A meta-analysis and systematic review of the effect of loving-kindness and compassion meditations on negative interpersonal attitudes

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Abstract

Negative interpersonal attitudes can affect people's well-being, interpersonal relationships, and cooperation. Overcoming negative interpersonal attitudes is a key subject in loving-kindness and compassion meditations (LCMs). However, the results and study design of previous research on negative interpersonal attitudes have been inconsistent. Therefore, it is necessary to summarize the effects of LCMs and explore moderators through meta-analysis. A literature search was conducted in the Cochrane Central Register of Controlled Trials, ISI Core Collection, Medline, ProQuest Dissertations & Theses, and PsycINFO databases up to April 2, 2021. Of the 281 identified empirical studies on LCMs, 25 measured negative interpersonal attitudes, and 21 were included in the meta-analysis. The results showed that the effects of LCMs on negative interpersonal attitudes in daily life were significant both for randomized controlled trials ($g = -.203$) and uncontrolled trials ($g = -.539$). The instant effects after meditation were also significant in randomized controlled experiments ($g = -.187$). Leave-one-out sensitivity analysis and nonsignificant subgroup analysis showed that the results were robust except for randomized controlled experiments. Although no significant moderators were identified, moderator analysis suggested that reducing bias and sending wishes to difficult targets were especially effective, and LCM subtypes might impact the results. Individual studies found that the contribution of meditation practice during interventions was weak. In sum, LCMs have the potential to reduce negative interpersonal attitudes, especially in multiweek interventions. Future studies should further explore the underlying mechanisms and consider the implications of study design features, such as the induction of negative interpersonal attitudes and the targets of LCMs.

Keywords Loving-kindness · Compassion · Appreciative joy · Meditation · Negative interpersonal attitudes

Attitudes are internal psychological feelings and evaluations of an individual in response to a particular object (Albarracin et al., 2008; Devos, 2008) and are considered to include emotions, cognition, and behavioral intentions (Baron et al., 1988). Interpersonal attitudes indicate feelings toward other people. Among interpersonal attitudes, explicitly unfriendly emotions (e.g., anger, hostility), negative cognition (e.g., implicit or explicit bias toward stigmatized groups) and behavioral intentions that are detrimental to the interests of others (e.g., intentions to engage in aggressive behaviors, punishment or revenge behaviors) can be considered negative interpersonal attitudes. In previous research, negative interpersonal attitudes have often been considered to include anger, hostility, revenge, and bias, among others (Kang & Falk, 2020; Parrott & Zeichner, 2003). Negative interpersonal attitudes can influence people's well-being, self-esteem, and scholastic attainment, and they can positively predict aggressive behavior (Liu et al., 2021) and even affect physical diseases (Russell et al., 2016). Thus, many studies have explored how to reduce negative interpersonal attitudes and the effects of interventions.

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In Buddhism, loving-kindness and compassion meditations (LCMs) are important meditation practices to counter negative interpersonal attitudes (Bodhi, 2012). During LCMs, practitioners generate prosocial attitudes toward imagined targets, usually by silently repeating blessing phrases such as "may you be happy" or "may you be free from suffering". In some traditions, meditators imagine that blessings flow from themselves to one or several visual targets, such as light or rivers, without any words (Zeng et al., 2015). The targets varied from easier ones, such as friends, to more difficult ones, such as disliked people. LCMs have four subtypes, which cultivate four "immeasurables" (sublime attitudes): loving-kindness, compassion, appreciative joy, and equanimity. Of them, loving-kindness meditation is to wish the self and the other health and happiness, compassion meditation is to wish to alleviate suffering, appreciative joy meditation is to have an appreciation for the self and the other's success and virtue and to wish for continued happiness, and equanimity meditation is to understand and accept a target and ones' karma, which aims to cultivate a nonattachment state and achieve a feeling of equanimity and peacefulness (Zeng et al., 2017a). In Buddhism, each of these four attitudes has a "direct enemy", namely, anger, cruelty, envy, and attachment. Buddhism classically considers the elimination of these "direct enemies" as the successful cultivation of the four immeasurables (Bodhi, 2012). Although the four subtypes of LCMs cultivate different attitudes in different wishes, one of the major purposes of LCMs is to counter negative interpersonal attitudes (Zeng et al., 2019).

To date, many studies on the effects of LCMs have concentrated on positive aspects. Zeng et al. (2015) found through a meta-analysis that LCMs could enhance positive affect; and Luberto et al. (2018) reported in a review that LCMs could increase positive prosocial emotions and behaviors. In terms of negative aspects, researchers have also summarized the effects of LCMs on treating clinical conditions (Graser & Stangier, 2018). In contrast, a summary of the effects of LCMs in reducing negative interpersonal attitudes is lacking, although previous studies have shown inconsistent results and have varied significantly in terms of study design, intervention and measures. For example, some studies reported that a 9-week intervention successfully reduced anger in daily life (Chapin et al., 2014), while others did not observe an instant effect on anger in response to conflict vignettes after 15 min of meditation (Kirby & Laczko, 2017). Furthermore, the mechanisms underlying the effects also need clarification. The direct operations of LCMs generate positive attitudes. Although Buddhists believe such practices could counter negative attitudes, how exactly the negative attitudes are reduced is not specified in the classics and instead requires empirical studies to provide answers. Notably, some details of the study designs are also related to how LCMs reduce negative attitudes. For example, some studies deployed LCMs before vignettes that induce potential negative attitudes (e.g., Condon, 2014; Kirby & Baldwin, 2017), which could be considered an evaluation of whether LCMs could inhibit the provocation of negative attitudes in the next step of experiments. In contrast, many studies did not involve the induction of negative interpersonal attitudes (e.g., Logie & Frewen, 2015; Zeng et al., 2017a), and the observed effects might reflect different things, such as the downward regulation of existing negative interpersonal attitudes or an overall decrease in negative attitudes in daily life. Similarly, some studies used LCMs that included disliked or difficult people as targets or even directly targeted those objects that caused negative attitudes in experiments (e.g., Kirby & Baldwin, 2017; Kirby & Laczko, 2017), while others were limited to oneself or friends, who elicited more positive attitudes in practitioners (e.g., Kang & Falk, 2020; Zeng et al., 2017a). This difference raised questions regarding whether directly targeting objects of negative attitudes is more effective in attitude change and whether effects could be generalized across targets (e.g., from friends to disliked people). However, these differences in study design have not been distinguished and summarized.

To date, no systematic review has focused on negative interpersonal attitudes. Although early integrative reviews noted studies on negative interpersonal attitudes (e.g., Hofmann et al., 2011), they were not systematically concluded in these studies; they only collected some scattered variables. Because previous reviews did not focus on negative interpersonal attitudes, the mechanisms underlying the effects were not illustrated. More importantly, these studies merely provided narrative summaries and lacked objective evaluations of effects or identification of potential moderators that may impact the inconsistent findings.

In sum, reducing negative interpersonal attitudes is considered a very important function of LCMs, but the literature lacks a summary that clarifies the mixed results and potential mechanisms. Although low levels of some unidimensional positive interpersonal attitudes could represent negative interpersonal attitudes to some extent, the concrete classification easily confounded positive interpersonal attitudes and negative interpersonal attitudes. Thus, the current study intended to provide a comprehensive review of explicitly negative interpersonal attitudes, which included anger, hostility, envy, revenge, bias, and the results of scales explicitly referring to negative attitudes toward others. A meta-analysis was conducted to objectively evaluate the overall effects on negative interpersonal attitudes, and subgroup analyses were conducted to investigate the variance in the effects of interventions with different designs and subtypes of LCMs. The information unable to be addressed by meta-analysis was reviewed literally, which included 1) mediator and moderator effects that were investigated in previous studies; 2) the contribution of meditation practice; and 3) the long-term effect of LCMs on negative interpersonal attitudes.

Methods

Search strategy

Although the meta-analysis was not registered, there was no review to explore the effects of LCMs on negative interpersonal attitudes. The current study collected LCM studies published before April 2, 2021, by searching the Cochrane Central Register of Controlled Trials, Institute for Scientific Information (ISI) Web of Science Core Collection, Medline, ProQuest Dissertations & Theses, and PsycINFO databases and then extracted studies that measured negative interpersonal attitudes. The search was limited to articles published in English, and the search terms were consistent with a previous systematic review (Lv et al., 2020): "immeasurable OR kindness OR compassion OR ((Appreciative OR Sympathetic) AND Joy) OR equanimity OR metta OR mudita OR karuna OR upekkha" combined with "Meditat*", which were adjusted in different databases. The reference lists of studies included in the current search (both empirical studies and reviews) were verified in case of any omission.

Inclusion criteria and study selection

The studies included in the current meta-analysis needed to satisfy the following inclusion criteria: a) articles published in academic journals or dissertations in English; b) quantitative research on negative interpersonal attitudes, including anger (trait anger, state anger, anger expression out), hostility, envy, revenge, negative attitudes in the Self Others Four Immeasurables Scale, bias toward others (i.e., African Americans, homeless people, strangers, stigmatized individuals); and c) LCM practices should account for 50% of major practices. The exclusion criteria were a) meditation practices that were only based on the imagery in which the participant receives love and compassion from others; b) studies that only measured negative variables (e.g., stress, depression) but not negative interpersonal attitudes or the variables of negative interpersonal attitudes could not be extracted independently (e.g., negative emotions including sadness, self-blame, anxiety); and c) cross-sectional research (cross-sectional studies that were reviewed in the supplemental material; Carvalho, 2019; McCall et al., 2014). The participants, length of interventions, and randomization (RCT or NRCT) were not restricted in the current research.

After excluding duplicates and adding articles from other resources, two authors independently screened out articles without LCMs by titles/abstracts. Two authors independently examined whether they satisfied the inclusion criteria by reviewing full articles. Any uncertainties were resolved by the two authors who screened out the study and a third author.

Data extraction and coding

From eligible studies, the following data were extracted: sample size for the experimental group and the control group, mean age, *F value* between groups from preintervention to postintervention, *t value* for the experimental group and the control group from preintervention to postintervention, mean and standardized deviation of the experimental group at each time point, mean and standardized deviation of the control group at each time point, and the correlation between preintervention and postintervention. If no correlation was reported, the missing correlation value was imputed as 0.5 (Follmann et al., 1992).

The following variables were coded: published year, type of participants (clinical, nonclinical), design (multiweek interventions, one-shot practice), randomization (RCT, NRCT), control conditions (waitlist, active control), protocol, intervention components (different subtypes of LCMs), induction of negative interpersonal attitudes, meditation targets, consistency between measurement objects and meditation targets, length of intervention, and required meditation practice. Other information, such as the mediator, moderator, long-term effects and duration, and relation between meditation practices and change of outcomes, was also extracted for narrative review.

All the data and coding were extracted by two authors independently. If there was any inconsistency between authors, the first author confirmed the objective information according to articles and consulted with coders to confirm the data for a consistent result. If there were any uncertainties, we sent an email to the corresponding author to verify the missing data and other details. Studies without sufficient data or replies from the corresponding author were excluded from this meta-analysis.

Analysis strategy

The analysis was conducted by Comprehensive Meta-Analysis 3.3.70 (CMA; Borenstein et al., 2014). The effect size of each study and overall effect sizes were all presented as Hedge's *g* and 95% confidence intervals (95% CI) using a random-effects model: $g = 0.2$ means a small effect, $g = 0.5$ means a medium effect, and $g = 0.8$ means a large effect, and the significance level was $p < 0.05$ (Cohen, 1988). Hedge's *g* was calculated by means, standardized deviations, and sample sizes for each group preintervention and postintervention and the correlation between preintervention and postintervention. If there was no preintervention, Hedge's *g* was calculated by postintervention. In NRCTs, Hedge's *g* was calculated by 1) means and sample sizes preintervention and postintervention and paired group *t* values or 2) means, standardized deviations, sample sizes of each measurement

and correlation between preintervention and postintervention. All other forms of data did not show the effects of intervention from preintervention to postintervention or the difference between groups; thus, they were not included in the meta-analysis. When the study reported more than one target variable, the multiple results were pooled by the formula $\overline{Y} = \frac{1}{m}\left(\sum_{i=1}^{m} Y_i\right)$ and $V\left(\overline{Y}\right) = \left(\frac{1}{m}\right)^2 \left(\sum_{i=1}^{m} V_i + \sum_{j \neq k} \left(r_{jk}\sqrt{V_j}\sqrt{V_k}\right)\right)$, where Y indicated the overall effect size of the study, Y_i indicated the effect size of each variable, m was the number of variables, $V_{i/j/k}$ was the variance of each variable, and r_{jk} was the correlation between variables. When the study had multiple controlled groups or LCM groups, they were included with pooled data by the formula $\overline{X}_1 = \frac{n_{11}\overline{X}_{11} + n_{12}\overline{X}_{12}}{n_{11}+n_{12}}$ and $S_1 = \sqrt{\frac{(n_{11}-1)S_{11}^2 + (n_{12}-1)S_{12}^2 + \frac{n_{11}n_{12}}{n_{11}+n_{12}}\left(\overline{X}_{11}-\overline{X}_{12}\right)^2}{n_{11}+n_{12}+1}}$, where n, X, and S were the sample size, mean, and standardized deviation of each group, respectively; Borenstein et al., 2009; p. 22, 230).

Heterogeneity was measured by the Q test (Hedges & Olkin, 1985) and I^2 statistic (Higgins et al., 2003). For the Q test, heterogeneity was significant when $p < 0.1$ (Nasser, 2020); for the I^2 statistic, heterogeneity was significant when $I^2 > 50\%$ (Higgins et al., 2003). If heterogeneity was significant, leave-one-out sensitivity analysis and moderator analysis were conducted to explain the heterogeneity. Moderator analysis included 1) control conditions (waitlist, active control); 2) types of participants (clinical, nonclinical); 3) intervention components (loving-kindness meditation, compassion meditation, appreciative joy meditation, mixed meditation); 4) induction of negative interpersonal attitudes after intervention (with induction, without induction); 5) meditation targets (with or without good wishes directed at difficult targets); 6) consistency between measurement objects and wishing targets (consistent, inconsistent); and 7) outcomes (bias, other-focused negative emotions, revenge, negative attitudes toward others). The regression analysis was analyzed by the length of the multiweek interventions and experimental studies. Publication bias was analyzed by Egger's test, which could examine the asymmetry of the funnel plot. When it was significant, trim and fill analyses were used to adjust the effect size for publication bias.

A narrative review was conducted for limited aspects that could not be taken into account in the meta-analysis, including information on mediators, correlations among changes in variables in interventions, effects of frequencies of meditation practice, and long-term effects of meditation. Overall, the narrative review was based on all studies, including studies lacking sufficient data for meta-analysis.

Quality evaluation of studies

The *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins et al., 2011) has assessed current RCT studies. The assessment included six risks of bias and other biases: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective outcome reporting (reporting bias), and other sources of bias evaluated by the difference of experiments group and control group preintervention, which was graded by high risk, low risk, and unclear risk. Studies with NRCT and a single group were evaluated by the Risk Of Bias In Non-Randomized Studies of Interventions (ROBINS-I; Sterne et al., 2016), which included seven risks: bias due to confounding, bias in the selection of participants into the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in the measurement of outcomes, and bias in the selection of the reported results. The risks were graded by critical, serious, moderate, low risk and no information. The quality of the studies was evaluated by two estimators independently. Any inconsistency was resolved in consultation with both estimators, and they ultimately achieved consensus.

Results

Search results and features of the studies

The initial search retrieved 2,413 relevant articles, and after removing 667 duplicates, 1,746 records remained. Based on the titles and abstracts, 1,288 records were excluded for irrelevance to LCMs. Before screening full-text records, 35 articles from other resources (e.g., references) were included in the article list, and the list of candidates was 493 articles. After screening articles by full-text records, 212 articles were excluded because they were not LCM studies. According to the inclusion criteria, 254 articles did not measure independent negative interpersonal attitude variables, and 2 articles were cross-sectional. Twenty-five studies from 24 records were included for review. Four studies had insufficient data and were unable to be contacted (Belgard, 2018; Korsmo, 2019; Price-Blackshear, 2017; Reddy et al., 2013). A total of 21 studies were included in the meta-analysis, which included 2 theses, 2 dissertations, and 17 studies in journal articles. The process is shown in Fig. 1.

Among the 21 studies, 9 were randomized controlled multiweek interventions, 7 were randomized controlled experiments and 5 were NRCTs or single groups, which were computed as pre-post designs. Overall, in RCT studies, 35.1% were high risk, 43.0% were low risk, and 21.9% were unclear. In the NRCT or single design studies, 17.1% were critical risk, 31.4% were serious risk, 17.1% were moderate risk, 22.9% were low risk, and 11.5% were unclear. Details
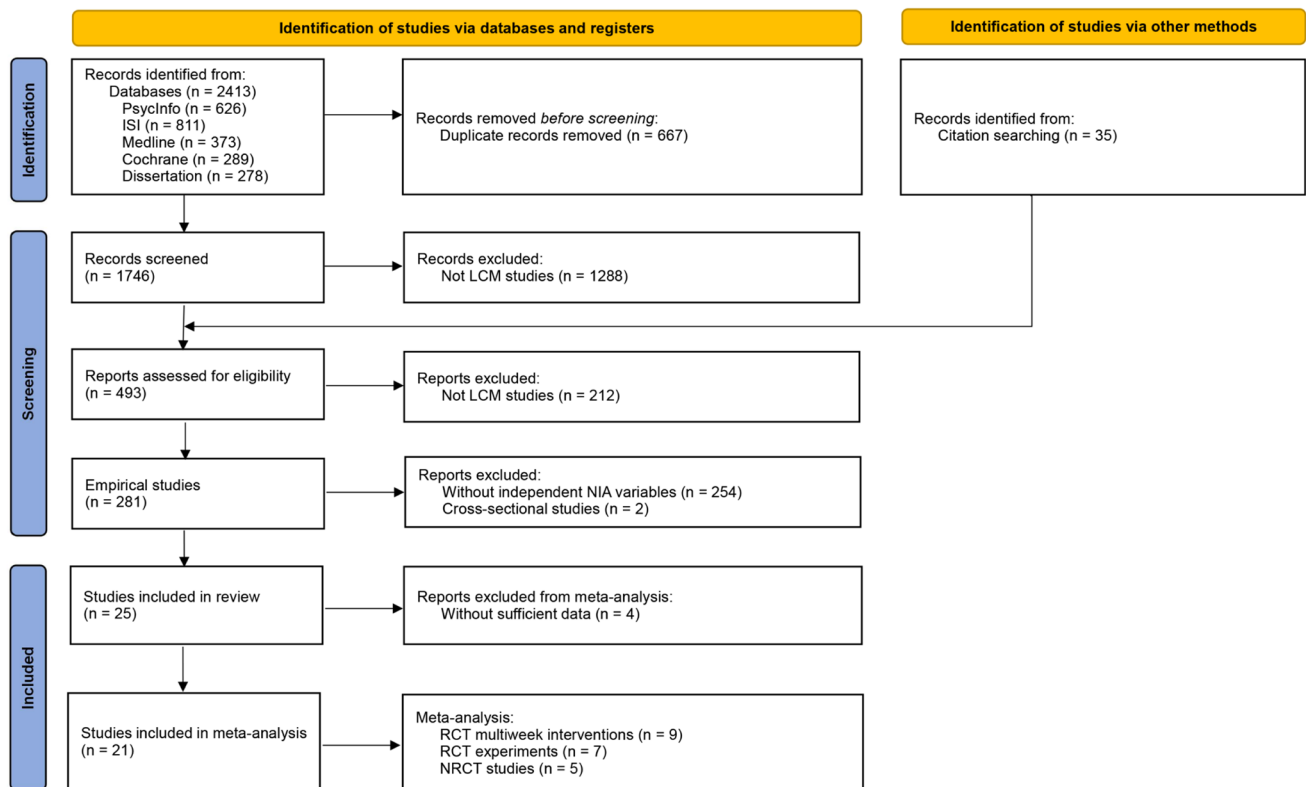
Fig. 1 Flowchart of study selection

of the assessment of each study are shown in Table S1 and Table S2, and figures of unweighted risk of bias are presented in Figure S1 and Figure S2 in the supplemental material.

Meta-analysis for randomized controlled multiweek interventions

Handing and overall effect size

There were 557 participants in all 9 randomized controlled multiweek interventions. Five studies had more than one measure for negative interpersonal attitudes, which was pooled for a final result. Five studies were RCTs with a waitlist group, three studies were compared with an active control group, 1 study was a 3-arm design, and the data of two control groups were pooled. As a result, the number of effect sizes was nine. The details taken in the meta-analysis are shown in Table 1, and additional information is presented in Table S3 in the supplemental material.

The overall effects showed that multiweek LCM interventions caused a small but significant decrease in negative interpersonal attitudes compared with the control group ($g = -0.203$, $SE = 0.074$, 95% CI $= [-0.349, -0.058]$, $p = 0.006$), and the forest plot is presented in Fig. 2. The

heterogeneity analysis results were insignificant, which included $Q(8) = 2.920$, $p = 0.939$, $I^2 = 0.000\%$. All results were robust in leave-one-out sensitivity analysis (Figure S3). Egger's test indicated that there was no publication bias in the current analysis ($t(7) = 0.871$, $p = 0.413$, 95% CI $= [-1.345, 2.913]$). A funnel plot is shown in Figure S4 in the supplemental material.

Moderator analysis

The subgroup analysis for the subtype of LCMs was conducted only for the comparison between loving-kindness meditation and compassion meditation because appreciative joy meditation had only one study. The studies with different control groups did not show a significant difference in the effects ($Q(1) = 0.359$, $p = 0.549$), but the effects of studies compared with the waitlist control group were significant ($g = -0.256$, $SE = 0.102$, 95% CI $= [-0.455, -0.057]$, $p = 0.012$, $k = 5$), while those compared with the active control group were not ($g = -0.156$, $SE = 0.133$, 95% CI $= [-0.415, 0.104]$, $p = 0.240$, $k = 3$). The only study with a mixed control group was not included in the analysis. The difference between the two subtypes of LCMs was insignificant ($Q(1) = 0.129$, $p = 0.720$), but the effects of loving-kindness meditation were marginally significant ($g = -0.212$,

Table 1 Details of randomized control multiweek interventions in meta-analysis

Study	Participants	Protocol	Control Conditions	Intervention components	Induction	Wish difficult targets	Variables	Measures targets consistent with wish targets	Length (weeks)
Carson et al., 2005	Adults with chronic low back pain	-	Active Control	LKM	No	Yes	Anger; hostility	No	8
Zeng et al., 2019	Adults	HOJ	Waitlist	AJM	No	Yes	Negative attitudes toward others; envy	No	4
Lang et al., 2019	Veterans with PTSD	CBCT	Active Control	CM	No	Yes	Anger	No	10
Poehlmann-Tynan et al., 2020	Parents of children aged 9 months to 5 years 4 months	CBCT	Waitlist	CM	No	Yes	Anger	No	8
Condon, 2014	Adults	-	Mindfulness Meditation + Active Control	CM	Yes	Yes	Anger	No	8
Frazier-Meyers, 2017	Elementary students	CALM	Waitlist	CM	No	Yes	Anger	No	4
Herriman, 2019	Elementary Students	CALM	Waitlist	CM	No	Yes	Anger	No	8
Kang et al., 2014	University students	-	Waitlist	LKM	No	Yes	Explicit/ implicit attitudes toward homeless/ African American	No	6
Kang & Falk, 2020	General public	-	Active Control	LKM	No	No	Implicit attitudes toward stigmatized individuals	No	4

LKM indicates Loving-kindness meditation; AJM indicates Appreciative joy meditation; CM indicates Compassion meditation

$SE = 0.115$, 95% CI = [-0.436, 0.013], $p = 0.065$, $k = 3$), while the effects of compassion meditation were insignificant ($g = -0.154$, $SE = 0.114$, 95% CI = [-0.377, 0.069], $p = 0.177$, $k = 5$). There were no significant differences between the effects of different protocols ($Q(1) = 0.083$, $p = 0.773$; Compassion Approach to Learning Meditation: $g = -0.207$, $SE = 0.184$, 95% CI = [-0.567, 0.152], $p = 0.258$, $k = 2$; Cognitively Based Compassion Training: $g = -0.124$, $SE = 0.222$, 95% CI = [-0.559, 0.310], $p = 0.575$, $k = 2$). The studies without clear protocols were not included in the subgroup analysis. For different outcomes, effects on other-focused negative emotions and bias did not have significant differences ($Q(1) = 1.220$, $p = 0.269$; other-focused negative emotions: $g = -0.111$, $SE = 0.103$, 95% CI = [-0.314, 0.091], $p = 0.282$, $k = 6$; bias: $g = -0.294$, $SE = 0.169$, 95% CI = [-0.548, -0.041], $p = 0.023$, $k = 2$), and one study with

mixed outcomes was not analyzed in this subgroup analysis. Specifically, when multiple variables in each study were calculated separately, although effects on state other-focused negative emotions, trait other-focused negative emotions, explicit bias, and implicit bias did not have significant differences ($Q(3) = 2.474$, $p = 0.480$), implicit bias was significantly impacted by LCMs ($g = -0.370$, $SE = 0.139$, 95% CI = [-0.642, -0.098], $p = 0.008$, $k = 2$), while other variables were not (state other-focused negative emotions: $g = -0.112$, $SE = 0.105$, 95% CI = [-0.318, 0.094], $p = 0.288$, $k = 6$; trait other-focused negative emotions: $g = -0.142$, $SE = 0.160$, 95% CI = [-0.456, 0.172], $p = 0.376$, $k = 3$; explicit bias: $g = -0.258$, $SE = 0.152$, 95% CI = [-0.555, 0.038], $p = 0.089$, $k = 2$). The number of studies with clinical participants ($k = 1$), studies with induction of negative interpersonal attitudes ($k = 1$), studies of consistent targets of measured

Randomized controlled multiweek interventions

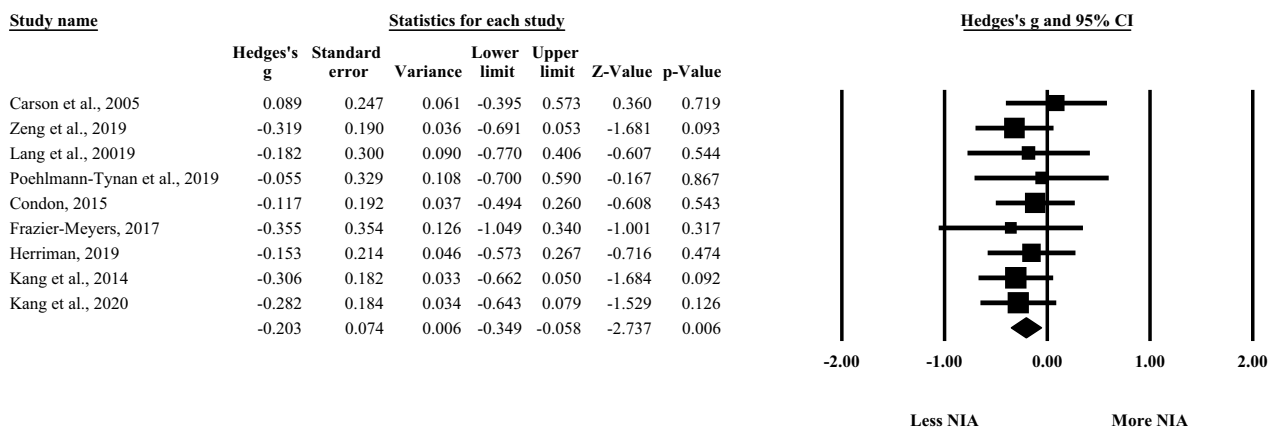| Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Carson et al., 2005	0.089	0.247	0.061	-0.395	0.573	0.360	0.719
Zeng et al., 2019	-0.319	0.190	0.036	-0.691	0.053	-1.681	0.093
Lang et al., 20019	-0.182	0.300	0.090	-0.770	0.406	-0.607	0.544
Poehlmann-Tynan et al., 2019	-0.055	0.329	0.108	-0.700	0.590	-0.167	0.867
Condon, 2015	-0.117	0.192	0.037	-0.494	0.260	-0.608	0.543
Frazier-Meyers, 2017	-0.355	0.354	0.126	-1.049	0.340	-1.001	0.317
Herriman, 2019	-0.153	0.214	0.046	-0.573	0.267	-0.716	0.474
Kang et al., 2014	-0.306	0.182	0.033	-0.662	0.050	-1.684	0.092
Kang et al., 2020	-0.282	0.184	0.034	-0.643	0.079	-1.529	0.126
	-0.203	0.074	0.006	-0.349	-0.058	-2.737	0.006

Fig. 2 Forest plot for meta-analysis for randomized control trail (RCT) studies on negative interpersonal attitudes in multiweek interventions

attitudes with wish targets ($k = 0$), and the number that meditation did not include sending good wishes to difficult targets ($k = 1$) were all insufficient for subgroup analysis. After eliminating a single study in each moderator analysis, the results did not change in significance (nonclinical participants: $g = -0.205$, $SE = 0.077$, 95% CI = [-0.355, -0.054], $p = 0.008$, $k = 8$; without induction: $g = -0.219$, $SE = 0.081$, 95% CI = [-0.377, -0.061], $p = 0.007$, $k = 8$). Considering that intervention length probably affected the effects on negative interpersonal attitudes, regression analysis was performed for randomized controlled multiweek interventions. The results showed that it was nonsignificant for the prediction of intervention effects ($B = 0.049$, $SE = 0.039$, 95% CI = [-0.028, 0.126], $p = 0.215$).

Meta-analysis for randomized controlled experiments

Handing and overall effect size

There were 616 participants in all 7 randomized controlled experiments. Two studies had more than one measure for negative interpersonal attitudes and were pooled for a final result. Three studies had 3-arm designs: one had two different control groups, one compared different wish targets, and the other compared two types of LCMs with a waitlist group. Data from these groups were pooled as a whole for each study before the total meta-analysis and subgroup analysis. Thus, there were 7 effect sizes in the meta-analysis of randomized controlled experiments. The details taken in the meta-analysis are shown in Table 2, and additional information is presented in Table S4 in the supplemental material.

As shown in Fig. 3, the overall effects of LCMs were significant on negative interpersonal attitudes compared with the control group at a small-level effect size ($g = -0.187$, $SE = 0.009$, 95% CI = [-0.372, -0.002], $p = 0.048$). The heterogeneity analysis result was insignificant, which included $Q(6) = 8.766$, $p = 0.187$, $I^2 = 31.556\%$. However, leave-one-out sensitivity analysis showed that the results were not robust (Figure S5). For publication bias, Egger's test indicated no significant absence of studies ($t(5) = 1.725$, $p = 0.145$), and a funnel plot is shown in the supplemental material (Figure S6).

Moderator analysis

The current study performed subgroup analysis in randomized controlled experiments to explore whether there were differences between different subgroups in effect sizes. No significant differences were found in the subgroup analysis between different outcomes (bias and other-focused negative emotions, including anger, envy and others; $Q(1) = 1.482$, $p = 0.224$). However, it is notable that the effects of bias were significant ($g = -0.369$, $SE = 0.147$, 95% CI = [-0.657, -0.081], $p = 0.012$, $k = 2$), while those of other-focused negative emotions were not ($g = -0.118$, $SE = 0.145$, 95% CI = [-0.402, 0.166], $p = 0.415$, $k = 4$). Similar to that in multiweek interventions, moderator analysis was also made among state other-focused negative emotions and explicit bias, and the difference and all subgroup results were insignificant ($Q(1) = 0.477$, $p = 0.490$; state other-focused negative emotions: $g = -0.137$, $SE = 0.141$, 95% CI = [-0.415, 0.140], $p = 0.331$, $k = 4$; and explicit bias: $g = -0.297$, $SE = 0.182$, 95% CI = [-0.653, 0.060], $p = 0.103$, $k = 4$). State negative interpersonal response and implicit bias

Table 2 Details of randomized control experiments in meta-analysis

Study	Participants	Control Conditions	Intervention components	Induction	Wish difficult targets	Variables	Measures targets consistent with wish targets	Length
Zeng et al., 2017b	University students	Active Control	AJM	No	No	Other-focused negative emotion	No	6
Logie & Frewen, 2015	University students majoring in psychology	Mindfulness Meditation + Active Control	LKM	No	No	Negative attitudes toward others	No	15
Zeng et al., 2017a	Female adults in university	Active Control	Mixed: AJM + CM	No	No	Envy	No	6
Kirby & Baldwin, 2017	Parents of children aged 2 to 12 years old	Active Control	LKM	Yes	Yes	Anger	No	15
Kirby & Laczko, 2017	University students living with parents	Active Control	LKM	Yes	Yes	Anger	No	15
Parks et al., 2014	University students	Waitlist	LKM	No	Yes	Attitudes toward homeless people	Mixed	8
Stell & Farsides, 2016	University students	Active Control	LKM	Yes	Yes	Implicit attitudes toward African/Asian American	Mixed	4

LKM indicates Loving-kindness meditation; AJM indicates Appreciative joy meditation; CM indicates Compassion meditation

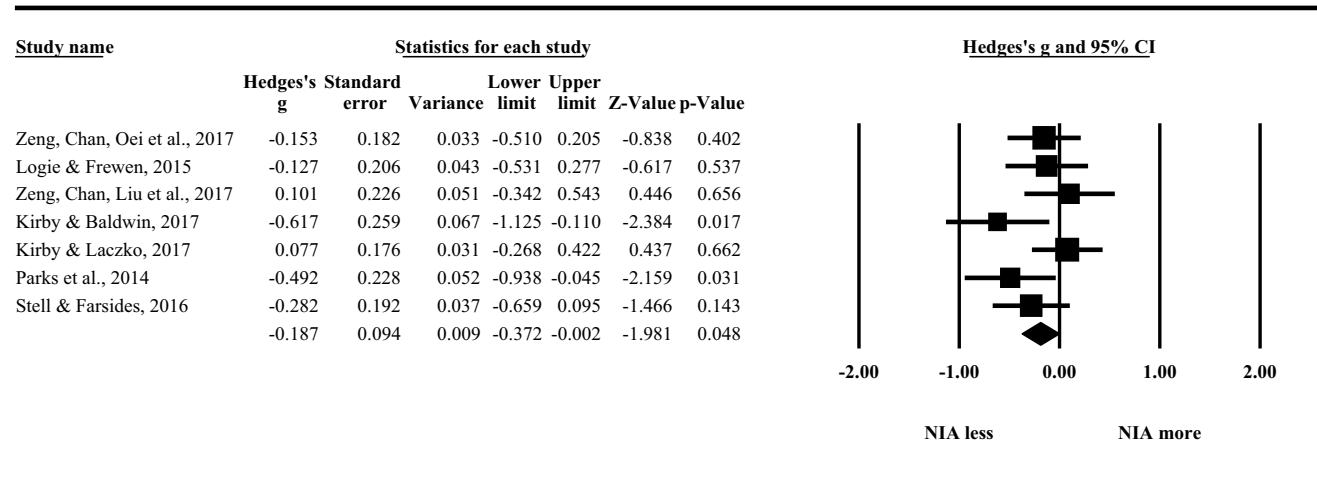# Randomized controlled laboratory experiments

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Zeng, Chan, Oei et al., 2017	-0.153	0.182	0.033	-0.510	0.205	-0.838	0.402
Logie & Frewen, 2015	-0.127	0.206	0.043	-0.531	0.277	-0.617	0.537
Zeng, Chan, Liu et al., 2017	0.101	0.226	0.051	-0.342	0.543	0.446	0.656
Kirby & Baldwin, 2017	-0.617	0.259	0.067	-1.125	-0.110	-2.384	0.017
Kirby & Laczko, 2017	0.077	0.176	0.031	-0.268	0.422	0.437	0.662
Parks et al., 2014	-0.492	0.228	0.052	-0.938	-0.045	-2.159	0.031
Stell & Farsides, 2016	-0.282	0.192	0.037	-0.659	0.095	-1.466	0.143
	-0.187	0.094	0.009	-0.372	-0.002	-1.981	0.048

Hedges's g and 95% CI

-2.00   -1.00   0.00   1.00   2.00

NIA less   NIA more

Fig. 3 Forest plot for meta-analysis for randomized control trail (RCT) studies on negative interpersonal attitudes in laboratory experiments

both had only one study for each of them. For the subgroup analysis of meditation targets, the difference was nonsignificant ($Q(1) = 1.246$, $p = 0.264$), and the effect sizes of these two subgroups were both nonsignificant, but meditation with difficult targets had marginally significant effects (meditation with difficult targets: $g = -0.295$, $SE = 0.156$, 95% CI = [-0.601, 0.012], $p = 0.060$, $k = 4$; meditation without difficult targets: $g = 0.077$, $SE = 0.117$, 95% CI = [-0.306, 0.152], $p = 0.512$, $k = 3$). For induction of negative interpersonal attitudes after meditation, comparison found no significant difference ($Q(1) = 0.116$, $p = 0.733$) between subgroups with induction ($g = -0.240$, $SE = 0.193$, 95% CI = [-0.618, 0.138], $p = 0.214$,

$k=3$) and without induction (g = -0.164, SE = 0.112, 95% CI = [-0.384, 0.056], p = 0.145, $k=4$). For the control condition, intervention components and consistency of measures targets with meditation targets, the number of subgroups were insufficient, so they were concealed. The meta-regression indicated that meditation length could not predict the effects on negative interpersonal attitudes (B = 0.001, SE = 0.022, 95% CI = [-0.043, 0.045], p = 0.951).

Meta-analysis for uncontrolled trials

Handing and overall effect size of uncontrolled trials

There were 101 participants included in these 5 studies, which resulted in 5 independent effect sizes. The information is shown in Table 3, while additional information is shown in Table S5 in the supplemental material.

A forest plot is shown in Fig. 4. The results of 5 pre-post designs reported that LCMs showed a significant medium-sized effect on negative attitudes toward others compared with preintervention (g = -0.539, SE = 0.128, 95% CI = [-0.789, -0.288], $p < 0.001$). It was not significant in the heterogeneity analysis ($Q(4)$ = 5.712, p = 0.222, I^2 = 29.969%). Sensitivity analysis was conducted with leave-one-out analysis (Figure S7), and the overall effects were not influenced by any single study. The funnel plot is shown in Figure S8 in the supplemental material, and Egger's test indicated nonsignificant publication bias ($t(3)$ = 0.686, p = 0.542). Thus, the current result was reliable. The subgroup classification overlapped with the classification of multiweek interventions and high-intensity interventions (i.e., intervention components, meditation target, with or without induction, measures with or without specific subjects), and subgroup analysis was not conducted in uncontrolled trials.

Table 3 Details of uncontrolled trials in meta-analysis

Study	Participants	Intervention components	Induction	Wish difficult targets	Variables	Measures targets consistent with wish targets	Length (days)
Chapin et al., 2014	Adults with chronic low back pain	CM	No	Yes	Anger	No	9 weeks
Alba, 2013, study 1	General public	Mixed	Yes	Unclear	Revenge	Unclear	4
Alba, 2013, study 2	Adults	Mixed	Yes	Unclear	Revenge	Unclear	10
Wong, 2011	Adults	LKM	No	Unclear	Anger; hostile	No	4
Cebolla et al., 2019	University students	CM	No	No	Negative attitudes towards others	No	-

LKM indicates Loving-kindness meditation; AJM indicates Appreciative joy meditation; CM indicates Compassion meditation. The target data of Cebolla et al. (2019) was collected in laboratory experiment and was omitted

Non-randomized controlled trials

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Chapin, 2014	-0.784	0.313	0.098	-1.397	-0.171	-2.508	0.012
Alba, 2013, study1	-0.507	0.229	0.052	-0.956	-0.058	-2.211	0.027
Alba, 2013, study2	-0.240	0.178	0.032	-0.588	0.108	-1.350	0.177
Wong, 2011	-0.846	0.209	0.044	-1.255	-0.437	-4.055	0.000
Cebolla et al., 2019	-0.433	0.332	0.111	-1.085	0.218	-1.304	0.192
	-0.539	0.128	0.016	-0.789	-0.288	-4.217	0.000

Hedges's g and 95% CI

-2.00   -1.00   0.00   1.00   2.00

NIA less   NIA more

Note: NIA represents negative interpersonal attitudes.

Fig. 4 Forest plot for meta-analysis for non-randomized control trail (NRCT) studies on negative interpersonal attitudes

Narrative review

Potential mediators

Limited studies have explored mediators of the effects of LCMs on negative interpersonal attitudes, and the mediators have concentrated on cognitive factors. Stell and Farsides (2016) indicated that loving-kindness meditation reduced racial bias by increasing controlled processing (efforts to constrain processing to task-relevant information), decreasing automatic processing (automatic stereotype activation), and increasing positive other-regarding emotions (i.e., gratitude, elevation, love, and awe). It could also significantly mediate the effect, while positive nonother-regarding emotions (i.e., amusement, buoyancy, hope, curiosity, happiness, pride and contentment) did not. Kang et al. (2014) suggested that psychological stress mediated implicit bias toward homeless people but not African Americans, while cognitive control did not show mediating effects in bias toward either of these two groups of people.

Other research has explored potential mediators by correlation or regression analysis, but the variables were completely different. Zeng et al. (2019) showed that changes in high/medium/low-arousal positive emotions, low-arousal negative emotions, sense of joy/self-transcendence in appreciative joy, positive attitudes toward oneself and others, and life satisfaction were all correlated with changes in envy, while changes in high-arousal negative emotions, positive interpersonal bias in appreciative joy, and negative attitudes toward oneself and others were nonsignificant. For negative attitudes toward others, medium/low-arousal positive emotions, high/medium/low-arousal negative emotions, and negative attitudes toward oneself showed significant correlations, while life satisfaction, envy, all dimensions of appreciative joy, high-arousal positive emotions, and positive attitudes toward oneself and others were nonsignificant. Kang and Falk (2020) found that greater activity in the right temporoparietal junction (brain region correlated with mentalizing) showed greater deductions in bias stigmatized individuals over time, but the ventral striatum (brain region correlated with positive valuation processing) did not. Chapin et al. (2014) indicated that expectations of pain and expectations of quality of life improvement were negatively correlated with anger in people with chronic low back pain. Kirby and Baldwin (2017) found that social desirability was significantly correlated with the change in anger.

Contribution of meditation practice

Seven studies reported data about meditation practice at home. Only three studies reported the contribution of meditation practice, and the results were inconsistent. Carson et al. (2005) indicated that practice could predict daily anger the next day. However, Chapin et al. (2014) found that the correlation between total minutes spent in compassion meditation (one of the subtypes of LCMs) and anger was nonsignificant. Reddy et al. (2013) indicated that practice frequency was uncorrelated with changes in any psychological variables.

Long-term effects

Five studies reported the effects of LCMs during follow-up periods ranging from 2 weeks to 3 months. Two of them supported that the effects on negative interpersonal attitudes could be maintained for 2 weeks to 1 month (revenge: Study 1 in Alba, 2013; envy, negative attitudes toward others: Zeng et al., 2019). Carson et al. (2005) showed that effects on hostility were maintained for 3 months, but the effects on state anger were marginal, and the effects on trait anger and anger expression out were nonsignificant. The second study by Alba (2013) showed nonsignificant results in a follow-up effect analysis on revenge, and Belgard (2018) showed that the effects on anger were not maintained for 2 weeks.

Discussion

Status of studies and overall effects

The current study provided the first systematic review on the effects of LCMs in decreasing negative interpersonal attitudes. Only one-tenth of the LCM studies (25 out of 246) involved negative interpersonal attitudes. In contrast, a recent review found that nearly one-fifth of LCM studies measured depression (Lv et al., 2020). This is slightly surprising, considering that the elimination of negative interpersonal attitudes was considered the primary purpose of LCMs in Buddhism (Bodhi, 2012). It is also notable that the negative interpersonal attitudes in the current study tried to include a wide range of negative interpersonal attitudes, and there were even fewer studies that measured the "direct enemies" listed by Buddhism (i.e., anger, cruelty, envy, and attachment). Such a finding suggested that the interest of modern psychology in LCMs somehow differs from Buddhism. Although the modern application of LCMs is not necessarily consistent with the purpose of Buddhism, future studies should pay more attention to negative interpersonal attitudes and other long-claimed effects.

Overall, the meta-analysis showed that general effects on negative interpersonal attitudes in daily life were confirmed in both the randomly assigned intervention and the pre-post designed studies, which indicated that LCMs could reduce negative interpersonal attitudes. Therefore, the impact on general negative interpersonal attitudes is robust. Meanwhile, the results of the instant effects on negative

interpersonal attitudes were also significant in the randomly assigned experimental studies. However, sensitivity analysis indicated that the omission of some studies would affect the overall effects, so the results should be accepted cautiously. The unstable results might be caused by the small number of randomized controlled experimental studies. In addition, it may take practice to change negative interpersonal attitudes in the long run, while meditation practice in experimental studies was always limited to 6–15 min, possibly restricting the effects of LCMs. To examine the effects of short-term meditation, more studies are needed to draw solid conclusions. Additionally, although the heterogeneity of all these designs was nonsignificant, the multiple factors affecting the effects and the potential mechanism are discussed as follows.

Impacts of meditation components

In the current search of LCMs, there were 3 subtype meditations. However, due to limited studies, subgroup analysis of LCM subtypes was only conducted in randomized multiweek interventions, which found no significant difference between loving-kindness meditation and compassion meditation. Therefore, the overall effect was robust in randomized multiweek interventions, while the nonsignificant effects of each subgroup were probably caused by few studies. Particularly for loving-kindness meditation, it showed marginal significance in randomized multiweek interventions and significant effects in randomized experimental results, which indicated loving-kindness meditation could reduce negative interpersonal attitudes regardless of general attitudes or instant attitudes. Compared with loving-kindness meditation, compassion meditation and appreciative joy meditation had fewer studies on negative interpersonal attitudes, which may result in nonsignificant results. On the other hand, the practice of appreciative joy is difficult and rare (Harris, 2013; Royzman & Rozin, 2006). Previous studies have found that appreciative joy relies more on emotional attachment (Royzman & Rozin, 2006); thus, it is more difficult to feel appreciative joy toward strangers or disliked individuals, which may explain the difference.

The meditation targets were also compared in subgroup analysis in experimental studies to examine whether sending wholesome wishes to difficult targets, usually hated people, could affect negative interpersonal attitudes directly and effectively. The difference between the 2 subgroups was insignificant, but the effects of meditations with difficult targets were marginally significant with a small effect size, while those of meditations without difficult targets were not significant. Such results suggested that meditations with difficult targets, which try to directly improve attitudes toward those who currently elicit negative attitudes, might be more effective, although such a conclusion would require more empirical evidence. At the same time, the effects of

meditations without difficult targets are also worth noting regarding of whether LCMs for easier targets could generalize to more difficult ones. Additionally, Condon and Makransky (2020) indicated that emotions or attitudes toward others change as meditation practice progresses, with or even after changes in emotions or attitudes toward the self. Therefore, the following questions need to be examined in the future: 1) Can LCMs for the self change attitudes toward others? 2) Do LCMs for others have a greater impact on negative interpersonal attitudes than those for the self? 3) Do LCMs for self and for others have an interactive effect between long-term intervention and short-term practice?

Impact of induction of negative interpersonal attitudes

For experimental studies, whether there was an induction of negative interpersonal attitudes after meditation was evaluated as a moderator. The induction of negative interpersonal attitudes indicates that participants are induced to generate negative interpersonal attitudes (e.g., anger) in a vignette or behavioral experiment. Although the effect size of experimental studies with induction was larger than that without induction, there was no significant difference between these two groups. Partly because of the small number of studies, the effect sizes of these two groups were both insignificant. Of note, LCMs generate positive attitudes by sending wishes to others, while negative attitudes decrease indirectly. Previous research also suggested that it was necessary to clarify how LCMs work on negative attitudes: they reduce negative attitudes that already exist or by positive attitudes to suppress the rise of negative attitudes (Zeng et al., 2017a). In the current study, the effects of LCMs in studies with induction were more inclined to suppress the generation of negative interpersonal attitudes, while the effects of studies without induction were likely to reduce negative interpersonal attitudes in daily life. Thus, studies with and without induction possibly explored different aspects of effects. In addition, there might be more room for negative interpersonal attitude suppression or decrease in experiments with induction, while experiments without induction may have encountered a floor effect. In contrast, however, induction of negative interpersonal attitudes means keeping a positive attitude in a negative state, while the lack of induction is a natural state producing a positive attitude; thus, the latter may be simpler. In any case, we believe that experiments with and without induction imply essential differences, and we recommend continuing to separate these two in the future, trying to allow each to accumulate sufficient evidence.

Impact of different outcomes

Subgroup analysis of different outcomes (bias, other-focused negative emotions) was conducted to compare whether LCMs had different impacts on these outcomes, and the difference was

nonsignificant. Nonetheless, the effects on bias were significant both in multiweek interventions and experimental studies, while other-focused negative emotions were not. This might suggest that LCMs reduce bias, especially implicit bias, toward stigmatized individuals (e.g., overweight people, homeless people, other racial groups) more effectively. Therefore, compared with negative emotions toward others, negative cognition might be more influenced by LCMs. The impact on bias suggests that LCMs could be applied to reduce bias toward specific subjects (e.g., other races, stigmatized individuals). However, studies on bias are limited, and not all have received evidence to support it. Therefore, researchers still need to accumulate more evidence for the application of specific domains of discrimination or stigma.

The current study also planned to compare the results of measures targets that are consistent or inconsistent with meditation targets to verify whether precise wishing could have better effects. Due to insufficient data, subgroup analysis was not conducted. Considering the practical value of reducing negative attitudes toward some specific groups, future research could develop some meditation interventions toward concrete targets, but not for friends, family, or disliked ones without any characteristic, to verify the hypothesis. Of note, individuals are more likely to be influenced by expectancy or demand effects when the targets in measures are matched with those in interventions, which requires consideration in future research.

Possible mechanism of the effects of LCMs

In the current study of negative interpersonal attitudes, we note that limited research has explored the mediators or moderators in the process of LCMs, and the findings have been inconsistent. One explanation for inconsistency could be different mechanisms for specific variables in negative interpersonal attitudes. For example, Zeng et al. (2019) found that envy was more correlated with positive variables, while negative attitudes toward others were more related to negative variables. The results suggested that although LCMs could reduce variables in negative interpersonal attitudes, the mechanism may be different for specific variables. Due to the small number of studies, however, we are unable to further distinguish the differences between their mechanisms, which leaves this topic as a direction for future research. Another possibility for inconsistency relates to methodological issues. For example, some studies measured mediator and outcome variables with independent tools (e.g., Kang et al., 2014), while other studies measured them with the same set of survey packages (e.g., Zhou et al., 2021). The latter may be easier to observe the significant correlation but more vulnerable to common method bias. Although the impact of such a possibility was not confirmed due to limited research, future studies should try to reduce confounding factors.

In addition, although most studies of LCMs on negative interpersonal attitudes were analyzed based on self-reported data, physiological mechanisms have been explored. Previous research has investigated the relation between negative interpersonal attitudes and the activity of specific brain regions (Kang & Falk, 2020). These results overcome the inherent limitations of results derived from self-reported measures. Further research could explore other related brain mechanisms. In addition, previous research found that negative interpersonal attitudes from working memory training were correlated with activity in the left posterior insula and the left frontoparietal area (Takeuchi et al., 2014), which was different from the study in LCMs. Future research could compare the brain mechanisms underlying the effects of LCMs with those underlying the effects of other interventions.

Contribution of meditation practice

The experiments supported that LCMs could decrease general and instant negative interpersonal attitudes. However, the contribution of meditation practice to interpersonal attitudes in daily life has rarely been explored in multiweek interventions, and the results have been inconsistent across different studies. It is notable that the significant result from Carson et al. (2005) was on a daily measure of anger, while nonsignificant results were found when subjects were asked to recall their state over the past two weeks (Chapin et al., 2014; Reddy et al., 2013). This suggested that the means of measurement or the inaccuracy of self-reports might impact the results, but many other factors might also confound the results (see Zeng et al., 2017c). In brief, little evidence supports the contribution of repeated meditation practice, and more studies in the future are needed.

Limitations

The current meta-analysis has several limitations. First, the number of studies was limited. Thus, some subgroup analyses were composed of only 2 or 3 studies, which made the conclusions less convincing. Second, considering the limited number of studies on each variable, the current study merged several variables and measures into a meta-analysis and cannot provide a detailed analysis of their differences. For example, different subtypes of LCMs may impact negative interpersonal attitudes through different mechanisms, which could not be further explored in the current study due to the limited studies of appreciative joy meditation or compassion meditation. Third, the current meta-analysis included only literature published in English. Although the participants in the studies were not limited to English speakers, the results were probably biased to some degree by the omission of non-English-language studies. Fourth, the current meta-analysis merged studies with clinical and nonclinical participants. Although the only study with clinical participants did not affect the total

results, the effect on clinical participants was insignificant, while the total effect of studies with nonclinical participants was significant. The clinical and nonclinical effects and mechanisms may be different. However, due to the limited research of LCMs with clinical participants on negative interpersonal attitudes, the difference could not be analyzed by data analysis. More empirical studies are required to understand the effects on negative interpersonal attitudes of clinical participants and distinguish the difference between LCMs' effects on clinical and nonclinical participants. Despite these limitations, the current article summarizes the effects of LCMs on negative interpersonal attitudes until now and finds support for the idea that LCMs can decrease negative interpersonal attitudes both in general and instantly. Therefore, LCMs have practical value in reducing some social problems, such as racial bias and discrimination. This study also suggested several directions for future studies. In particular, it encouraged further consideration of the implications arising from the details of the study design, such as the induction of negative interpersonal attitudes and the choice of targets at whom the wishes are directed.

Declarations

There were no ethical issues involved in the research.

Consent Current study did not collect data from participants.

Competing interests The study was developed and led by authors. There is no other conflict of interest.

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