI)
Carro et al. (2022)	33 (16, 17)	NR (grade 2nd)	51.5%	100% Hispanic/Latino	NR	NR	Argentina	Quasi (WLC)	Social integration (SPI)
Faraji et al. (2019)	20 (10, 10)	NR (grades 3–5)	NR	NR	Bully behaviors	NR	Iran	Quasi (NR)	Bullying (IBS)
Haydicky et al. (2015)	16 (NA)	15.5 (ages 13–18)	27.8%	59% parents born in North America, 9% parents European origins, 21% parents from Asia, 9% parents from Caribbean	ADHD	71% parents employed full-time, 97% parents have secondary school education or above	Canada	Single group (NA)	Peer difficulties (Conners-3)
Liu et al. (2021)	189 (92, 97)	15.9 (grade 8)	59.3%	100% Chinese	NR	NR	China	Cluster RCT (TAU)	Bullying (OBQ-CV)
Matsuba et al. (2021)	82 (46, 36)	12.7 (grades 5–6)	59.8%	Mostly local Acholi Tribe	NR	NR	Uganda	Quasi (WLC & TAU)	Friendship (NIH-F)
Meadows (2018)	38 (27, 11)	9.1 (grades K–8)	49.2%	84.6% African American, 7.7% White, 7.7% multi-racial	10.8% emotional disturbances, 2.3% multiple disabilities, 8.5% special education	Low-SES population	USA	Cluster RCT (WLC)	Peer difficulties (SDQ)
Mendelson et al. (2010)	92 (48, 44)	10.1 (grades 4–5)	60.8%	83.5% African American, 7.2% mixed race, 4.1% Latino, 4.1% White	NR	Low-SES population	USA	Cluster RCT (WLC)	Relations with peers (PIML)

Table 1 (continued)

References	Samples		Studies			Design (type of controls)	Related outcomes (measures)
	Total N (treatment N, control N)	Mean age (age range/grade levels)	% girls	Race/ethnicity	Mental/health conditions		
Menghetti (2015)	24 (NA)	15.5 (ages 14–18)	75%	75% Latino, 13% African American, 8% White, 4% Vietnamese	Exhibit signs of emotional dys-regulation	Single group (NA)	Bullying (IBS)
Meyer and Eklund (2020)	296 (138, 158)	9.3 (grades 4–5)	53%	86.8% Hispanic/Latino, 13.2% others	NR	Quasi (WLC)	Classroom cohesion and friction (MCI-SFR)
Mueller (2014)	22 (NA)	6.3 (ages 5–7)	50%	72.7% New Zealand European ethnicity, 9.1% Maori ethnicity, 4.5% Maori/Cook Island ethnicity	NR	Single group (NA)	Positive and negative peer interactions (PBS & BPI)
Ricard et al. (2013)	303 (125, 178)	NR (NR)	37.3%	79.8% and 83% Hispanic for treatment and control group respectively	Violating school's disciplinary code of conduct	Quasi (TAU)	Social isolation (YOQ-30.2)
Schonert-Reichl et al. (2015)	99 (48, 51)	10.2 (ages 9–11.2)	44%	66% English first language, 25% East Asian, 10% other languages	NR	Cluster RCT (AC)	Peer acceptance (Peer nominations)
Terjestam et al. (2016)	309 (184, 125)	NR (grades 5, 7, 8)	48.3%	NR	NR	Cluster RCT (AC)	Peer difficulties (SDQ)
Valero et al. (2021)	30 (15, 15)	10.6 (ages 9–14)	23.3%	NR	ADHD	RCT (WLC)	Peer difficulties (Conners-3)
Waldemar et al. (2016)	120 (62, 58)	11.1 (grade 5)	47.7%	51.5% White, 32.6% Mixed, 12.1% Black, 1.5% Native Brazilians, 2.3% NR	NR	Quasi (WLC)	Peer difficulties (SDQ)

AC, active control; ADHD, attention deficit/hyperactivity disorder; BPI, Behaviour Problems Index; PBS, Positive Behaviour Scale; Conners-3, Conners-3rd Edition; IBS, Illinois Bullying Scale; K, kindergarten; MCI-SFR, My Class Inventory-Short Form Revised; NA, not applicable; NIH-F, Emotion Measures in the NIH Toolbox - Friendship; NR, not reported; OBQ-CV, Chinese Version of the Olweus Bully/Victim Questionnaire; PIML, Relations with Peers and School People in My Life; PROMIS-P, The Patient-Reported Outcomes Measurement Information System-Peer Relationship; Quasi, Quasi-experimental design; RCT, randomized controlled trial; RSC, The Readiness for Social Contact; SDQ, Strengths and Difficulties Questionnaire; SES, socioeconomic status; SPI, social preference index; SSS, The School Situation Survey; TAU, treatment as usual; WLC, wait-list control; YOQ, Youth Outcome Questionnaire

Table 2 Intervention characteristics and fidelity

References	Design		Training	Delivery	Receipt	Enactment
	Program name	Implementation context				
Aholo Kohut et al. (2020)	– MBI-A – A pediatric tertiary hospital	– Mindfulness content included – Delivery dosage – Delivery approach	– Facilitator – Qualification and training	– Delivery adherence – Supervision	– Participant attendance – Participant engagement	– Mindfulness related outcome (measures) – Home practice – Adherence to home practice
		– Modified MBSR for pediatric IBD – Activities adapted for pediatric IBD (e.g., the effects of stress on pain and physical symptoms) – 120 min/week for 8 weeks – Child-group + one-time parent workshop	– Two clinical psychologists – NR	– NR – NR	– Attendance and punctuality recorded – Satisfaction questionnaire and focus group about program benefits and satisfaction	– Significant improvement in mindfulness (CAMM) – Home practice required – Mean duration of home practice = 5.31 min/day
Anand and Sharma (2014)	– NR – A public high school	– Modified MBSR – Stress reduction (e.g., stress and its mechanisms) – 40 min/week for 8 weeks – Classroom-based	– NR – NR	– NR – NR	– Intervention completers attended at least 5 sessions – Feedback proforma to obtain program benefits and satisfaction	– NR – Home practice required – Mean practice days = 47, mean duration of formal practice = 8.57 min
		– Manualized intervention based on SCT and ESPS programs with age-appropriate adaptations – SEL – 45 min/week for 24 weeks – Classroom-based	– Graduate research assistants with contemplative practice experience + homeroom teachers – 15-h training for research assistants	– Regular observation of the facilitators – Weekly off-site supervision	– NR – NR	– NR – Home practice required – Educated parents using school website, involved parents in home assignment, recorded mindfulness diaries
Berger et al. (2018)	– C2C-I – 3 public elementary schools	– Manualized intervention based on MBSR and MSC with age and cultural adaptations – Group art therapy – 45–60 min/week for 8 weeks – Child group + parent–child meeting + teacher meeting	– Doctoral student in Psychology – Formal MBSR training + regular meditation + 2 years mindfulness clinical practice	– NR – NR	– NR – NR	– No significant change in mindfulness (CAMM) – NR – NR
Bokoch and Hass-Cohen (2020)	– MATG-P – Primary school	– Manualized intervention based on MBSR and MSC with age and cultural adaptations – Group art therapy – 45–60 min/week for 8 weeks – Child group + parent–child meeting + teacher meeting	– Doctoral student in Psychology – Formal MBSR training + regular meditation + 2 years mindfulness clinical practice	– NR – NR	– NR – NR	– No significant change in mindfulness (CAMM) – NR – NR

Table 2 (continued)

References	Design	Training	Delivery	Receipt	Enactment
	– Program name – Implementation context	– Facilitator – Qualification and training	– Delivery adherence – Supervision	– Participant attendance – Participant engagement	– Mindfulness related outcome (measures) – Home practice – Adherence to home practice
Carey (2017)	– 60 mindful minutes – An inner-city Catholic primary school	– Trainee educational psychologist + class teacher – Extensive reading and independent practice in MBP for the trainee psychologist	– NR – NR	– NR – Student feedback form to explore program benefits and satisfaction	– Significant change in mindfulness at follow-up but not at posttest (CAMM) – Home practice required – Class teacher completed practices with children between sessions and kept weekly records – NR – NR – NR
Carro et al. (2020)	– NR – A public primary school	– 2 mindfulness based-practices trainers + class teacher – NR	– NR – NR	– NR – NR	– NR – NR – NR
Carro et al. (2022)	– NR – A private school	– 2 researchers + class teacher – NR	– NR – NR	– NR – NR	– NR – NR – NR
Faraji et al. (2019)	– NR – A primary school	– NR – NR	– NR – NR	– Exclusion criterion: absent for more than 4 sessions – NR	– NR – Home practice required – NR
Haydicky et al. (2015)	– MYmind – NR	– Doctoral students in psychology – 12-week mindfulness course + regular mindfulness practice	– One facilitator ran all child groups and followed the manual closely – On-site and weekly supervision	– Intervention completers attended at least 6 sessions – Reflection sheets to gauge treatment impact and enhance motivation, rewarded for practicing in session and at home	– No significant change in experiential avoidance (AAQ) – Home practice required – Daily email and reminding messages, CDs, workbooks, and rewards to support home practice

Table 2 (continued)

References	Design	Training	Delivery	Receipt	Enactment
	– Program name – Implementation context	– Mindfulness content included – Delivery dosage – Delivery approach	– Facilitator – Qualification and training	– Delivery adherence – Supervision	– Participant attendance – Participant engagement – Mindfulness related outcome (measures) – Home practice – Adherence to home practice
Liu et al. (2021)	– MiSP.b – A middle school	– Manualized 10-session mindfulness course for schools – NR – 40–45 min/week for 10 weeks – Classroom-based	– Trained mindfulness instructor – 8-week mindfulness training + teaching – training on the MiSP.b	– NR – NR	– Significant improvement in mindfulness (FFMQ) – Home practice encouraged + 10–15 min daily practice guided by instructor – Students recorded practice time in workbook
Matsuba et al. (2021)	– MindUP – 2 private primary schools	– Manualized mindfulness program with cultural and age-appropriate adaptations – SEL – 45 min/week + 3 min × 3 times/day for 15 weeks – Classroom-based	– Ugandan teachers – 7-day workshop + ongoing training support	– Teachers kept a record of program implementation – NR	– NR – NR – NR
Meadows (2018)	– NR – A public school	– Manualized intervention based on MBCT and MBSR – NR – 30 min × 2 times/week for 12 weeks – Classroom-based	– A trained mindfulness facilitator – NR	– Inconsistent reporting of students' attendance – NR	– NR – NR – NR
Mendelson et al. (2010)	– NR – 4 urban public elementary schools	– General MBP – NR – 45 min × 4 times/week for 12 weeks – Group-based	– 2 instructors from Holistic Life Foundation – NR	– NR – NR	– 40–74% students completed at least 75% sessions across different schools – Student/teacher focus groups to explore program benefits – Significant improvement in involuntary responses to stress (RSQ) – Home practice encouraged – NR

Table 2 (continued)

References	Design	Training	Delivery	Receipt	Enactment
	– Program name – Implementation context	– Facilitator – Qualification and training	– Delivery adherence – Supervision	– Participant attendance – Participant engagement	– Mindfulness related outcome (measures) – Home practice – Adherence to home practice
Menghetti (2015)	– NR – A high school	– NR – DBT protocol training from experts	– NR – Supervision from DBT experts	– NR – NR	– No significant change in emotion regulation (DERS) – NR – NR
Meyer and Eklund (2020)	– Mindful Moments – 2 elementary schools	– Manualized intervention underpinned by MBSR – NR – 2 min × 3 times/day for 10 weeks – Classroom-based	– School teachers – 2-h training	– 68% completion rate (teacher log data), 93% (researcher observation) – Weekly consultation	– No significant change in mindfulness (CAMM) – NR – NR
Mueller (2014)	– NR – A primary school	– General MBP with age-appropriate adaptations – Conflict resolution skills – 10–15 min × 3 times/week for 6 weeks – Classroom-based	– A PhD candidate in Psychology + a registered class teacher – 3-day intensive training for the PhD researcher	– NR – NR	– NR – NR – NR
Ricard et al. (2013)	– Teen Talk – Disciplinary Alternative Education Program	– A briefer DBT infused skills group intervention adapted from standard DBT – Emotional regulation, distress tolerance, and interpersonal effectiveness – 45–50 min × 2 times/week for 4 weeks – Group-based	– Counseling interns (5 doctoral + 2 master's level) – Monthly training	– NR – Regular staff meetings + daily site-based supervision	– Students receiving an average of 6 sessions – NR – NR

Table 2 (continued)

References	Design	Training	Delivery	Receipt	Enactment
Schonert-Reichl et al. (2015)	– Program name – Implementation context	– Facilitator – Qualification and training	– Delivery adherence – Supervision	– Participant attendance – Participant engagement	– Mindfulness related outcome (measures) – Home practice – Adherence to home practice
	– Mindfulness content included – Delivery dosage – Delivery approach	– School teachers – Intensive 1-day training	– Completed 100% lessons and 81–95% daily practices – One booster session	– NR – NR	– Significant improvement in mindfulness (MAAS-C) – NR – NR
Terjestam et al. (2016)	– Compas – 4 public secondary schools	– School teachers – 3 × 3 h training	– Fidelity informally checked during supervision meeting – Weekly supervision	– Attendance noted at each session – NR	– Significant improvement in effortful control (EC scale) – NR – NR
	– General MBP – SEL – 11–20 min × 3 times/week for 8 weeks – Classroom-based	– School teachers – 3 × 3 h training	– Fidelity informally checked during supervision meeting – Weekly supervision	– Attendance noted at each session – NR	– Significant improvement in effortful control (EC scale) – NR – NR
Valero et al. (2021)	– Manualized four units mindfulness program – SEL – 40–50 min/week + 3 min × 3 times/day for 12 weeks – Classroom-based	– School teachers – Intensive 1-day training	– Completed 100% lessons and 81–95% daily practices – One booster session	– NR – NR	– Significant improvement in mindfulness (MAAS-C) – NR – NR
	– General MBP – SEL – 11–20 min × 3 times/week for 8 weeks – Classroom-based	– School teachers – 3 × 3 h training	– Fidelity informally checked during supervision meeting – Weekly supervision	– Attendance noted at each session – NR	– Significant improvement in effortful control (EC scale) – NR – NR
Waldemar et al. (2016)	– MYmind – NR	– Professional certified by MYmind program + support observer – NR	– NR – NR	– NR – NR	– Home practice required – Activity book and audio-recording given to each family
	– Manualized intervention adapted from MBCT – NR – 60 min/week for 8 weeks – Child group + parent group	– School teachers – 3 × 3 h training	– Fidelity informally checked during supervision meeting – Weekly supervision	– Attendance noted at each session – NR	– Significant improvement in effortful control (EC scale) – NR – NR
Waldemar et al. (2016)	– M-SEL – 3 public elementary schools	– Young psychologists – NR	– NR – Weekly supervision meeting	– NR – NR	– Home practice not required – NR
	– General MBP with age-appropriate adaptations – SEL – 60 min × 8–12 sessions – Classroom-based	– School teachers – 3 × 3 h training	– Fidelity informally checked during supervision meeting – Weekly supervision	– Attendance noted at each session – NR	– Significant improvement in effortful control (EC scale) – NR – NR

AAQ, Acceptance and Action Questionnaire; CAMM, Child and Adolescent Mindfulness Measure; Compas, compassion and attention in the schools; C2C-I, call to care-Israel; DBT, dialectical behavior therapy; DERS, Difficulties of Emotion Regulation Scale; EC, effortful control; ESPS, enhancing resiliency and promoting prosocial behavior; IBD, inflammatory bowel disease; MAAS-C, Mindful Attention Awareness Scale adapted for children; MATG-P, mindfulness and art therapy group program; MBCT, mindfulness-based cognitive therapy; MBCT-C, mindfulness-based cognitive therapy for child; MBP, mindfulness-based practice; MBSR, mindfulness-based stress reduction; MISPb, Curriculum of Mindfulness in School Project; MSC, mindful self-compassion programs; M-SEL, mindfulness and social-emotional learning program; NR, not reported; RSQ, Responses to Stress Questionnaire; SCT, sustainable compassion training; SEL, social emotional learning

studies varied in their mandatory levels of home practice (i.e., required, encouraged, not required). Only four studies reported strategies to support home practice.

Risk of Bias

Summaries of the risk of bias are presented in the Supplemental Table 1. The study design of all the included studies showed moderate-to-strong quality. All included studies adopted reliable and valid measurements, and their data collection methods were strong. In terms of selection bias, most studies showed a moderate quality with some risk of bias. About 60% of the studies adequately controlled relevant confounders and indicated high participant completion rates (over 80%), whereas the remaining studies showed weak evidence in these two domains. The “Blinding” domain overall contained high risk, with most studies not clearly reporting if assessors were blinded to the treatment allocation or if participants were blinded to the research question.

Meta-analyses

Pre–post Within-Group Effects Figure 2 presents the pooled within-group effects of MBIs on overall peer relationships (Fig. 2a) and its two subdomains, negative peer interactions (Fig. 2b) and positive peer interactions (Fig. 2c). Based on the combined results of the 20 studies (Fig. 2a), MBI groups showed a small and significant postintervention improvement in peer relationships, $g = 0.48$, 95% CI [0.33, 0.62]. The z test result indicated that the pooled effect size significantly differed from zero, $z = 6.34$, $p < .001$. The Q -statistic provides a test of the null hypothesis that all studies in the analysis share a common effect size. If all studies shared the same effect size, the expected value of Q would be equal to the degrees of freedom (df ; Borenstein, 2019). In this analysis, $Q = 87.53$, $df = 19$, $p < .001$; therefore, we could reject the null hypothesis that the true effect size was identical in all the studies. In addition, $I^2 = 78.29$, indicating that 78% of the observed variance across studies reflected variation in true effects rather than sampling error. The variance of true effects (T^2) = 0.08; the standard deviation of true effects (T) = 0.27. The 95% prediction interval was -0.12 to 1.07 , which means the true effect size in 95% of all comparable populations falls in this interval. This wide interval suggests the within-group effects varied across populations. While MBIs could generate a positive effect as large as 1.07 in some populations, MBIs might show a trivial negative within-group effect in other populations.

Fourteen studies assessed the effects of MBIs on negative peer interactions. As shown in Fig. 2b, the meta-analysis suggested a medium improvement in negative peer interactions with a weighted mean effect $g = 0.50$, 95% CI [0.29, 0.71]. The z test result suggested that the overall effect size

differed significantly from zero, $z = 4.73$, $p < .001$. In addition, $Q = 84.76$, $df = 13$, $p < .001$, $I^2 = 84.66$, $T^2 = 0.12$, $T = 0.34$; the 95% prediction interval was -0.27 to 1.28 .

In the eight studies that examined positive peer interactions, MBIs also showed a small, positive weighted mean effect, $g = 0.40$, 95% CI [0.24, 0.56], an effect size that significantly differed from zero, $z = 4.90$, $p < .001$. In addition, $Q = 15.49$, $df = 7$, $p = .03$, $I^2 = 54.80$, $T^2 = 0.03$, $T = 0.16$; the 95% prediction interval was -0.04 to 0.83 .

For the seven studies that included follow-up assessments, we calculated a within-group effect size from pretest to follow-up assessment, with follow-up periods that ranged from 1 month (Menghetti, 2015) to 6 months postintervention (Berger et al., 2018; Valero et al., 2021). As shown in Supplemental Fig. 1, the meta-analysis showed a significant medium-to-large effect on overall peer relationships ($g = 0.77$, 95% CI [0.37, 1.17], $z = 3.73$, $p < .001$), which suggested an increase in effect size over time.

Between-Group Effects Fig. 3 presents the pooled between-group effects of MBIs for the 15 studies that compared MBI groups with a control condition (i.e., waitlist control, treatment-as-usual, or active control). MBI groups showed more improvements in overall peer relationships (Fig. 3a) than controls did, with a small and significant effect size ($g = 0.40$, 95% CI [0.18, 0.62], $z = 3.55$, $p < .001$). In terms of the two subdomains, the analyses yielded small positive effects on negative peer interactions (Fig. 3b; $g = 0.44$, 95% CI [0.12, 0.76], $z = 2.70$, $p = .007$) and positive peer interactions (Fig. 3c; $g = 0.30$, 95% CI [0.04, 0.56], $z = 2.24$, $p = .03$), which indicated MBI groups showed greater reductions in negative peer interactions and greater improvements in positive peer interactions compared with controls.

Moderator Analyses

We conducted moderator analyses to assess whether the study, participant, and intervention characteristics accounted for the variance in MBI effects on overall peer relationships. Table 3 presents the univariate moderator analyses of the primary effect sizes (i.e., within-group effect sizes). Two moderators contributed significantly to within-group variance: participant age and facilitator background. Across age groups, MBIs showed the largest effect among adolescents ($g = 0.67$, 95% CI [0.28, 1.05]), followed by school-age children ($g = 0.43$, 95% CI [0.27, 0.58]), and mixed age groups ($g = 0.20$, 95% CI [0.07, 0.34]). In terms of facilitator background, MBIs delivered by a mixture of schoolteacher and nonteaching personnel showed the largest effect ($g = 0.52$, 95% CI [0.39, 0.65]), followed by MBIs delivered by nonteaching personnel only ($g = 0.43$, 95% CI [0.22, 0.65]) and MBIs delivered by schoolteacher only ($g = 0.18$, 95% CI [0.09, 0.28]). The effects of MBIs did not vary significantly

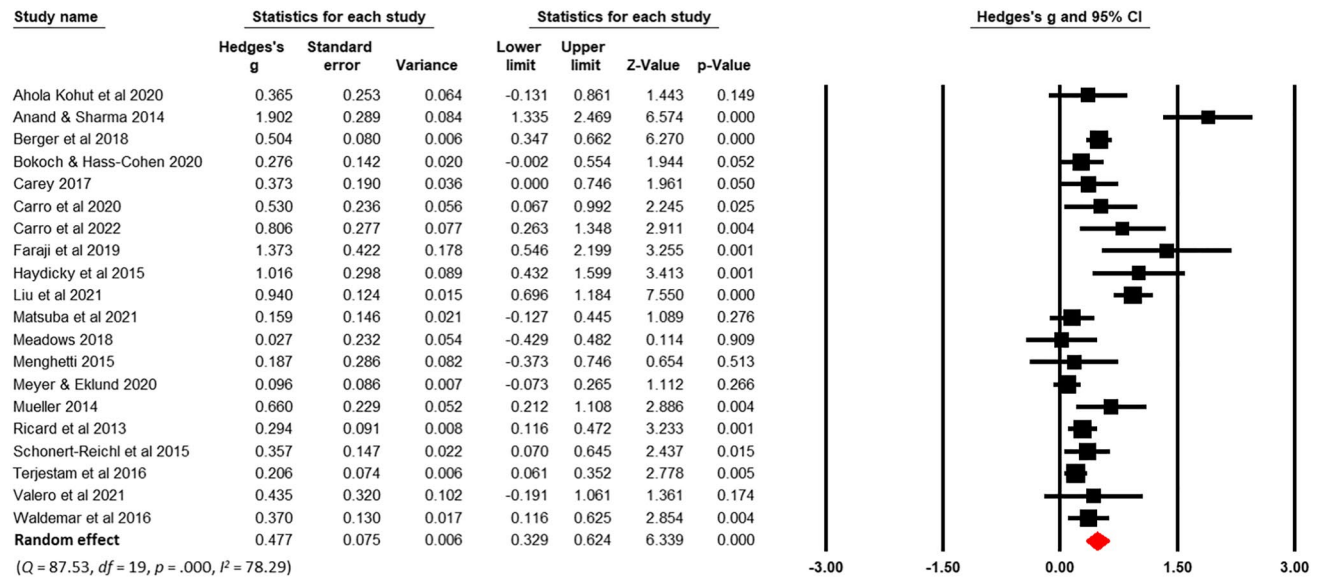
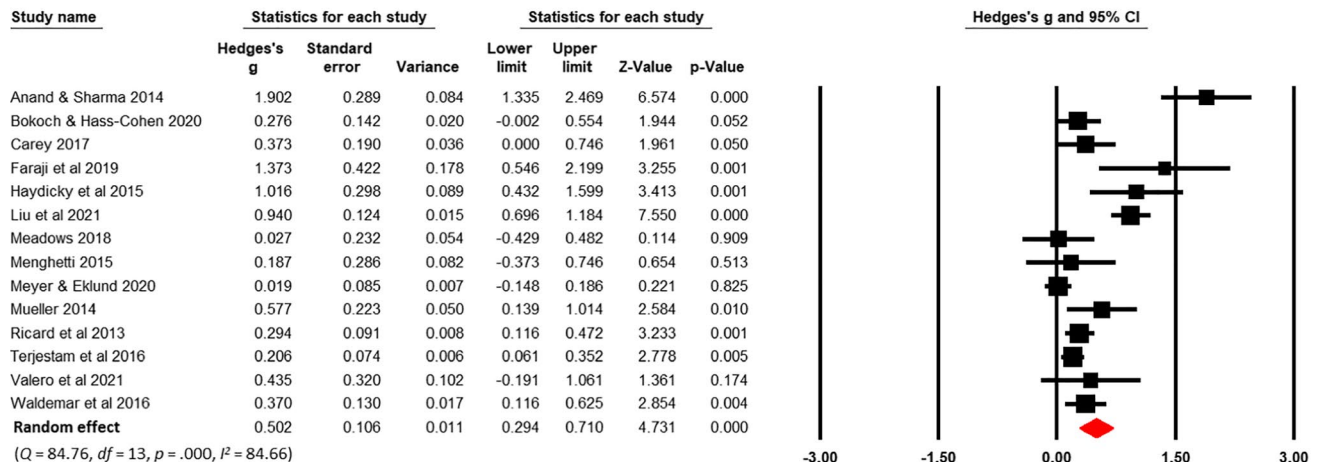
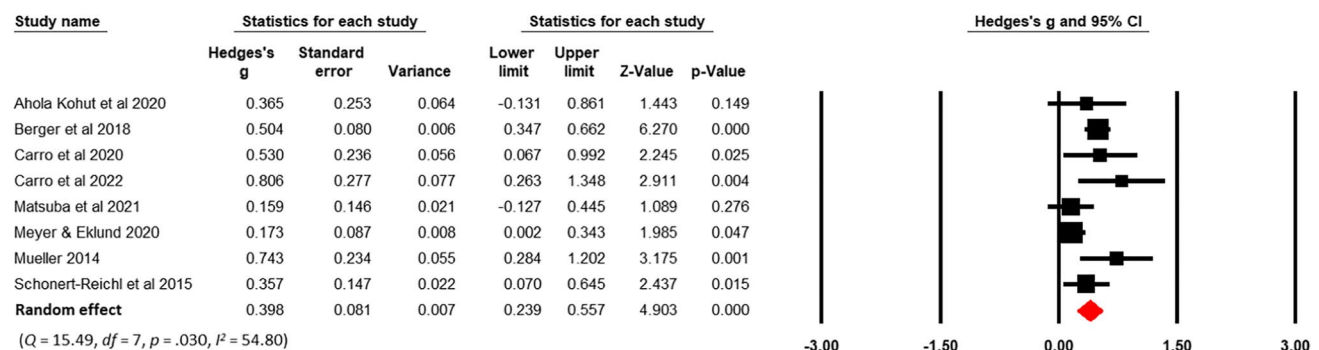
(a) All peer relationship outcomes ($k = 20$)^b**(b) Negative peer interactions ($k = 14$)****(c) Positive peer interactions ($k = 8$)**

Fig. 2 Within-group effect sizes for mindfulness-based interventions on peer relationship outcomes. *Note.* Effect sizes were adjusted to the consistent direction for all outcomes; positive values indicate positive intervention effects, and negative values indicate negative intervention effects. One study that only reported posttest results (Mendelson

et al., 2010) was excluded from within-group pre–post analysis. ■ denotes effect sizes of individual studies, ◆ denotes the pooled effect size; k = number of studies, CI = confidence interval, df = degree of freedom

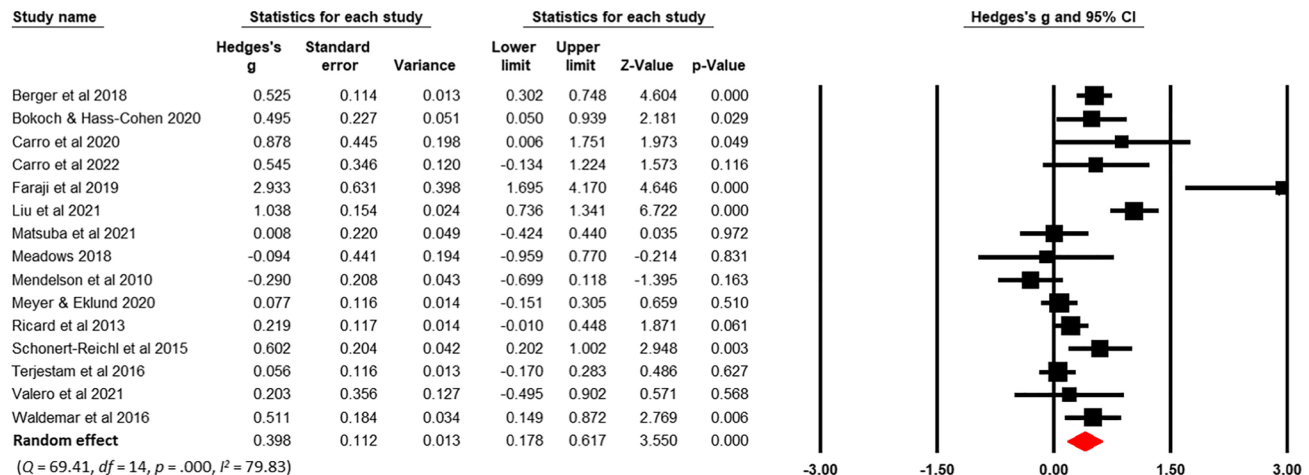
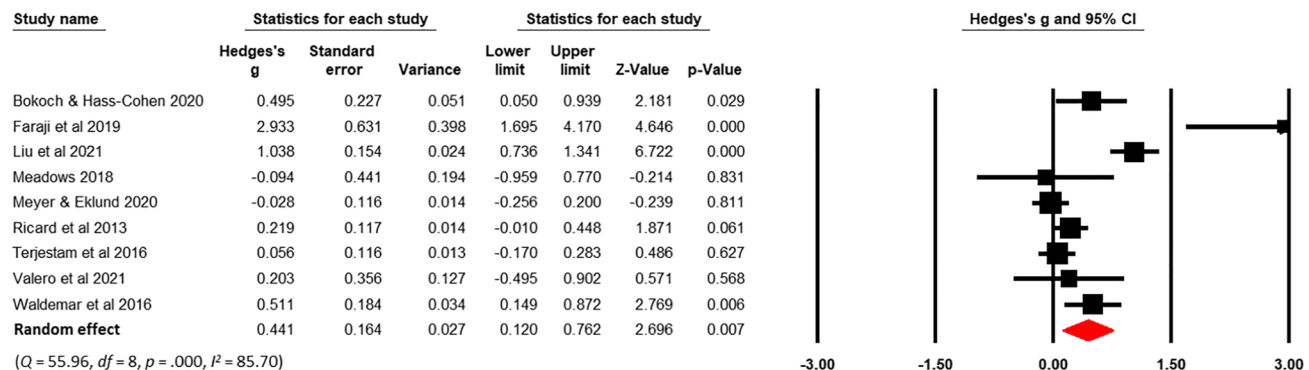
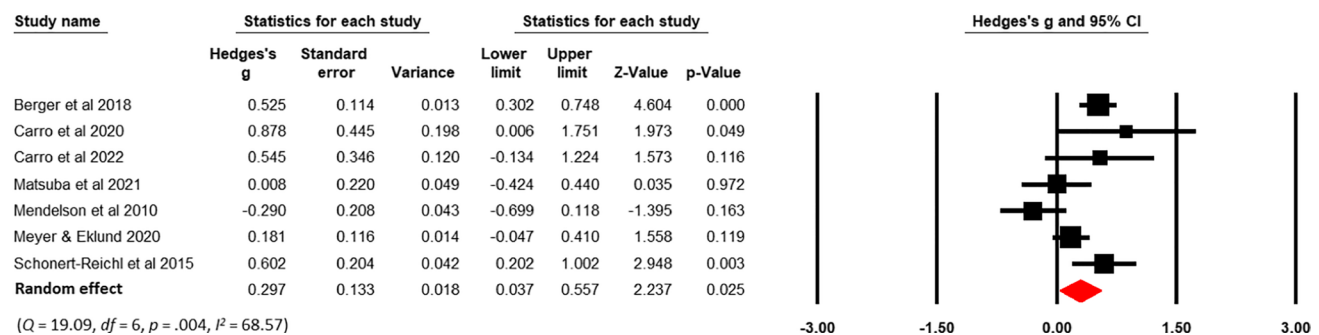
(a) All peer relationship outcomes ($k = 15$)**(b) Negative peer interactions ($k = 9$)****(c) Positive peer interactions ($k = 7$)**

Fig. 3 Between-group effect sizes for mindfulness-based interventions on peer relationship outcomes. *Note.* Effect sizes were adjusted to the consistent direction for all outcomes; positive values indicate positive intervention effects; negative values indicate negative

intervention effects. ■ denotes effect sizes of individual studies, ◆ denotes the pooled effect size; k = number of studies, CI = confidence interval, df = degree of freedom

by other moderators, such as participant gender, preexisting clinical conditions, intervention dosage, and research design.

Sensitivity Analyses

We conducted two sensitivity tests to examine the robustness of our results. First, we calculated pooled effect sizes and

conducted moderator analyses of overall peer relationships without two outliers (within-group effect: $g = 0.41$, 95% CI [0.29, 0.54], $z = 6.39$, $p < .001$; between-group effect: $g = 0.34$, 95% CI [0.14, 0.53], $z = 3.35$, $p = .001$; Supplemental Fig. 2). Second, we calculated within-group effect sizes by assuming correlation values of 0.7 and 0.9 for studies that did not report pre–posttest correlations (within-group effect on overall peer

Table 3 Moderator analyses of within-group intervention effect on peer relationship by study characteristics ($k = 20$)^a

Study characteristics	Peer relationship				
	k	Hedge's g (95% CI)	Q_b	df	p
Participant age					
School-age children (6–12 years)	10	0.43 (0.27, 0.58)***	7.85	2	0.02*
Adolescents (13–18 years)	7	0.67 (0.28, 1.05)***			
Mixed	3	0.20 (0.07, 0.34)**			
Participant gender					
Predominantly female (female $\geq 50\%$)	8	0.46 (0.22, 0.70)***	0.001	1	0.97
Predominantly male (female $< 50\%$)	10	0.45 (0.24, 0.66)***			
Participant pre-existing condition					
Predominantly clinical/at-risk	7	0.44 (0.22, 0.67)***	0.08	1	0.78
None/not mentioned	13	0.49 (0.30, 0.68)***			
Type of mindfulness intervention					
Manualized mindfulness-based program	14	0.52 (0.30, 0.73)***	1.29	1	0.26
General mindfulness practice	6	0.37 (0.22, 0.51)***			
Any adaptation of intervention program ^b					
Yes	15	0.53 (0.34, 0.72)***	2.15	1	0.14
No	5	0.32 (0.13, 0.52)**			
Other activities involved in intervention					
Yes	13	0.44 (0.29, 0.60)***	0.32	1	0.57
No	7	0.56 (0.18, 0.94)**			
Dosage ^c					
Low	6	0.48 (0.20, 0.76)***	0.01	2	0.99
Medium	7	0.47 (0.18, 0.75)**			
High	7	0.47 (0.28, 0.65)***			
Facilitator					
Non-teaching personnel only ^d	9	0.43 (0.22, 0.65)***	18.20	2	0.0001***
Schoolteacher only	4	0.18 (0.09, 0.28)***			
Mixed	5	0.52 (0.39, 0.65)***			
Intervention target					
Children only	16	0.48 (0.31, 0.65)***	0.01	1	0.93
Children and others (parents/teachers)	4	0.46 (0.16, 0.77)**			
Group setting					
Classroom-based intervention	13	0.49 (0.30, 0.68)***	0.08	1	0.78
Group-based intervention	7	0.44 (0.22, 0.67)***			
Study design					
Controlled studies	14	0.39 (0.25, 0.54)***	1.93	1	0.17
Non-controlled studies	6	0.74 (0.27, 1.20)**			

^aSubgroups for gender and facilitator may not add up to $k = 20$ due to information not reported in individual studies. ^bProgram adaptation includes adaptation based on participant age, language, and culture. ^cDosage is categorized by sample distribution: low = 380 min or below (33rd percentile), medium = 381–720 min (67th percentile), high = above 720 min. ^dNon-teaching personnel include outside clinicians, mindfulness trainers, and school counselors. Q_b = test for homogeneity of effect sizes between subgroups. * $p < .05$, ** $p < .01$, *** $p < .001$.

relationships assuming correlation $r = 0.7$: $g = 0.47$, 95% CI [0.33, 0.61], $z = 6.55$, $p < .001$; assuming correlation $r = 0.9$: $g = 0.43$, 95% CI [0.31, 0.55], $z = 6.96$, $p < .001$; Supplemental Fig. 3). In both sensitivity tests, the results were consistent with our main analyses. MBIs showed small, positive, and significant effects on overall peer relationships, negative peer interactions, and positive peer interactions.

Publication Bias

Supplemental Fig. 4 presents funnel plots of all the included studies. In within-group analyses ($k = 20$), most studies appeared to distribute symmetrically around the combined effect size and toward the top of the funnel plot; one relatively small study published a large effect (Anand & Sharma,

2014). The Egger's test result (intercept = 2.03, $p = .02$) indicated the presence of small-study effects, namely, the tendency for the smaller studies to show larger effects (the Egger's test is a weighted linear regression of intervention effect on its standard error; when the effects of smaller studies differ systematically from larger studies, the regression line will not run through the origin, and the more the intercept deviates from zero indicates the more pronounced the funnel plot asymmetry); the rank correlation test also indicated potential bias, Kendall's $\tau = 0.36$, $p = .01$ (Kendall's τ is the measure of association between studies' standardized treatment effects with their variances using a rank correlation method; a significant correlation coefficient indicates potential bias). However, the classic fail-safe N ($k = 799$) suggested that 799 studies were needed to make the intervention effect nonsignificant (i.e., it is unlikely that some nonsignificant missing studies would nullify the observed effect); the Orwin fail-safe N ($k = 18$) suggested that 18 studies with a mean effect size of zero were needed to make the pooled effect size trivial ($g < 0.2$). Under the random effects model, the trim and fill analysis did not identify potentially missing studies to the left or the right of the mean.

In between-group analyses ($k = 15$), one small study published a particularly large effect (Faraji et al., 2019). The Egger's test and rank correlation test both appeared to indicate no evidence of bias (Egger's test: intercept = 1.47, $p = .14$; rank correlation: Kendall's $\tau = 0.13$, $p = .24$). The classic fail-safe N ($k = 211$) suggested 211 studies would be needed to make the observed effect nonsignificant, and the Orwin fail-safe N ($k = 10$) suggested that 10 studies with a mean effect size of zero were needed to make the pooled effect size trivial ($g < 0.2$). Under the random effects model, the trim and fill analysis (Supplemental Fig. 5) did not identify potentially missing studies to the left and one missing study to the right of the mean (i.e., the actual effect might be larger than our observed effect).

In summary, publication bias might exist in our within-group effect analyses. However, this result should be interpreted with caution. The funnel plot asymmetry might also come from between-study heterogeneity, varied study quality, or other factors (Egger et al., 1997). The small number of included studies also limited the statistical power of the Egger's test, rank correlation test, and trim and fill analysis.

Discussion

Peer relationships play a critical role throughout childhood and adolescence (Rubin et al., 2006). This systematic review aimed to explore the effectiveness of MBIs on peer relationships among children and adolescents and to understand factors related to intervention implementation and fidelity. Based on the aggregated data from 21 studies, the

meta-analysis demonstrated that MBIs showed a significant within-group postintervention improvement in peer relationships ($g = 0.48$), including reducing negative peer interactions ($g = 0.50$) and promoting positive peer interactions ($g = 0.40$). Compared with control groups, MBIs showed significant between-group effect sizes on overall peer relationships ($g = 0.40$), negative peer interactions ($g = 0.44$), and positive peer interactions ($g = 0.30$).

Several potential mechanisms may explain the association between MBIs and a range of peer relationship outcomes. Mindfulness may nurture perspective taking and empathy for others, which has the potential to improve interpersonal functioning (Germer & Neff, 2013). One empirical study found that children exposed to MBIs reported greater empathy and perspective taking and increased peer acceptance, relative to the control group (Schonert-Reichl et al., 2015). Furthermore, the development of empathy and perspective taking may be especially helpful in reducing stereotyping and prejudice, thus improving social connections while reducing social exclusion. Studies with hundreds of Israeli–Jewish children revealed that compared with the control group, children in the mindfulness group showed significantly reduced prejudice toward Israeli–Palestinian youth and were more willing to engage socially with them (Berger et al., 2018). In addition, by bringing awareness to a particular object (e.g., breath, thoughts), mindfulness training could enhance the ability to regulate attention and emotion (Flook et al., 2015), which in turn leads to decreased aggressive and impulsive behaviors in children (Tao et al., 2021). A longitudinal study of 558 adolescents reported that impulsivity mediated the effect of mindfulness on peer victimization (Georgiou et al., 2020). Another study with over 300 students found that compared with the control group, children in the mindfulness group showed significant improvement in self-regulation and peer problems (Terjestam et al., 2016). Although these studies made important advances toward understanding the interpersonal benefits of MBIs, few empirical studies have assessed the potential mediating factors between MBIs and peer relationships among children and adolescents, and more attention should be paid to developing an understanding of the underlying mechanism.

As for the two indicators of peer relationships, we found that the included studies focused mostly on the effects of MBIs on reducing negative peer interactions ($k = 12$) rather than on promoting positive peer relationships ($k = 7$), and two studies examined both. However, positive and negative peer interactions may not present opposite ends of a continuum (Bagwell & Schmidt, 2013). For example, although children who are popular in their peer groups in general are more likely to have close friends, a study found that more than 30% of the popular children were found to have trouble maintaining reciprocal and intimate friendships, whereas nearly 40% of the rejected children did have mutual friends

(Gest et al., 2001). Interventions developed to reduce negative peer interactions may not be the most suitable for helping children develop and sustain positive peer relationships. Future studies may benefit from exploring how MBIs further strengthen positive peer interactions, such as peer attachment, peer acceptance, and friendship quality.

Based on seven studies that included follow-up assessments, we found that MBIs showed a larger within-group effect size at follow-up ($g = 0.77$) than at postintervention ($g = 0.48$). This result is consistent with a previous meta-analysis of MBIs in youth populations, which reported that MBIs showed greater effect at follow-up than post intervention across combined outcome domains (Klingbeil et al., 2017). One possible explanation is that continued practice and time may increase intervention effects to a level that children can notice and report in follow-up assessments (van de Weijer-Bergsma et al., 2014). However, two meta-analyses that evaluated MBIs among youth found small significant between-group effects on mental wellbeing (Carsley et al., 2018) and anxiety (Odgers et al., 2020) at postintervention, but the intervention effects became nonsignificant at follow-up.

Given the small number of included studies that reported follow-up results and their lack of control groups, we cannot draw the conclusion that MBIs would show greater effect over time on peer relationships. It is possible that extraneous variables, such as child development, may contribute to changes in their peer relationships (Burgdorf et al., 2019). Using more rigorous designs, future studies should continue to explore whether MBIs generate increased long-term effects on child peer relationships.

In this study, we also examined the moderating effects of intervention characteristics. Our findings suggest that MBIs showed a larger mean effect on peer relationships in studies of adolescents ($g = 0.67$) compared with studies of younger, school-age children ($g = 0.43$), and studies with mixed age groups showed the smallest effect ($g = 0.20$). It is possible that adolescents benefit more from mindfulness practice because they need more sophisticated social skills and may face exposure to more peer problems. Compared with school-age children, adolescents spend increased time with peers outside of schools and establish more intimate peer relationships, which places greater demands on social capabilities, such as empathy, self-disclosure, and problem solving (Rubin et al., 2006). Moreover, researchers reported that the incidence of bullying peaks among adolescents in secondary schools (Hymel & Swearer, 2015), and mindfulness may play an even more important role in dealing with problematic, stressful peer interactions during adolescence.

In addition, 40% of our included studies targeting school-age children did not report incorporating developmental adaptations of MBI programs, and some interventions may not be developmentally appropriate for this younger age

group. Age-appropriate MBIs targeting peer relationships should be developed to meet children's developmental needs, such as shortening the practices; using a more gradual, simplified manner; or involving props, movements, and metaphors. Considering characteristics of peer relationships may change as individuals develop (Bagwell & Schmidt, 2013), MBIs that target specific age groups may be more effective than mixed age groups are due to the sensitivity to specific developmental needs. For example, parental involvement may be particularly important to help children generalize learned skills to peer interactions in the neighborhood because younger children need more adult guidance in peer interactions (Bierman, 2004).

Previous research has demonstrated that the type of facilitator might impact the MBIs' effectiveness (Carsley et al., 2018). Our findings suggest that compared with MBIs that included only schoolteachers ($g = 0.18$) or only nonteaching personnel ($g = 0.43$), MBIs involving collaborative efforts from both parties may be more effective ($g = 0.52$). Across the included studies, five studies included the collaboration of schoolteachers and nonteaching personnel in different ways. Four involved both teachers and outside clinicians in delivering the intervention; in the remaining study, schoolteachers attended all program sessions but were not trained to administer the program and instead served as role models for the students by practicing the mindfulness exercises with them. Schoolteachers play a critical role in creating opportunities for students to interact with peers in classrooms (Neri Tejada et al., 2022). Equipping teachers with mindfulness practices may provide them with techniques for creating a positive and warm classroom climate, which allows students' social interactions to flourish (Meyer & Eklund, 2020). In addition, given that teachers remain in the classroom outside of the program, they can continue incorporating elements of mindfulness into the classroom to support their students (Rawana et al., 2018). On the other hand, although all schoolteachers in the included studies received short training sessions on the program curriculum (2 h to 7 day), outside facilitators who have more experience and knowledge of mindfulness may better help students understand the curriculum (Carsley et al., 2018). Our findings suggest that MBIs seem to be particularly beneficial when involving collaborative efforts from both schoolteachers and nonteaching personnel.

Other moderator variables were not significantly associated with the effects of MBIs on peer relationships, but some of the subgroup differences were worth noting. In terms of study participants, MBI effects did not differ between predominantly clinical or at-risk samples and non-clinical samples. This finding appears to contradict previous meta-analyses of MBIs with youth, which found larger effect sizes in clinical samples than nonclinical samples (Tao et al., 2021; Zoogman et al., 2015). Previous literature

claimed that MBIs might have particular utility for clinical populations considering their severe baseline symptoms and therefore more room for improvement (Tao et al., 2021; Zoogman et al., 2015). However, some of the clinical samples in our reviewed studies may not exhibit more severe peer relationship difficulties than nonclinical samples, such as children with inflammatory bowel disease (Ahola Kohut et al., 2020). Whether MBIs have stronger effects among children with severer peer relationship difficulties warrants further investigation.

The effects of MBIs also did not vary significantly by intervention dosage (see Table 3 and Supplemental Fig. 6). This finding is in line with a previous children-focused meta-analysis that found MBIs' effects on anxiety were not associated with the total time of formal mindfulness training (Odgers et al., 2020). However, Zenner et al. (2014) found that the total minutes of MBIs, which include training sessions and home practice, significantly moderated intervention effectiveness among children and adolescents. One possible explanation for the inconsistent finding is the varied measurement of intervention dosage (Strohmaier, 2020). In the current review, we only examined whether the total minutes of intervention delivered was related to peer relationship outcomes. Several other important aspects of dosage, such as the amount of home practice, were not analyzed as moderators because few included studies provided such information. Given that the substantial time commitment of long-term mindfulness practice could be challenging for children, more research is needed to examine the association between different components of intervention dosage and peer relationships.

Last, in terms of study design, noncontrolled and controlled studies did not show significant difference in MBI effects. Notably, intervention studies without control conditions are subject to increased biases and confounders (Arditi et al., 2016). Our risk of bias assessment showed that non-controlled studies had higher risks, particularly in the confounding variables and blinding domains. Given that controlled studies may be more difficult to implement in child populations in real-world conditions (Arditi et al., 2016), it is important to consider research design rigor as well as implementation feasibility when applying MBIs in school and community settings. Also, future MBI studies should further clarify the relation among study design, risk of bias, and intervention effect size, while developing methods to minimize confounding problems in noncontrolled studies (Arditi et al., 2016).

As moderator tests in meta-analyses are particularly likely to be underpowered (Valentine et al., 2010) and given our small number of included studies, we do not have enough evidence to conclude whether certain participant and study characteristics influenced intervention effects. Future research should continue investigating factors that

may influence MBI effectiveness on peer relationships when more data are available. Understanding how MBIs work differently across subpopulations and intervention modalities will inform the development of specifically targeted mindfulness programs in the future.

The study also narratively synthesized intervention fidelity. Fidelity data were limitedly reported across the studies, with only two studies out of 21 reporting findings on all five components, and there was high variation in the way each component was assessed and reported. Although most of the studies included detailed information on the design (e.g., intervention approach) and the facilitators' qualifications, the other three critical parameters—program delivery, receipt, and enactment—contributing to the validity of mindfulness programs were rarely described.

Fidelity measures can help examine the extent to which the delivery of interventions adhere to the original protocol (Rawana et al., 2018), but data regarding the assessment of fidelity were rarely reported and relied mostly on self-reports in our reviewed studies. Furthermore, limited data regarding participants' attendance rates and engagement were reported. Although eight articles mentioned that they collected participant attendance in intervention sessions, only two of them reported the average proportion of the participant's session attendance. Whereas five studies reported that they checked participants' engagement and program impact using qualitative interviews or reflection sheets, only one study involved formal measures. Another limitation is that only two studies assessed and reported the participants' adherence to mindfulness practices outside of the intervention. One study mentioned tracking participants' home practice but did not report the results.

Our findings are similar to the results from several broader reviews of MBIs, showing that intervention fidelity was not consistently and comprehensively reported across intervention studies (Emerson et al., 2020; Feagans Gould et al., 2016; Kechter et al., 2019). This paucity of intervention fidelity reports may limit our confidence in specifying the underlying mechanisms of change of MBIs (Kechter et al., 2019). Previous research has also revealed that higher levels of intervention fidelity are generally related to greater improvements in participant outcomes (Durlak & DuPre, 2008). Future studies should report and monitor intervention fidelity in a standardized format to improve the transparency and generalizability of the MBI evidence.

Limitations and Future Research

The findings of this meta-analysis should be interpreted with caution, given the small number of available studies ($k = 21$) included and the possible publication bias detected. The small number of studies further highlights the need for future studies to explore the impact of MBIs

on child and adolescent peer relationships. The small sample size may also limit the statistical power of the subgroup analyses, which did not yield statistically significant results except for participant age and facilitator background. The inclusion of more detailed demographic information and intervention characteristics would be helpful in future pursuits of understanding the within-group variability in treatment effects.

In addition, a variety of measurement approaches were used in the included studies. The most commonly used measures were self-reports on general peer relationships, such as the Strengths and Difficulties Questionnaire Peer Problem subscale and the Conners-3 Peer Relationship subscale. Over the past 25 years, the study of peer relationships has moved from a global and homogeneous state to a state of refinement, differentiation, and complexity. The use of broader variables (e.g., peer relationships) was replaced by the use of more explicit and precise variables (e.g., peer acceptance) that previously had been bundled together within the broad construct (Bukowski & Adams, 2005). Future studies may adopt more nuanced assessments that directly measure the different dimensions of peer relationships to explore whether the effects of MBIs vary across specific aspects of peer relationships.

Note that our meta-analysis included studies using nonrandomized designs, which are subject to biases introduced by sampling and confounders (Higgins et al., 2019). Therefore, the results need to be interpreted with caution. Moreover, only two of the 15 controlled studies compared MBIs with active control groups, which are useful to control for expectancy effects. Most studies used treatment-as-usual or wait-list control groups, in which participants might be aware that they were not in an active intervention and were not expected to show improvements after the intervention (Dunning et al., 2019). It is also worth noting that few studies reported whether the assessors were blinded.

Similarly, previous literature highlighted these methodological limitations of existing MBIs. For instance, Felver et al. (2016) found that only a small portion of MBIs for youth in school settings used experimental design, and few used an active control condition; Burgdorf et al.'s (2019) review of MBIs for parents suggested several limitations, such as a small number of studies available for inclusion and the lack of randomization. Consistent with these discussions, our findings call for future studies to adopt more rigorous experimental designs with active control groups and evaluate outcomes with rigorous blinding processes over longer periods of time.

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Author Contribution XD conceptualized and designed the study, screened studies, extracted data, assessed quality of studies, wrote the initial draft of the manuscript, and contributed to manuscript revision; ND screened studies, extracted data, and assessed quality of studies; SS screened studies, extracted data, and assessed quality of studies; SL conceptualized and designed the study, analyzed data, wrote the initial draft of the manuscript, and contributed to manuscript revision. All authors approve the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Declarations

Ethical Statement The manuscript does not contain clinical studies or patient data.

Conflict of Interest The authors declare no competing interests.

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