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REVIEW ARTICLE

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The effectiveness of mindfulness-based stress reduction (MBSR) on the mental health, HbA1C, and mindfulness of diabetes patients: A systematic review and meta-analysis of randomised controlled trials

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Abstract

The clinically standardised mindfulness-based stress reduction (MBSR) has been utilised as an intervention for improving mental health among diabetes patients The present study aimed to assess the effectiveness of mindfulness-based stress reduction (MBSR) on the mental health, haemoglobin A1c (HbA1C), and mindfulness of diabetes patients. A systematic review and meta-analysis approach was employed to review randomised controlled trials published in the English language between the inception of eight databases to July 2022. Eleven articles from 10 studies, with a combined sample size of 718 participants, were included in the systematic review, and nine studies were included in the meta-analysis. In the meta-analysis, outcomes at post-intervention and follow-up were compared between the MBSR intervention and control groups with an adjustment of the baseline values. The results showed that MBSR demonstrated effects at post-intervention

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and follow-up (in a period between one to 12 months with a mean length of 4.3 months) in reducing anxiety and depressive symptoms, and enhancing mindfulness, with large effect sizes. However, the effect of MBSR on reducing stress was observed at follow-up, but not at post-intervention. Effects of MBSR on HbA1C were not detected at post-intervention and follow-up. The findings suggest that MBSR appears to be an effective treatment for improving mental health conditions and mindfulness in people with diabetes. The measurement of cortisol is recommended to be used as a biological measure to evaluate the effectiveness of MBSR in diabetes patients in future research.

KEYWORDS
blood glucose, diabetes, MBSR, mental health, meta-analysis, mindfulness

INTRODUCTION

Diabetes, a chronic metabolic disorder marked by high blood glucose levels, has significant negative effects on patients' health (International Diabetes Federation, 2021). Over time, poorly controlled diabetes leads to complications including coronary artery disease, neuropathy, retinopathy, nephropathy, and peripheral vascular disease (Chen et al., 2021). Clinically, haemoglobin A1c (HbA1C) is used as a marker of diabetes control over the previous 2 to 3 months (Ellis et al., 2018). High HbA1C is associated with increased end organ failures including kidney, heart, eye/blindness, and limb amputations (Wang & Hng, 2021).

Diabetes is also associated with mental health problems, including stress, anxiety, and depression. Multiple factors, such as being overwhelmed by the daily burden of diabetes management activities (e.g. exercise, healthy nutrition, and blood glucose monitoring), concerns related to the long-term complications of diabetes, and frustration with the uncontrollability and unpredictability of blood glucose levels, often lead to diabetes patients commonly having high levels of chronic stress (Ellis et al., 2019). High stress levels are in turn associated with a reduction in daily diabetes self-care activities (Ellis et al., 2018), which may lead to higher blood glucose levels (Bo et al., 2020). The physiological stress response also stimulates the release of cortisol, which functions to downregulate insulin through disturbance of the hypothalamic–pituitary–adrenal axis in addition to stimulating gluconeogenesis (Dreger et al., 2015; Joseph & Golden, 2017). The disrupted insulin signalling drives the hampered neurotransmission of serotonin, dopamine, and norepinephrine leading to elevated blood glucose levels (Joseph & Golden, 2017).

Research has showed that depression/anxiety and diabetes are often comorbid (Joseph & Golden, 2017). Diabetes is likely to trigger chronic stress, which increases cortisol levels. The higher levels of cortisol in turn are associated with higher levels of anxiety and depression (Joseph & Golden, 2017; Vedhara et al., 2003). Among diabetes patients, anxiety and depression are linked to impaired blood glucose management and worse health-related outcomes in diabetes (including weight gain, less adherence to therapy, increased long-term diabetic macrovascular and microvascular complications), which lead to higher costs to the health care system (Joseph & Golden, 2017).

Psychotherapies that help diabetes patients manage chronic stress, anxiety, and depression are beneficial to assist in the treatment of diabetes and thus in reducing the costs of health care for diabetes patients (Ellis et al., 2018, 2019). Among other psychotherapies, in the past decade, the clinically standardised mindfulness-based stress reduction (MBSR) has been utilised as an intervention for diabetes patients.

MBSR is a clinically standardised intervention that supports participants to adopt the perspective of openness, curiosity, and acceptance of what is occurring in the present moment with a nonjudgmental attitude (Kabat-Zinn, 1982). The intervention delivers eight 2.5-h weekly group sessions and a full-day retreat after the sixth week (Kabat-Zinn, 2017). Research has reported significant reductions in stress (Ellis et al., 2019; Hartmann et al., 2012; Latheef & Latheef, 2017; Ravari et al., 2020), anxiety (Chen et al., 2021; Hamidi et al., 2020; Ravari et al., 2020), depression (Ellis et al., 2018; Hartmann et al., 2012; Latheef & Latheef, 2017; Ravari et al., 2020), and HbA1C (Ravari et al., 2020) in diabetes patients following a course of MBSR intervention. The practices within MBSR cultivate mindfulness, which refers to the awareness that arises through nonjudgementally paying attention to the present moment (Bishop et al., 2004; Kabat-Zinn, 1982, 2013). Mindfulness has been found to be a protective factor for mental health (Kabat-Zinn, 2013; Li et al., 2020). The cultivation of mindfulness is likely to lead to nonreactive acceptance of one's diabetic experience, which may in turn contribute to positive treatment outcomes (Ni et al., 2020).

Although literature has reported that MBSR is effective for improving mental health outcome, glucose conditions, and mindfulness among diabetes patients, systematic reviews and meta-analyses that provide a clear and comprehensive understanding of available studies employing randomised controlled trials (RCTs) to evaluate such effectiveness are limited. Our search in eight databases (MEDLINE, EMCARE, CINAHL, PsycInfo, PubMed, SCOPUS, EMBASE, and Cochrane) located two systematic reviews on the effects of mindfulness-based interventions (MBIs) on diabetes patients (Ni et al., 2020; Noordali et al., 2017). Both reviews reported that MBIs were efficacious for improving mental health conditions and reducing HbA1C levels. However, there are several limitations of the two reviews. First, as the authors stated that "the combination of various mindfulness-based interventions in one review might mask the effectiveness of each single included intervention" (Ni et al., 2020, p. 380), both reviews did not provide specific information of the effects of MBSR on health outcomes in people with diabetes. While MBSR and MBCT have similarities, they are two different interventions with different focuses. It is thus important to evaluate the efficacy of these two interventions separately. Second, the effects of MBIs on mindfulness was not included in both reviews. Third, Ni et al.'s (2020) study included depression as the only mental health outcome, whereas meta-analysis was not conducted in Noordali et al.'s (2017) study. To address the research gaps in these two reviews, our study specifically focused on the effects of MBSR on three important mental health outcomes (e.g. stress, anxiety, and depression), HbA1C, and mindfulness with meta-analysis being conducted. Two research questions (RQs) are proposed:

RQ1: Are the differences between the MBSR and control groups significant in terms of the effects of MBSR on the outcomes measured at post-intervention?

RQ2: Are the differences between the MBSR and control groups significant in terms of the effects of MBSR on the outcomes measured at follow-up?

METHODS

This systematic review and meta-analysis was conducted following the guideline of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and registered in the Open Science Framework (https://osf.io/n97ar) after data extraction. The hypotheses in the registration were replaced by the RQs in this paper.

Inclusion and exclusion criteria

Inclusion criteria were RCT studies published in peer-reviewed journals with a focus on MBSR interventions for diabetes patients, and with mental health as the primary outcome and HbA1C and mindfulness as the secondary outcomes. The exclusion criteria were articles that were published in a language other than English and were nonempirical (e.g. editorials, comments, opinion pieces, and letter to editors), systematic reviews and meta-analyses. Articles with full texts unavailable, theses/dissertations, and book chapters were also excluded.

Search strategy

The database search was conducted by the first author between the 10th and 13th of March 2022 in eight electronic databases (MEDLINE [Ovid], EMCARE [Ovid], CINAHL, PsycInfo [ProQuest], PubMed, SCOPUS, EMBASE, and Cochrane) for articles published from inception to March 2022. The second author repeated the search, results of which were the same as that of the first author. The search was repeated on the 25th of July 2022, and no new articles meeting the inclusion criteria were found. Both Medical Subject Headings (MeSH) terms and keywords were used in the search. The full search strategy using the Cochrane's PICO search tool (Higgins et al., 2022) and the full search strategies for all databases are presented in Tables S1 and S2, respectively.

Study selection

The first stage of the study selection was the title and abstract screening, which was independently conducted by two authors (VF and WL) using codes of "yes," "no," or "maybe" based on the inclusion and exclusion criteria. Studies that received a unanimous "yes" rating were included, and articles that were rated unanimously as "no" were excluded, for the next stage of study selection. Studies that received "maybe" or nonunanimous ratings were discussed between the raters until an agreement was made on whether to include or exclude (Astridge et al., 2023; Li et al., 2021).

The second stage of the study selection was the full-text methodological appraisal to determine the methodological quality of eligible articles using the Mixed Methods Appraisal Tool (MMAT) Version 2018 (Hong et al., 2019), which was independently conducted by the three authors (VF, AL, and UM). Fleiss' kappa (k) was used to determine the inter-rater agreement indices, $k < 0.20$, 0.20–0.40, 0.41–0.60, 0.61–0.80 and over 0.80, indicating poor, fair, moderate, substantial, and perfect agreements, respectively (Fleiss, 1971). All articles with $k \leq 0.40$ were discussed and a post-discussion rating was conducted with ks all over 0.40.

Data extraction

Data were extracted from the eligible studies using a standard data extraction form, which contained columns for the first author, publishing year, research design, sample size, demographic variables, measures, psychiatric history, primary and secondary outcomes, and effect sizes. The extracted data was independently assessed by the three authors to evaluate if the evidence presented in the data extraction form and in the included papers supported the findings of each study, using codes of "unequivocal," "credible," or "unsupported." All articles met the inclusion criterion of rater agreement index = $((N_{unequivocal} + N_{credible}) / N_{reviewers})$ over .80 (Astridge et al., 2023; Li et al., 2021).

Data synthesis

Data synthesis was performed using narrative synthesis and meta-analysis. In the narrative synthesis, the similarities and differences between the findings of the included studies were mapped to identify the patterns in the data (Li et al., 2021).

The Comprehensive Meta-Analysis V3 (Borenstein et al., n.d.) software was used in the meta-analysis. Several included studies reported data on more than one outcome, where the different outcomes were based on the same participants, the effect sizes of the outcomes were thus computed using multiple outcomes model where correlations between different outcomes in one study were considered (Borenstein, 2019; Borenstein et al., 2021). Outcomes at post-intervention and follow-up were compared between the MBSR intervention and control groups with an adjustment of the baseline values. The random effects model was employed to compute the effect size of an outcome across studies. For studies reporting multiple effect sizes, of one outcome variable, which were not independent (e.g. multiple effect sizes by subscales for the mindfulness scale within one study; effect sizes of one outcome variable by intention-to-treat and per protocol analyses), if the overall effect size of the outcome variable was not available, a two-level meta-analysis was employed (Astridge et al., 2023). First, the mean effect size within each study with multiple effect sizes was computed using the fixed effect model to obtain a synthetic effect size for the study. The results of the analyses are presented in Tables S3 and S4. Second, the synthetic effect size was then entered to the main meta-analysis to compute the overall effect size across studies using the random effects model (Borenstein et al., 2021; Hedges, 2019).

Hedges' *g* with 95% confidence interval (95% CI) was used to report effect sizes, with values of 0.20, 0.50, and 0.80 corresponding to small, medium, and large effect sizes, respectively. *I* squared (I^2) was used to evaluate heterogeneity among the studies, with I^2 values of 25, 50, and 75 representing low, medium, and high heterogeneity, respectively (Borenstein et al., 2021). Begg–Mazumdar and Egger's tests were used to assess publication bias, which occurs due to nonstatistically significant studies remaining unpublished (Borenstein et al., 2021). An insignificant *p* value indicates the absence of publication bias (Borenstein, 2019).

Assessment of risk of bias in the included studies

To assess the risk of bias in the included studies, the Prediction Model Study Risk of Bias Assessment Tool (PROBLAST; Wolff et al., 2019) was employed. The evaluation assessed the participants, predictors, outcomes, and analyses of each study, and the risk of bias was rated as being low, high, or unclear. The first two authors independently rated the included articles as being at low risk of bias. Moderator and sensitivity analyses were also conducted to assess bias in the included studies.

RESULTS

Summary of the studies

As indicated in the PRISMA diagram in Figure 1, 11 articles from 10 studies were included in the systematic review. Two articles (Hartmann et al., 2012; Kopf et al., 2014) were from the same study with different follow-up timepoints. Sufficient data were not available for two studies (Kian et al., 2018; Kopf et al., 2014), the authors of which were contacted to request the missing data. No responses were received. The two studies were thus excluded from the meta-analysis, resulting in nine studies being included in the meta-analysis.

Of the 10 included studies, three studies were conducted in Iran ($n = 3$), followed by Canada ($n = 2$), Germany ($n = 1$), the USA ($n = 1$), China ($n = 1$), Korea ($n = 1$), and India ($n = 1$). The

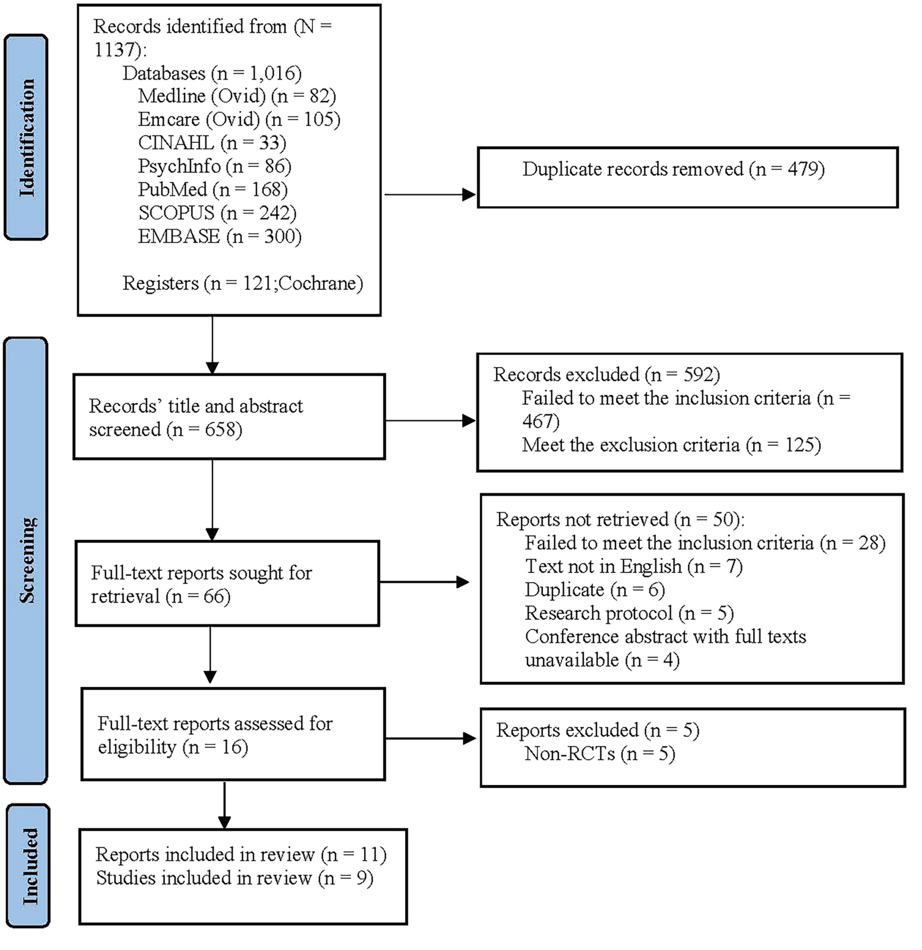

FIGURE 1 The PRISMA flow diagram.

studies contained sample sizes ranging from 38 to 110 participants, with a combined sample size of 718 participants. Forty-eight participants had type 1 diabetes, 474 were type 2 diabetics, 124 had either type 1 or type 2 diabetes, 94 had unspecified diabetes, and 88 were pregnant women with gestational diabetes. Of the 10 included studies, three fully employed standardized MBSR (8-week sessions with a full-day retreat); five employed 8-week MSBR sessions without the full-day retreat; and two employed modified MBSR with a shorter duration for each session. The types of control groups included treatment as usual (TAU), diabetes education, diabetes support, and waiting list. Table 1 presents the summary of characteristics of the included studies.

Test of RQ1: The short-term effects of MBSR on the outcomes at post-intervention

Of the 10 included studies, three, six, and six studies reported effects on anxiety (Chen et al., 2021; Hamidi et al., 2020; Ravari et al., 2020), depression (Chen et al., 2021; Ellis et al., 2019; Hartmann et al., 2012; Latheef & Latheef, 2017; Nathan et al., 2017; Ravari et al., 2020), and stress (Ellis et al., 2019; Hartmann et al., 2012; Jung et al., 2015; Latheef & Latheef, 2017; Nathan et al., 2017; Ravari et al., 2020), respectively. As presented in Figure 2 of the forest plot, the pooled effect sizes comparing the MBSR and control group post-test scores demonstrated that the MBSR intervention had a large effect size on anxiety (Hedges' $g = -2.407$, 95% CI [−3.631, −1.183], $p = .000$), and depression (Hedges' $g = -1.110$, 95% CI [−1.988, −0.232], $p = .013$). That is, anxiety and depression in the MBSR group were significantly lower by 2.407 and 1.110 standard deviations than the control group. However, MBSR did not have a significant effect on stress (Hedges' $g = -0.409$, 95% CI [−1.287, 0.469], $p = .361$) at post-intervention. The heterogeneity test demonstrated substantial heterogeneity for anxiety ($I^2 = 98.773$, $p < .001$), depression ($I^2 = 94.075$, $p < .001$), and stress ($I^2 = 85.118$, $p < .001$).

Three studies reported differences in HbA1C between the MBSR and control groups at the post-test timepoint (Ellis et al., 2019; Hartmann et al., 2012; Ravari et al., 2020). As presented in Figure 2, the pooled effect size for HbA1C (Hedges' $g = -0.118$, 95% CI [−1.345, 1.110], $p = .851$) indicated that MBSR did not have a significant effect on HbA1C. The heterogeneity test demonstrated substantial heterogeneity ($I^2 = 72.221$, $p = .027$).

Two studies reported the between-group effects of MBSR on mindfulness (Latheef & Latheef, 2017; Rozworska et al., 2020). As presented in Figure 2, the pooled effect size for mindfulness (Hedges' $g = 1.834$, 95% CI [0.278, 3.391], $p = .021$) indicated that MBSR had a large effect size on mindfulness. That is, mindfulness in the MBSR group was significantly higher by 1.834 standard deviations, respectively, than the control group. The heterogeneity test demonstrated substantial heterogeneity ($I^2 = 85.118$, $p < .001$).

Meta-regression was performed to explore which moderators may be accountable for the substantial heterogeneity. Moderators of country ($Q = 8.92$, $df = 6$, $p = .178$), sample size ($Q = 0.20$, $df = 1$, $p = .655$), MBSR protocol ($Q = 1.81$ $df = 3$, $p = .405$), the type of control group ($Q = 2.00$, $df = 3$, $p = .573$), and publishing year ($Q = 3.11$, $df = 1$, $p = .078$) were found not to be predictive for the heterogeneity. The measure ($Q = 146.05$, $df = 114$, $p < .001$) and diabetes type ($Q = 45.41$, $df = 4$, $p < .001$) were found to contribute to the substantial heterogeneity.

Publication bias was not detected, as indicated by the nonsignificance of the two-tailed Begg–Mazumdar test (Kandell's tau = −0.284, $p = .079$), and the Egger's test (intercept = −3.282, $t = 0.939$, $df = 18$; $p = .361$).

The results from Kian et al.'s (2018) study that was not included in the meta-analysis showed that MBSR had negative effects on depression, anxiety, and HbA1C at post-intervention.

TABLE 1 Summary of the characteristics of included studies.

Authors, year	Country	Research design	Demographic information	Scales	Diabetes types	MBSR protocol
Chen et al., 2021	China	2-arm RCT: MBSR + intensive education vs. intensive education with 2 timepoints (pre and post-tests)	$N = 94$ MBSR group: $n = 47$ (male: 26; female: 21), $M_{age} = 63.98$ (SD = 4.34) control group: $n = 47$ (male: 28, female: 19), $M_{age} = 64.11$ years (SD = 4.36)	Symptom Checklist 90 (SCL-90)	Unspecified diabetes	8-week MBSR sessions without the full-day retreat, duration of each session unreported
Ellis et al., 2019	USA	3-arm RCT: MBSR vs. CBT vs. control (diabetes support) with 3 timepoints (pre and post-tests, and 3-month FU)	$N = 48$ MBSR group: $n = 16$ (male: 6, female: 10), $M_{age} = 18.20$ (SD = 1.43) CBT group: $n = 16$ (male: 11, female: 5), $M_{age =}$ 18.10 (SD = 1.30) Control group: $n = 16$ (male: 7, female: 9), $M_{age} = 18.5$ (SD = 1.6)	Center for Epidemiologic Studies Depression Scale (CES-D) & Perceived Stress Scale (PSS)	Type 1 diabetes	9-week modified MBSR sessions (1.5–2 h per session) without the full-day retreat
Hamidi et al., 2020	Iran	2-arm RCT: MBSR vs. TAU with 3 timepoints (pre and post-tests, and 1-month FU)	$N = 88$ (24–28 week pregnant women) MBSR group: $n = 44$, $M_{age} = 29.50$ (SD = 5.22) Control group: $n = 44$, $M_{age} = 29.59$y (SD = 4.63)	Spielberg Situational and Trait Anxiety Inventory (STAI)	Gestational diabetes	8-week MBSR sessions (2.5 h per session) with the full-day retreat

TABLE 1 (Continued)

Authors, year	Country	Research design	Demographic information	Scales	Diabetes types	MBSR protocol
Hartmann et al., 2012[a]	Germany	2-arm RCT: MBSR vs. TAU with 3 timepoint (pre and post-tests, and 12-month FU)	$N = 110$ MBSR group: $n = 53$ (male: 40, female: 13), M = 58.70 (SD = 7.40)control group: $n = 57$ (male: 46, female: 11), M = 59.30 (SD = 7.80);	Patient Health Questionnaire (PHQ-9)	Type 2 diabetes	8 weekly MBSR sessions without the full-day retreat and with a booster session after 6 months, duration of each session unreported
Jung et al., 2015	Korea	3-arm RCT: MBSR vs. walking vs. control (patient education) with 2 timepoints (pre and post-tests)	$N = 56$ MBSR group: $n = 21$ (male: 10, female: 11), $M_{age} = 67.00$ (SD = 9.13) Walking group: $n = 18$ (male: 9, female: 9), $M_{age} = 63.33$ (SD = 8.83) Walking group: $n = 17$ (male: 8, female: 9), $M_{age} = 68.47$ (SD = 6.17)	Perceived Stress Response Inventory (PSRI)	Type 2 diabetes	8-week MBSR sessions (1–2 h per session) without the full-day retreat
Kian et al., 2018	Iran	2 arm RCT: MBSR vs. TAU with 3 timepoints (pre and post-tests, and 3-month FU)	$N = 59$ MBSR group: $n = 29$ (male: 8, female: 21), $M_{age} = 53.48$ (SD unreported) Control group: $n = 30$ (male: 3, female: 27), $M_{age} = 59.03$ (SD unreported)	Hamilton Depression Rating Scale (HDRS) & Hamilton Anxiety Rating Scale (HARS)	Type 2 diabetes	8-week MBSR sessions (2.5 h per session) without the full-day retreat

(Continues)

TABLE 1 (Continued)

Authors, year	Country	Research design	Demographic information	Scales	Diabetes types	MBSR protocol
Kopf et al., 2014[a]	Germany	2-arm RCT: MBSR vs. TAU with 4 timepoints (pretests, and 1-year, 2-year and 3-year FUs)	$N=110$ MBSR group: $n=53$ (male: 13, female: 40), $M_{age}=58.7$ (SD unreported, range: 56.7–60.8 years) Control group: $n=57$ (male: 11, female: 46), $M_{age}=59.3$ (SD unreported, range: 57.2–61.3 years)	Patient Health Questionnaire (PHQ-9)	Type 2 diabetes	8-week MBSR sessions without the full-day retreat, duration of each session unreported
Latheef & Latheef, 2017	India	2-arm RCT: MBSR vs. TAU with 3 timepoints (pre and post-tests, and 1-month FU)	$N=38$ MBSR group: $n=18$ (male: 7, female: 11), M_{age} unreported (range: 35–59 years) MBSR group: $n=20$ (male: 8, female: 12), M_{age} unreported (range: 35–59 years)	Center for Epidemiologic Studies Depression Scale (CES-D) & Perceived Stress Scale (PSS) & Mindfulness Attention Awareness Scale (MAAS)	Type 2 diabetes	8-week MBSR sessions (2.5 h per session) without the full-day retreat
Nathan et al., 2017	Canada	2-arm RCT: MBSR vs. waiting list with 3 timepoints (pre and post-tests, and 3-month FU)	$N=62$ MBSR group: $n=30$ (male: 15, female: 15), $M_{age}=59.7$ (SD $=9.1$) Control group: $n=32$ (male: 12, female: 20), $M_{age}=59.8$ (SD $=8.7$)	Patient Health Questionnaire (PHQ-9) & Perceived Stress Scale (PSS)	Type 1 & 2 diabetes	8-week MBSR sessions (2.5 h per session) with the full-day retreat

TABLE 1 (Continued)

Authors, year	Country	Research design	Demographic information	Scales	Diabetes types	MBSR protocol
Ravari et al., 2020	Iran	2-arm RCT: MBSR vs. TAU with 2 timepoints (pretest and post-tests)	$N = 101$ adult women MBSR group: $n = 50$, $M_{age} = 56.4$ (SD = 4.57) Control group: $n = 51$, $M_{age} = 57.70$ (SD = 5.65)	Depression Anxiety Stress Scales (DASS)	Type 2 diabetes	8-week MBSR sessions (2.5 h per session) without the full-day retreat
Rozworska et al., 2020	Canada	2-arm RCT: MBSR vs. waiting list with 3 timepoints (pre and post-tests, and 3-month FU)	$N = 62$ MBSR group: $n = 30$ (male: 15, female: 15), $M_{age} = 59.7$ (SD = 9.1) Control group: $n = 32$ (male: 12, female: 20), $M_{age} = 59.8$ (SD = 8.7)	Five Facet Mindfulness Questionnaire (FFMQ)	Type 1 & 2 diabetes	8-week MBSR sessions (2.5 h per session) with the full-day retreat

Note: FU = follow-up timepoint; TAU = treatment as usual; RCT = randomised controlled trial; M_{age} = mean age; SD = standard deviation.

[a]Data in the two articles were from the same studies.

Study name	Group by Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	p-Value
		Statistics for each study					
Chen et al. 2021	Anxiety	-2.701	0.203	0.041	-3.099	-2.303	0.000
Hamidi et al. 2020	Anxiety	-4.339	0.275	0.076	-4.878	-3.800	0.000
Ravari et al. 2020	Anxiety	-0.240	0.198	0.039	-0.629	0.149	0.226
	Anxiety	-2.407	0.625	0.390	-3.631	-1.183	0.000
Chen et al. 2021	Depression	-2.191	0.260	0.067	-2.700	-1.682	0.000
Ravari et al. 2020	Depression	-0.106	0.198	0.039	-0.493	0.282	0.592
Ellis et al. 2019	Depression	-0.788	0.358	0.128	-1.491	-0.086	0.028
Hartmann et al. 2012	Depression	-0.060	0.142	0.020	-0.338	0.218	0.673
Latheef & Latheef 2017	Depression	-2.881	0.459	0.210	-3.780	-1.982	0.000
Nathan et al. 2017	Depression	-0.878	0.263	0.069	-1.394	-0.363	0.001
	Depression	-1.110	0.448	0.201	-1.988	-0.232	0.013
Ravari et al. 2020	HbA1C	-0.527	0.201	0.040	-0.921	-0.133	0.009
Ellis et al. 2019	HbA1C	0.054	0.345	0.119	-0.622	0.729	0.876
Hartmann et al. 2012	HbA1C	0.126	0.142	0.020	-0.152	0.404	0.375
	HbA1C	-0.118	0.626	0.392	-1.345	1.110	0.851
Latheef & Latheef 2017	Mindfulness	3.097	0.477	0.227	2.163	4.032	0.000
Rozworska et al. 2020	Mindfulness	0.722	0.259	0.067	0.214	1.230	0.005
	Mindfulness	1.834	0.794	0.630	0.278	3.391	0.021
Ravari et al. 2020	Stress	-0.166	0.198	0.039	-0.554	0.222	0.401
Ellis et al. 2019	Stress	-0.183	0.345	0.119	-0.860	0.494	0.597
Hartmann et al. 2012	Stress	-0.065	0.142	0.020	-0.343	0.213	0.647
Latheef & Latheef 2017	Stress	-2.221	0.407	0.166	-3.019	-1.422	0.000
Nathan et al. 2017	Stress	-0.552	0.256	0.065	-1.054	-0.051	0.031
Jung et al. 2015	Stress	0.616	0.327	0.107	-0.025	1.257	0.060
	Stress	-0.409	0.448	0.200	-1.287	0.469	0.361

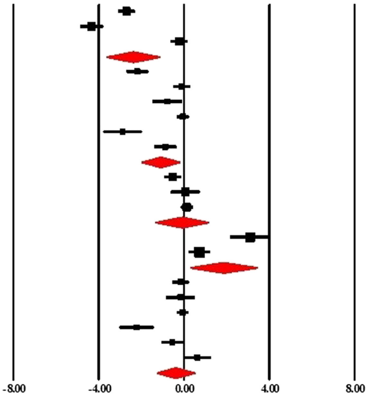

FIGURE 2 The forest plot of the between-group comparison at the post-test timepoint.

Study name	Group by Outcome	Hedges's g	Standard error	Variance	Lower limit	Upper limit	p-Value
		Statistics for each study					
Ellis et al. 2019	Depression	-0.143	0.345	0.119	-0.819	0.534	0.679
Hartmann et al. 2012	Depression	-3.926	0.243	0.059	-4.402	-3.450	0.000
Latheef & Latheef 2017	Depression	-6.112	0.770	0.593	-7.621	-4.603	0.000
Nathan et al. 2017	Depression	-1.120	0.270	0.073	-1.650	-0.590	0.000
	Depression	-2.717	0.912	0.831	-4.504	-0.930	0.003
Ellis et al. 2019	HbA1C	-0.157	0.380	0.145	-0.902	0.589	0.681
Hartmann et al. 2012	HbA1C	-2.139	0.178	0.032	-2.488	-1.790	0.000
	HbA1C	-1.165	1.268	1.607	-3.650	1.320	0.358
Latheef & Latheef 2017	Mindfulness	4.514	0.608	0.369	3.323	5.705	0.000
Rozworska et al. 2020	Mindfulness	1.008	0.267	0.071	0.485	1.531	0.000
	Mindfulness	2.683	1.292	1.671	0.149	5.216	0.038
Ellis et al. 2019	Stress	-0.114	0.345	0.119	-0.790	0.562	0.741
Hartmann et al. 2012	Stress	-2.791	0.200	0.040	-3.183	-2.399	0.000
Latheef & Latheef 2017	Stress	-3.678	0.528	0.279	-4.714	-2.643	0.000
Nathan et al. 2017	Stress	-0.996	0.266	0.071	-1.519	-0.474	0.000
	Stress	-1.876	0.902	0.813	-3.643	-0.109	0.037

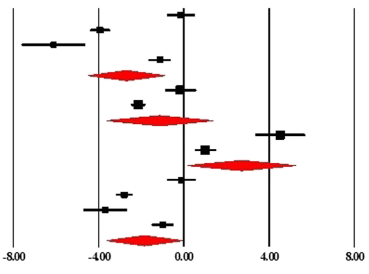

FIGURE 3 The forest plot of the between-group comparison at the follow-up test timepoint.

Test of RQ2: The long-term effects of MBSR on the outcomes at follow-up

Of the 10 included studies, four studies reported effects of MBSR on both depression and stress between the MBSR and control groups at follow-up (Ellis et al., 2019; Hartmann et al., 2012; Latheef & Latheef, 2017; Nathan et al., 2017). Data of the effect sizes on anxiety at follow-up were unavailable. As presented in Figure 3, the pooled effect size showed that the MBSR intervention had a large effect size on depression (Hedges' $g = -2.717$, 95% CI [−4.504, −0.930], $p = .003$), and stress (Hedges' $g = -1.876$, 95% CI [−3.643, −0.109], $p = .037$). That is, depression and stress were significantly lower in the MBSR group than the control group by 2.717 and 1.876 standard deviations, respectively. The I^2 value suggested substantial heterogeneity in depression ($I^2 = 97.646$, $p < .001$) and stress ($I^2 = 95.682$, $p < .001$).

Two studies reported the between-group effect sizes for HbA1C (Ellis et al., 2019; Hartmann et al., 2012). As presented in Figure 3, the pooled effect size for HbA1C (Hedges' $g = -1.165$, 95% CI [−3.650, 1.320], $p = .358$) indicated that MBSR did not have a significant effect on HbA1C, with substantial heterogeneity ($I^2 = 95.511$, $p < .001$).

Two studies reported the MBSR between-group effects at follow-up (Latheef & Latheef, 2017; Rozworska et al., 2020). As presented in Figure 3, the pooled effect size for mindfulness (Hedges' $g = 2.683$, 95% CI [0.149, 5.216], $p = .038$) indicated that MBSR had a large effect size on mindfulness. That is, mindfulness was significantly higher by 2.683 standard deviations in the MBSR group than the control group, with substantial heterogeneity ($I^2 = 96.417$, $p < .001$).

Meta-regression was performed, indicating that moderators of country (Q = 6.09, $df = 3$, $p = .090$), sample size (Q = 3.52, $df = 1$, $p = .061$), diabetes type (Q = 5.49, $df = 2$, $p = .064$), the type of control group (Q = 1.08, $df = 1$, $p = .298$), and MBSR protocol (Q = 5.49, $df = 2$, $p = .064$) were found to not be predictive of the heterogeneity. The measure (Q = 1.81, $df = 4$, $p = .006$) and publishing year (Q = 9.27, $df = 1$, $p = .002$) were found to be accountable for the substantial heterogeneity.

Publication bias was not detected, as indicated by the nonsignificance of the two-tailed Begg–Mazumdar test (Kandell's tau = 0.136, $p = .537$), and the Egger's test (intercept = 4.771, $t = 0.931$, $df = 10$; $p = .374$).

Two studies (Kian et al., 2018; Kopf et al., 2014) were not included in the meta-analysis due to insufficient data. Kopf et al.'s (2014) study indicated that the MBSR intervention group showed a lower level of stress in the MBSR group at the one-year follow-up, but not at the two- and three-year follow-ups, and effects on HbA1c were not observed at all three follow-ups. Kian et al.'s (2018) study reported that depression, anxiety, and HbA1C were significantly lower at follow-up in the MBSR group.

Sensitivity analysis

Four sensitivity analyses were performed to determine the robustness of the results (Tables S5 to S8). Removing two studies employing modified MBSR (Ellis et al., 2019; Jung et al., 2015) did not change the significance and the direction of the effect on all outcomes at both post-intervention and follow-up (Tables S5 and S6). Removing one study with a follow-up period of 12 months (Hartmann et al., 2012) did not change the significance and the direction of the effect on all outcomes at both post-intervention and follow-up. However, at follow-up, the evidence for stress was changed from significant ($p = .037$) to nonsignificant ($p = .141$), and the direction of the effect remained unchanged (Tables S7 and S8).

DISCUSSION

The aim of our systematic review and meta-analysis was to determine if MBSR had a beneficial effect on the mental health outcomes, HbA1C levels, and mindfulness of diabetes patients. Eleven articles reporting 10 studies with 718 participants were included.

Our meta-analysis results show that MBSR demonstrated large and clinically significant effects in reducing anxiety and depression symptoms at post-intervention, and the reductions were maintained at follow-up (in a period between one to 12 months with a mean length of 4.3 months). Our findings also show that participants in the MBSR group were more mindful at post-intervention compared to the control group and that the gains were maintained at the follow-up. Our findings are consistent with Khoury et al.'s (2013) review, which found that the mindfulness-based therapy group had reduced anxiety and depression and improved mindfulness at both post-intervention and follow-up compared to the control group. According to Kabat-Zinn (2013), MBSR supports people to cultivate meditative awareness by paying attention to the present moment, practicing the self-regulation of attention, and coping with stress by responding instead of reacting to stress. As a result, people with diabetes may feel more in control of their anxious mood and more aware of their current emotion with attitudes of nonjudgement and acceptance, which may contribute to the decrease in anxiety and depression levels and the improvement in mindfulness. The improvements in anxiety and depression conditions are encouraging because MBSR could be employed as an alternative to the conventional therapies, such as cognitive behavioural therapy, for improving mental health among diabetes patients.

Our findings show that the effects of MBSR on reducing stress are less conclusive. The reduction of stress was observed at follow-up, but not at post-intervention. The findings are interesting because MBSR is designed to reduce stress as indicated in its name. The sensitivity analysis suggests that effects on stress at follow-up disappeared after removing the study with a follow-up period of 12 months. This result suggests that the effects of MBSR on stress may emerge over time. It is possible that a change in stress may be more difficult to be observed in a short period, immediately after the eight-week intervention, due to difficulties and complication in diabetes management that contribute to chronic stress among people with diabetes. Moreover, in the included studies, the stress levels were assessed using self-reported measures, which might lead to response bias. Furthermore, due to the frustration related to diabetes management, long-term complications of diabetes and the uncontrollability and unpredictability of blood glucose levels, diabetes patients often have high levels of chronic stress (Ellis et al., 2019). The self-reported measures of stress may not accurately capture chronic stress. Hence, the biomarker of chronic stress (saliva, hair, or nail cortisol) that provides an objective, biological measure of the long-term change in stress (Phillips et al., 2021) is recommended in future studies.

The results of our study show that effects of MBSR on HbA1C levels were not observed at both post-intervention and follow-up. This finding is consistent with Schmidt et al.'s (2018) review which found that mindfulness-based interventions demonstrated little benefits on HbA1C. However, our finding is not consistent with Ni et al.'s (2020) review where HbA1C showed improvements with MBSR and MBCT interventions. Differences in the analytic methods used may contribute to the inconsistency between the current and Ni et al.'s studies. In the Ni et al. study, each outcome was analysed separately without considering the correlations between HbA1C and other outcomes based on the same participants in one study, as was done in the current study.

Analyses of the heterogeneity in the effect sizes suggest that substantial heterogeneity was present. This indicates that the effect sizes of MBSR on mental health outcomes, HbA1C, and mindfulness are high in some populations of diabetes patients and low in others (Borenstein, 2019). Therefore, it is necessary to exercise caution in generalising the results of the present study to all populations of diabetes patients.

The meta-regression analysis in our study suggests that the MBSR protocols (8-week MBSR with/without full-day retreat and shortened MBSR weekly sessions) did not moderate the efficacy of MBSR. This finding warrants future RCTs to assess the effects of low-dose MBSR on the mental health of diabetes patients. Our analysis shows that measures moderated the effectiveness of MBSR. The multiple outcomes model employed in the meta-analysis may contribute to this moderation effect. The multiple outcomes modelling included the outcome variables of stress, anxiety, depression, HbA1C, and mindfulness into one analytic model where the measures varied significantly. Our analysis also find that diabetes types of the participants and publishing year of the studies moderated the effectiveness of MBSR, suggesting that the heterogeneity may be further explained by differences in characteristics of the studies (scales and publishing year) or study populations (diabetes types).

There are limitations of the included studies and our review. First, no included studies provide sufficient data for computing effects of MBSR on anxiety at the follow-up. Second, only two studies reported effects on HbA1C and mindfulness. Therefore, caution needs to be exerted when interpreting the results. Third, no included studies were conducted with First Nations peoples. Future empirical studies are warranted to address these limitations.

Despite the limitations, our findings offer clinical significance within diabetes care. First, although MBSR does not show effectiveness in improving HbA1C, MBSR appears to be an effective intervention for reducing symptoms of anxiety, depression, and stress and improving mindfulness among people with diabetes. Second, using the cortisol level as a measure to evaluate the effectiveness of MBSR in diabetes patients may improve the accuracy of stress assessment and help understand the biological mechanism underlying the relationship of diabetes (e.g. the HbA1C level), chronic stress, anxiety, and depression.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

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DATA AVAILABILITY STATEMENT

Data of this systematic review is available in the supplementary materials.

ETHICS STATEMENT

Not applicable.

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SUPPORTING INFORMATION

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