



Review article

Effectiveness of mindfulness-based intervention in schizophrenia: A meta-analysis of randomized controlled trials

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ABSTRACT

Schizophrenia poses significant societal challenges, including interpersonal tension, an increased risk of suicide, and soaring medical costs. Although antipsychotics can prevent relapses, they often give rise to adverse effects and do not provide lasting relief. Mindfulness-based interventions (MBI) emerge as a hopeful avenue for improving outcomes. However, existing research and meta-analyses of the efficacy of MBI in schizophrenia remain limited. This study aimed to evaluate the efficacy of MBI as an adjunctive therapy for schizophrenia. Relevant randomized controlled trials (RCTs) were searched across PubMed, Embase, Web of Science, and Cochrane Library from inception dates up to January 12, 2023. Statistical analyses were conducted using Stata software (version 15.0) and Review Manager 5.4. The quality of the included RCTs was assessed using the revised Cochrane risk of bias tool. A total of 18 RCTs were included, with 675 patients and 704 health controls. Our meta-analysis revealed that MBI significantly improved psychosocial function, insight, and mindfulness in individuals with schizophrenia. The quality of the included RCTs had a low to moderate risk of bias. These findings suggest that MBI holds promise for improving the mental health of individuals with schizophrenia.

1. Introduction

Schizophrenia is a widely recognized psychotic disorder characterized by a range of symptoms such as hallucinations, delusions, and discernible sensory aberrations, in addition to disturbances in cognition and behaviors (Association, 2013). Apart from these evident manifestations, this multifaceted condition also leads to deficiencies in social cognition, including emotional regulation and awareness, which can profoundly impact the psychosocial function of affected individuals (Marder and Galderisi, 2017). Moreover, clinical insight, strongly associated with poor prognosis, is compromised in a significant proportion of individuals with schizophrenia (50%–80%) (Larabi et al., 2021). Clinical insight embodies an individual's understanding of their condition, attributions of their illness, and recognition of the need for treatment (Larabi et al., 2021; Ouzir et al., 2012).

Antipsychotic medications have long been the mainstream for schizophrenia treatment, providing relief from positive symptoms such as cognitive impairment, delusions, and hallucinations (Keepers et al., 2020). In addition, antipsychotics can stabilize emotions and behavior and curb impulsivity and hostility (Hoptman et al., 2014). However, antipsychotics give rise to many side effects, including movement

disorders (e.g., tremors, muscle stiffness), weight gain, and metabolic complications (e.g., diabetes, hyperlipidemia) (Carbon et al., 2018; Papola et al., 2019). Moreover, long-term use of antipsychotics may lead to cognitive and memory impairments in some patients, thereby impacting their learning and vocational abilities (Leucht et al., 2012). Recent studies have suggested that non-pharmacological therapies, including cognitive behavioral therapy (CBT) and mindfulness-based intervention (MBI), may have the potential to prevent psychotic episodes (Ashcroft et al., 2018; Jones et al., 2018; Pharoah et al., 2010; Xia et al., 2011). MBI is defined as a series of non-pharmacological therapies, including dialectical behavior therapy (DBT), acceptance and commitment therapy (ACT), mindfulness-based relapse prevention, and mindfulness-based stress reduction (Shen et al., 2023; Simkin and Black, 2014). Empirical evidence highlights the prominent role of MBI in the treatment of schizophrenia. MBI is based on the principles of mindfulness and aims to heighten patients' self-awareness of their present experiences, encouraging them to accept their feelings and emotions, instead of judging themselves. Mindfulness practice helps individuals with schizophrenia attenuate hallucinations and delusions, thereby mitigating associated emotional distress (Chien et al., 2017, 2019; Lee, 2019; Wang et al., 2016). In this way, MBI effectively enhances the

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mental health and overall life quality of individuals with schizophrenia. Through the cultivation of mindfulness, patients learn to direct their attention to the present experiences, thereby reducing anxiety about past events and future uncertainties (Gill and Hatcher, 2000; Kadan-Lottick et al., 2005). Mindfulness exercises develop patients' capacity to embrace their inner perceptions, help them better understand and control mood fluctuations, and ultimately alleviate emotional distress (Mistler et al., 2017; Palmer et al., 2012; Ziedonis et al., 2008). This, in turn, facilitates active social engagement, interpersonal associations, and ultimately, the quality of life. Some studies have also demonstrated the efficacy of MBI in enhancing the insight of individuals with schizophrenia. In the broader context, the relationship between insight and treatment compliance is significant, particularly during the treatment period, where improved insight greatly enhances patients' adherence to therapeutic regimens (Bastiaens and Agarkar, 2014).

To date, there have been limited meta-analyses of the efficacy of MBI in individuals with schizophrenia (Hodann-Caudevilla et al., 2020; Im et al., 2021). Although existing meta-analyses suggest that MBI could mitigate symptoms of schizophrenia and reduce the rehospitalization rate (Cramer et al., 2016), these analyses have certain limitations. Some studies included in these meta-analyses lacked a randomized controlled design, a key factor in elucidating the mechanisms of the efficacy of MBI. Moreover, these meta-analyses encompassed not only participants with schizophrenia but also individuals with unipolar and bipolar disorders, which could interfere with the findings. Additionally, two studies from the same dataset (Chien and Lee, 2013; Chien and Thompson, 2014) were included in these meta-analyses (Cramer et al., 2016; Louise et al., 2018), which may lead to bias. Consequently, although these meta-analyses offer valuable insights, they are not sufficient to provide conclusive evidence on the efficacy of MBI in individuals with schizophrenia. Therefore, to fill this knowledge gap, we did a meta-analysis to evaluate the effects of MBI on schizophrenia symptoms, in terms of schizophrenia symptoms, social function, treatment adherence, mindfulness levels, and core self-pattern improvements. We intend to validate the potential benefits of MBI as an adjunctive therapy for individuals with schizophrenia.

2. Methods

2.1. Protocol and registration

This study was registered with the PROSPERO (#CRD42023391532) and reported according to the relevant guidelines in the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) (Radua, 2021).

2.2. Inclusion and exclusion criteria

The PICOS structure (P, participants; I, intervention; C, comparators; O, outcomes, S, study; D, design) was used to frame a clear research question and refine the inclusion and exclusion criteria. Inclusion criteria covered: (1) participants: clinically diagnosed with schizophrenia, and meeting the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders-IV (DSM-4), Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-4-TR), DSM-5, and International Statistical Classification of Diseases and Related Health Problems-11 (ICD-11). Schizophrenia is characterized by two or more of the following symptoms over at least six months: hallucinations, delusions, incoherent speech, disordered thinking, dyskinesia, or persistent negative symptoms such as apathy, reduced speech, and social withdrawal. The individual's daily functioning was significantly affected by these symptoms and the effect of other mental illness or substance abuse had to be ruled out; (2) intervention: at least one experimental group received MBI; (3) comparators: the control group received treatment as usual care/routine care, consistent with clinical practice; (4) outcomes: psychiatric symptom

assessment, hope index, mindfulness, functional recovery, insight and treatment attitude, cognition, and insight; (5) study design: randomized controlled trial (RCT).

Articles were excluded if they met the following reasons: (1) duplicate publications; (2) potential sample overlap; (3) non-RCTs, systematic reviews, and meta-analyses; (4) studies involving non-participants with schizophrenia; (5) non-English literature; (6) studies lacking sufficient, necessary information, or outcome measures; (7) studies with substandard quality, characterized by sampling bias or inappropriate methodology; (8) schizoaffective/schizophreniform/spectrum patients.

2.3. Search strategy

Two researchers (Jiahong Li and Huiling Cai) searched for articles in PubMed, Embase, Web of Science, and Cochrane Library from inception to January 12, 2023. Medical Subject Heading (MeSH) terms and keywords were utilized for the literature search. The MeSH terms included "schizophrenia", "psychotic disorders", "psychosis", "mindfulness", and "mindfulness-based stress reduction". The keywords were derived from the MeSH terms and identified through searches of PubMed and Embase, as well as published meta-analyses and reviews. The literature search strategy is detailed in Supplementary Table S1.

2.4. Study selection and data extraction

Two reviewers (Keke Qin and Jingyuan Zeng) independently screened these retrieved studies. Initially, all these studies were imported into EndNote X9, and duplicates were identified and removed using automated and manual methods. Subsequently, the titles and abstracts of the remaining articles were screened, followed by a thorough full-text review. Additionally, the reference lists of relevant publications were reviewed for matching articles. Any uncertainties or discrepancies during the full-text review were addressed through discussions with a third reviewer (Yong Yu) to achieve consensus.

Data from eligible studies were independently extracted by two reviewers (Huolan Liang and Jiahong Li). The extracted information encompassed the first author, publication year, study design, setting/country, participant demographics, and characteristics (including the number of cases, age, and gender distribution), details of interventions, treatment duration, types of intervention, and outcome measures. Any disagreements were resolved through consultation with a third reviewer (Keke Qin).

2.5. Quality assessment

The quality of the included studies was independently evaluated by two reviewers (QKK and YY) using the revised Cochrane risk of bias assessment tool (Higgins et al., 2016). The bias from five domains (randomization procedure, deviation from the intended intervention, missing outcome data, outcome measurement, and selected reporting) was rated as "low," "high," or "moderate". Review Manager (RevMan 5.3) was employed to construct tables presenting the risk of bias assessment results.

2.6. Statistical analysis

Stata software (version 15.1, Stata Corp, College Station, TX) was utilized for data synthesis and meta-analysis. Standardized mean differences (SMD) with 95 % confidence intervals (CI) were computed to estimate the pooled mean effect sizes.

If a single research study presented with multiple arms, only the relevant arms and pooled appropriate data were included. A random-effects model was utilized to pool individual effect sizes. The primary outcomes were categorized based on follow-up duration, and outcome data immediately after intervention were collected for meta-analysis. Funnel plots and Egger's test were used to assess the publication bias

across studies.

3. Results

3.1. Study selection

The initial database search retrieved 15,130 articles, and additional 320 articles were selected from references in earlier reviews and research. After duplications were eliminated, 13,165 articles were reviewed based on the titles and abstracts, of which 13,088 articles were removed and the remaining 77 articles for full-text assessment. Among them, 59 studies were excluded according to our predefined eligibility criteria. Ultimately, 18 eligible studies were included in our analysis. The literature selection process is detailed in Fig. 1.

3.2. Study characteristics

We included 18 studies with 1379 individuals with schizophrenia (Böge et al., 2021; Chadwick et al., 2009, 2016; Chien et al., 2017, 2019; Chien and Lee, 2013; Chien and Thompson, 2014; Lam et al., 2020; Langer et al., 2012; Lee, 2019; Moussaoui et al., 2022; Özdemir and Kavak Budak, 2022; Shawyer et al., 2017; Shen et al., 2023; Shieh et al., 2018; Tang et al., 2021; Wang et al., 2016; Yılmaz and Okanlı, 2018; Yüksel and Bahadır-Yılmaz, 2021). Most eligible studies (50 %) were published within the last five years. Among the 18 studies, 16 were RCTs (Böge et al., 2021; Chadwick et al., 2009, 2016; Chien et al., 2017, 2019;

Chien and Lee, 2013; Chien and Thompson, 2014; Lam et al., 2020; Langer et al., 2012; Lee, 2019; Moussaoui et al., 2022; Özdemir and Kavak Budak, 2022; Shawyer et al., 2017; Shen et al., 2023; Shieh et al., 2018; Tang et al., 2021; Wang et al., 2016) and two were case-control studies (Yılmaz and Okanlı, 2018; Yüksel and Bahadır-Yılmaz, 2021). These investigations spanned geographical locations, with 10 studies conducted in Chinese-speaking nations (Chien et al., 2017, 2019; Chien and Lee, 2013; Chien and Thompson, 2014; Lam et al., 2020; Lee, 2019; Shen et al., 2020; Shieh et al., 2018; Tang et al., 2021; Wang et al., 2016), and the remaining 8 undertaken in Turkey (Özdemir and Kavak Budak, 2022; Yılmaz and Okanlı, 2018; Yüksel and Bahadır-Yılmaz, 2021), the UK (Chadwick et al., 2009, 2016), Germany (Böge et al., 2021), Australian (Shawyer et al., 2017) and Spain (Langer et al., 2012). MBI was given to the intervention group, whereas the control group received no treatment or medication only or was managed by treatment as usual (TAU) or waitlist approach. Importantly, MBI was delivered in a group setting. Table 1 shows the characteristics of the included studies.

3.3. Study quality and sensitivity analysis

Fig. 2 presents the risk of bias assessment results. In the meta-analysis of Risk of Bias, several studies exhibited a moderate to high risk in key bias domains. For example, the studies by Lam et al. (2020), Yüksel et al. (2021), Özdemir et al. (2022), Shieh et al. (2018), and Yılmaz et al. (2018) demonstrated a high risk of performance bias due to challenges in the blinding of participants and personnel. Such bias often

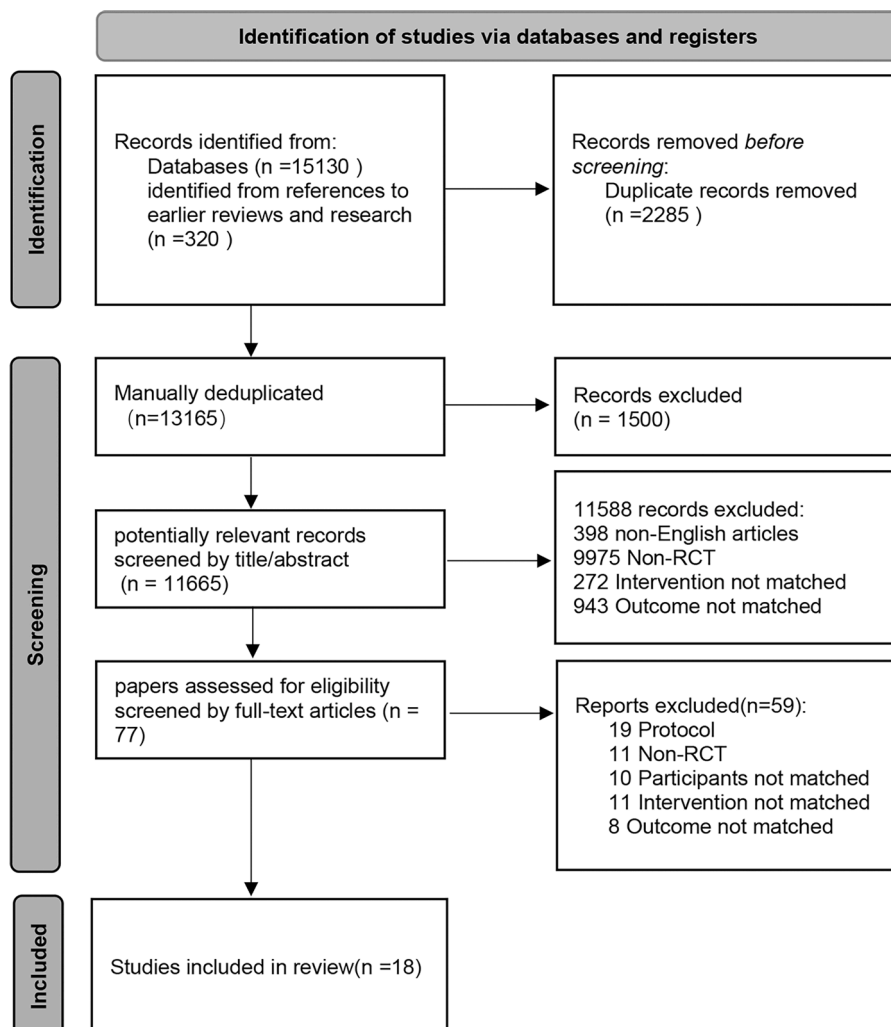


Fig. 1. Flowchart of literature screening.

Table 1
Study characteristics of the included studies.

First author	Year	Study design	Country	Number of cases experimental group	control group	intervention experimental group	Control group	treatment course	diagnostic tool
Wai Tong Chien	2019	RCT	China	56	56	MPGP	Medication only	6 Months	DSM-4-TR
Arzu Yüksel	2021	CCS	Turkey	19	19	MBPST	Do nothing	11 weeks	DSM-5
Aysel A. Özdemir	2022	RCT	Turkey	40	56	MBSR	Do nothing	16 weeks	DSM-5
Qiubi Tang	2021	RCT	China	31	31	MBCT	TAU	8 weeks	DSM-5
Kerem Böge	2021	RCT	Germany	18	20	MBGT+TAU	TAU	4 weeks	DSM-5& ICD-10
Angie Ho Yan Lam	2020	RCT	China	24	22	MBPP	TAU	8 weeks	DSM-4-TR& DSM-V
Emine Yilmaz	2018	CCS	Turkey	21	24	MBPST	TAU	8 weeks	DSM-5
Frances Shawyer	2017	RCT	Australian	49	47	ACT	TAU	8 weeks	DSM-5
Wai Tong Chien	2014	RCT	China	36	35	MBPP	TAU	24 months	DSM-4-TR
Álvaro I. Langer	2012	RCT	Spain	7	11	MBCT	TAU	10 weeks	DSM-4-TR
Paul Chadwick	2009	RCT	UK	11	11	MBGT	Do nothing	9weeks	DSM-4
Hui Shen	2023	RCT	China	50	50	MBI	Usual care	6weeks	DSM-4
Paul Chadwick	2016	RCT	UK	54	54	PBCT+TAU	waiting list	12 weeks	DSM-4-TR
Wai Tong Chien	2013	RCT	China	48	48	MBPP	Do nothing	3 months	DSM-5
Wai Tong Chien	2017	RCT	China	114	114	MBPEG	TAU	6months	DSM-4
Kun-Hua Lee	2019	RCT	China	30	30	MBI	TAU	8 weeks	DSM-4
Bi-Ling Shieh	2018	RCT	China	21	30	MBT	TAU	8 weeks	DSM-4
li-Qun Wang	2016	RCT	China	46	46	MPGP+ TAU	TAU	24weeks	DSM-4-TR

Notes. MBRT: mindfulness-based reduction training; MPGP: a mindfulness-based psycho-education group programme; MOIs: Brief mindfulness-oriented interventions; MBPST: mindfulness-based psychosocial skills training; MBSR: Mindfulness-based stress reduction training; MBCT: mindfulness-based cognitive therapy; MBGT: mindfulness-based group therapy; MBPP: The mindfulness-based psychoeducation programme; MBI: mindfulness-based intervention; PBCT: Group Person-Based Cognitive Therapy; MBPEG: mindfulness-based psychoeducation group; ACT : acceptance commitment therapy; TAU: Treatment-as-usual only; RCT: randomized controlled trial; CCS: Case-control study; DSM-4: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; DSM-4-TR: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision; DSM-5: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; ICD-10: International Statistical Classification of Diseases and Related Health Problems-11.

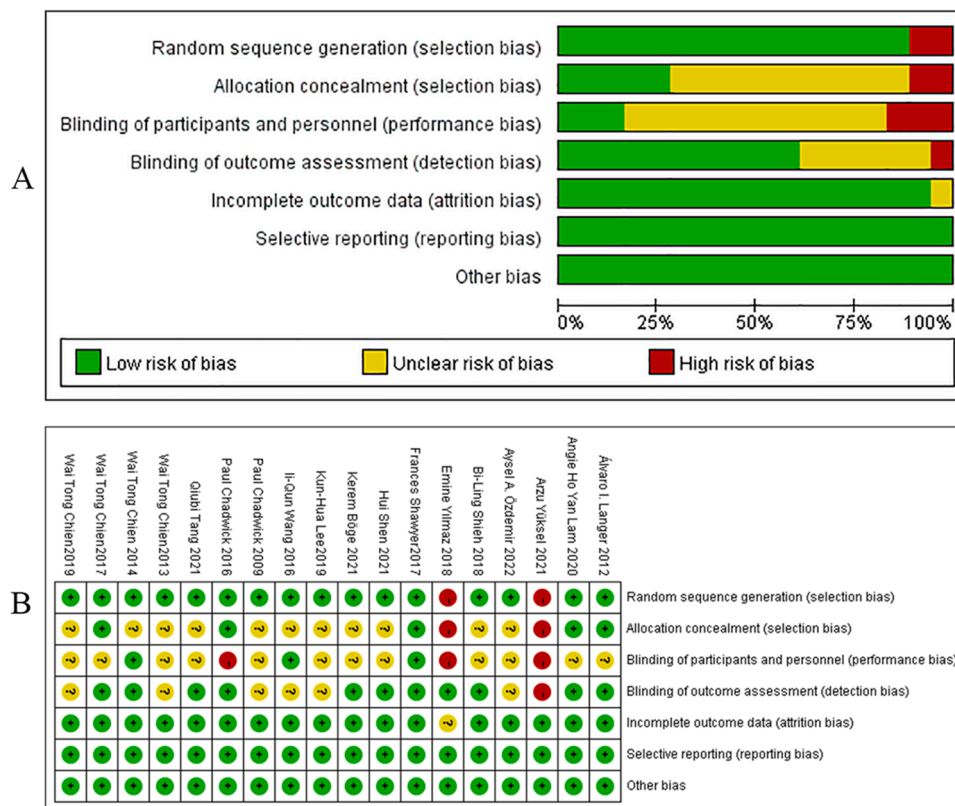


Fig. 2. (A) Risk of bias graph; (B) Risk of bias assessment summary.

arises when the nature of the intervention prevents effective blinding, as changes in behaviors or expectations may affect outcomes (Lam et al., 2020; Shieh et al., 2018). Furthermore, the risk of selection bias is

increased in the studies by Lam et al. (2020) and Shieh et al. (2018), possibly due to insufficient concealment of allocation that could lead to predictable assignment to intervention groups (Lam et al., 2020; Shieh

et al., 2018). Chadwick et al. (2009) showed high risks in three domains: selection bias in random sequence generation and allocation concealment, and reporting bias in selective reporting. Concerns regarding the reliability of the reported findings may arise as a consequence of poorly described randomization processes, inadequate concealment, and the omission of some pre-specified outcomes (Chadwick et al., 2009).

3.3. Meta-analysis outcomes

3.3.1. Individuals with schizophrenia symptoms

Among the 18 studies included in our meta-analysis, 9 studies (Chien et al., 2017, 2019; Chien and Lee, 2013; Chien and Thompson, 2014; Lee, 2019; Moussaoui et al., 2022; Shawyer et al., 2017; Shen et al., 2020; Shieh et al., 2018; Wang et al., 2016) assessed individuals with schizophrenia symptoms. Among them, seven studies (Chien et al., 2017, 2019; Lee, 2019; Shawyer et al., 2017; Shen et al., 2020; Shieh et al., 2018; Wang et al., 2016) utilized the Positive and Negative Syndrome Scale (PANSS) to gauge psychiatric symptoms, while the remaining two (Chien and Lee, 2013; Chien and Thompson, 2014; Moussaoui et al., 2022) employed the Brief Psychiatric Rating Scale (BPRS). Both PANSS and BPRS are widely recognized tools for assessing the severity of symptoms associated with mental illness. Typically, these assessments are conducted by qualified healthcare professionals to help diagnose and continuously monitor mental health conditions. Given the different measurement scales, we conducted separate meta-analyses for

PANSS and BPRS scales (Fig. 3A). The analysis results revealed the significant role of MBI in alleviating schizophrenia symptoms, as reflected by both PANSS Scale (SMD = -1.23, 95 % CI: -1.40, -1.06, $p = 0.000$) and BPRS Scale (SMD = -0.56, 95 % CI: -0.87, -0.25, $p = 0.000$). Notably, substantial heterogeneity was observed in PANSS assessments across studies ($I^2 = 95.3\%$). The Begg's test was employed to assess potential publication bias, and the results demonstrated non-significant asymmetry (PANSS, $p = 0.548$; BPRS, $p = 1.000$).

3.3.2. Psychosocial functioning

Seven studies (Chien et al., 2017, 2019; Chien and Lee, 2013; Chien and Thompson, 2014; Özdemir and Kavak Budak, 2022; Wang et al., 2016; Yılmaz and Okanlı, 2018) assessed the psychosocial functioning of individuals with schizophrenia, using Functional Remission of General Schizophrenia (FROGS) scale and Specific Levels of Functioning Scale (SLOF). These assessment tools are designed to provide clinicians and researchers with a comprehensive understanding of how individuals with schizophrenia perform in diverse functional domains. These domains reflect the effectiveness of psychiatric treatments, particularly their performance in daily living activities. The analysis unveiled an effect size of 1.74 (SMD = 0.54, 95 % CI: 0.20, 0.88, $p = 0.002$) for the SLOF scale, indicating positive impacts of MBI on psychosocial functioning recovery in individuals with schizophrenia compared to the controls (Fig. 3B). A similar pattern emerged in the FROGS scale (SMD = 1.67, 95 % CI: 1.47, 1.86, $p = 0.002$), where the results underscored the

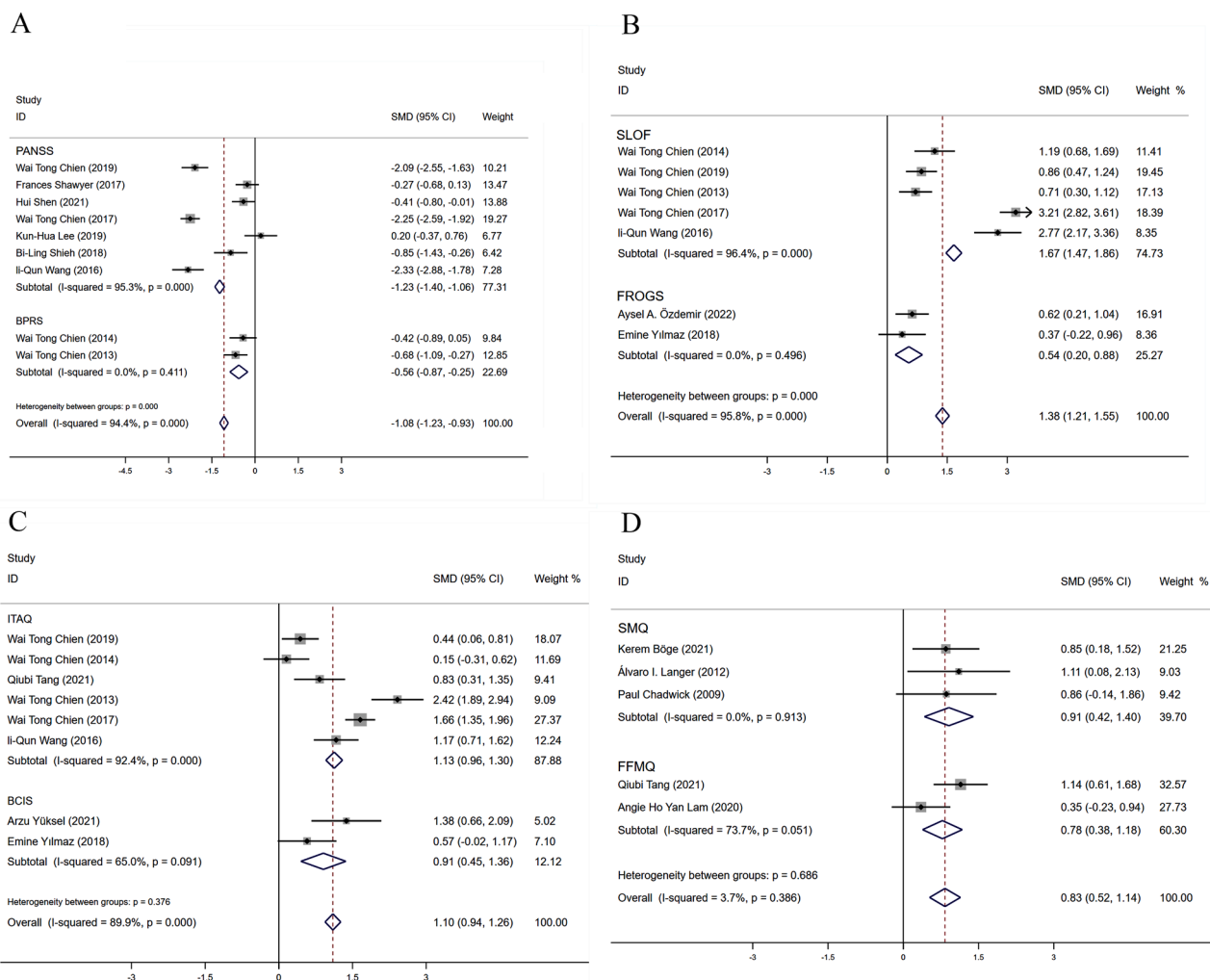


Fig. 3. (A) Effects of MBI on people with schizophrenia symptoms; (B) Psychosocial functioning profiles of individuals with schizophrenia; (C) Insight in patients with schizophrenia; (D) Mindfulness levels.

beneficial impact of MBI. Only the SLOF scale showed significant heterogeneity ($I^2 = 96.4\%$). There was no evidence of publication bias for either scale (SOLF, $p = 0.806$; FROGA, $p = 0.902$).

3.3.3. Insight

Six studies (Chien et al., 2017, 2019; Chien and Lee, 2013; Chien and Thompson, 2014; Tang et al., 2021; Wang et al., 2016) employed the Insight and Treatment Attitudes Questionnaire (ITAQ) to assess the insight into psychiatric illness and the need for treatment among individuals with schizophrenia. The ITAQ holds significant value for clinicians or researchers as it enables them to evaluate a patient's level of self-awareness regarding their mental health condition, understanding of treatment choices, and willingness to actively participate in their treatment plan (Michalakeas et al., 1994). Our analysis demonstrated that MBI significantly enhanced insight and treatment engagement (SMD = 1.13, 95 % CI: 0.96, 1.30, $p < 0.001$) (Fig. 3C). However, we observed substantial heterogeneity ($I^2 = 92.4\%$). The Begg's Test revealed no significant asymmetry, indicating no publication bias ($p = 1.000$).

Additionally, two studies utilized the Brief Core Schema Scales (BCIS) to assess core beliefs and cognitive patterns in individuals with schizophrenia. This tool assesses how individuals perceive and interpret information about themselves and their surroundings, and measures the influence of these beliefs on their emotions and behaviors. Our analysis revealed the significant effects of MBI on core beliefs and cognitive structures in individuals with schizophrenia (SMD = 0.91, 95 % CI: 0.45, 1.36, $p = 0.000$) (Fig. 3C), with no publication bias for either scale (ITAQ, $p = 1.000$; BCIS, $p = 1.000$).

3.3.4. Mindfulness

Five studies (Böge et al., 2021; Chadwick et al., 2009; Lam et al., 2020; Langer et al., 2012; Tang et al., 2021) employed two tools, namely the Five Facet Mindfulness Questionnaire (FFMQ) and the Southampton Mindfulness Questionnaire (SMQ) to assess mindfulness. The FFMQ focuses on five dimensions of mindfulness, including awareness, description, behavioral control, non-judgmental attitudes, and non-reactive attitudes to comprehensively assess various aspects of mindfulness (Carpenter et al., 2019). Meanwhile, the SMQ assesses mindfulness through awareness, non-judgmental attitude, non-reactive attitude, acceptance, and affective regulation (Chadwick et al., 2008). These tools offer valuable insights to researchers and clinicians regarding an individual's mindfulness levels, facilitating the research of MBI effectiveness and its impact on overall quality of life. Our meta-analysis using a fixed-effects model revealed an overall effect size of 0.83 (95 % CI: 0.52, 1.14, $p < 0.001$), indicating the significant role of MBI in promoting mindfulness among individuals with schizophrenia (Fig. 3D). Moreover, our results demonstrated significant effects of MBI, as shown by SMQ (SMD = 0.91, $I^2 = 0.0\%$, 95 % CI: 0.42, 1.4, $p < 0.000$) and FFMQ (SMD = 0.78, 95 % CI: 0.38, 1.18, $p < 0.001$) results. Begg's test did not indicate any risk of bias for either the FFMQ ($p = 1.000$) or SMQ ($p = 1.000$).

3.4. Sensitivity analysis

Sensitivity analysis affirmed the robustness of our meta-analysis results. During this analysis, we identified isolated deviations in the results of schizophrenia symptoms and insight, specifically associated with studies by Chien et al. (2017, 2019). However, further investigation indicated that these deviations did not compromise the reliability and robustness of the evaluation results.

4. Discussion

This systematic review represents the most thorough investigation to date of MBI in alleviating various symptoms associated with schizophrenia. The results of meta-analyses underscore the potential of MBI to

improve schizophrenia symptoms, psychosocial functioning, insight, and mindfulness among individuals with schizophrenia. In further elaboration, we will delve into the pivotal findings in a more comprehensive manner.

First, our investigation suggested that MBI might have a beneficial effect on alleviating psychiatric symptoms in individuals with schizophrenia, as indicated by assessment results of PANSS and BPRS scales. Our findings aligned with recent studies (Barbieri and Visco-Comandini, 2020; Böge et al., 2020; Liu et al., 2021), which demonstrated the efficacy of MBI in ameliorating schizophrenia symptoms compared to control interventions. The substantial relief in psychiatric symptoms can be primarily attributed to the effect of regulating emotions, mitigating cognitive impairment, and reducing stress by enabling patients to perceive and embrace their present thoughts, emotions, and physical sensations (Doron et al., 2020). This fundamental principle of MBI provides a constructive tool for patients to effectively cope with and mitigate the distress associated with schizophrenia.

Second, our findings indicated that MBI could enhance the daily functioning of individuals with schizophrenia, especially as suggested by possible effects on the SLOF scale. This underscores the potential benefits of MBI for the rehabilitation of individuals with schizophrenia, consistent with a recent study (Tong et al., 2016). The improvements in self-care skills, social interactions, and professional competence observed in daily life all stem from MBI's role in cultivating attention and self-awareness. The principles of mindfulness include focusing on the present experience while reducing judgments and reactions, which alleviates anxiety, emotional turmoil, and cognitive interference and improves daily functioning. Additionally, MBI can enhance patients' psychosocial functions, including cognitive abilities and further advance functional capacity.

Third, our analysis elucidated the efficacy of MBI in bolstering insight among individuals with schizophrenia, in support with the research results of Bulzacka et al. (2018) and Tseng et al. (2022). Mindfulness guides patients to pay their attention to the present moment, including thoughts, emotions, and physical sensations, thereby enhancing the awareness of their symptoms and emotional reactions (Williams et al., 2006). MBI also empowers patients to deal with these experiences without judgment and criticism, thereby reducing self-blame, anxiety, and ultimately resistance to treatment.

We observed a significant enhancement in mindfulness among hospitalized people with schizophrenia following MBI, in agreement with prior meta-analyses (Jansen et al., 2020). The core mechanisms of mindfulness cover attentional control, emotion regulation, and self-awareness, which are typically compromised in individuals with schizophrenia (Tang et al., 2015). Mindfulness training helps individuals with schizophrenia accept both pleasant and unpleasant experiences without judging or rushing to avoid or change them. This not only helps with mood regulation but also reduces inhibitory behaviors, improves motivation for initiative, and fosters hope and positive attitudes (Tabak et al., 2015). These changes may ameliorate negative symptoms and improve their prognosis (Tabak et al., 2015).

However, our analysis noted heterogeneity across studies. Subgroup analysis of schizophrenia symptoms showed that the primary source of heterogeneity stemmed from the FROGS scale. Furthermore, other sources of heterogeneity involve various factors. First, differences in study design, including sample selection, interventions, measurement tools, and research methodologies, could contribute to divergent outcomes. Second, because of the wide geographical distribution of the included studies, distinct demographic traits, medical history, and disease severity could influence the study results. Third, there were differences in MBI methods among different studies, such as mindfulness meditation forms, program durations, and intervention frequencies, which may lead to result heterogeneity. The multifaceted nature of MBI matters greatly. Different investigators and clinicians may adopt diverse intervention strategies and procedures, resulting in substantial differences in MBI effectiveness across studies. The heterogeneity is further

compounded by differences in intervention methods, study designs, and participant profiles. Therefore, the current meta-evidence supports the effectiveness of MBI for schizophrenia, while promising, it calls for more well-designed RCTs to confirm these findings and explain the observed heterogeneity.

Our findings have some limitations. First, in some comparisons, the available data came from a limited number of studies, and in some cases, only two studies were included. This limited data bring uncertainty to our effect estimates. Consequently, the CI for the effect estimate may span a wide range and affect the accuracy of the effect size. Second, certain reservations or significant risks of bias were observed in the included RCTs. For instance, in the absence of blinding of participants and personnel (performance bias), potential bias was introduced. In investigations involving psychotherapy, it is often not feasible to conceal the identity of the therapist and patient, thereby creating an inherent bias. Third, it is essential to acknowledge the diversity of MBIs, each with unique features and emphases. Examples include Mindfulness-Based Stress Reduction (MBSR), Mindfulness-Based Cognitive Therapy (MBCT), and various tailored therapies for specific populations or contexts (Chiesa and Malinowski, 2011). Finally, we could not perform subgroup analyses to explore potential differences in the effects of different MBI types. This limitation came from available data, as many studies did not specify the type of MBI used or incorporated multiple approaches within a single study. Despite these limitations, our meta-analysis offers valuable insights into the role of MBIs in the management of schizophrenia, laying the groundwork for future in-depth investigations into how specific MBI modalities have different effects on treatment outcomes.

Despite the potential benefits of MBI for schizophrenia, the relevant literature is relatively sparse. There are several possible reasons for this. First is resource limitations. Mental health services often face challenges of underfunding, which limits the ability to research new therapeutic approaches, especially in the realm of non-pharmacological interventions (Mojtabai et al., 2011). The second is time constraints. The treatment of schizophrenia requires persistent and ongoing care, and the implementation and evaluation of MBI often necessitate prolonged durations, potentially resulting in time constraints for research (Penttilä et al., 2014). Moreover, individuals with schizophrenia often confront considerable obstacles in obtaining care and support services, which may hinder their involvement in MBI programs (Davis and Kurzban, 2012).

To incorporate MBI into clinical practice, it is essential first to increase awareness and research regarding MBI as a treatment option for schizophrenia. This includes conducting more clinical trials to verify the efficacy and safety of MBI and to explore its applicability in different patient populations (Chadwick et al., 2009). To overcome resource and time limitations, more flexible MBI models, such as remote or digital mindfulness training programs, could be developed to not only reduce costs but also make treatment more accessible to patients (Boettcher et al., 2014). Lastly, establishing a multidisciplinary collaboration network that links mental health professionals, mindfulness practitioners, and researchers will be a crucial step in advancing the application of MBI in schizophrenia (Hofmann et al., 2012).

Several pivotal biomarkers are recommended for the evaluation of MBI efficacy in future RCTs. First, it is crucial to assess cortisol levels as they serve as an indicator of stress response. Elevated cortisol levels have been associated with anxiety and stress disorders, and MBIs have demonstrated a notable ability to effectively lower cortisol concentrations, indicating a decrease in stress (Turakitwanakan et al., 2013). Second, heart rate variability (HRV) is another vital measure because it reflects autonomic nervous system function and can indicate improved stress resilience owing to mindfulness practices (Krygier et al., 2013). Third, brain imaging techniques such as functional magnetic resonance imaging (fMRI) could provide insights into the neural mechanisms that underlie the positive outcomes of MBIs. Changes in brain areas associated with attention, emotion regulation, and self-awareness have been

observed after mindfulness training (Tang et al., 2015). Last, electroencephalogram (EEG) measures could be utilized to assess alterations in brain wave patterns to further understand the cognitive processes affected by MBIs (Lomas et al., 2015). The inclusion of these physiological measures into RCTs can offer a comprehensive understanding of how MBIs affect the mind and body, thus of its therapeutic potential in greater detail.

Clear and consistent guidelines are essential to standardize MBI practices. Standardization in MBIs can improve the comparability and reproducibility of research findings. First, it is essential to develop unified protocols for MBI programs, including specific meditation practices and durations, to ensure consistency. Kabat-Zinn emphasizes the importance of structured mindfulness programs in achieving therapeutic outcomes (Kabat-Zinn, 2003). Second, setting criteria for training and certification for MBI instructors is necessary to maintain teaching quality (Crane et al., 2012). This involves specifying qualifications, training duration, and supervision requirements. Third, standard outcome measures should be employed across studies for data comparison. Grossman et al. suggest using validated scales for mindfulness, stress, and well-being to assess MBI efficacy consistently (Grossman et al., 2004). Lastly, it is of utmost importance to closely monitor and report participant adherence to the intervention, as it significantly impacts MBI effectiveness (Davidson and Kaszniak, 2015). Incorporating these standardizations in future RCTs on MBIs will provide clearer guidelines and lay a solid groundwork for MBI research.

5. Conclusion

In conclusion, our meta-analysis supports the effectiveness of MBI in alleviating symptoms and improving mindfulness, psychosocial function, insight, and cognitive patterns among individuals with schizophrenia. However, further research is imperative, particularly on hallucinations and delusions, to comprehensively understand the impact of MBI on these specific symptoms. Despite these limitations, the overall significance of MBI is noteworthy. Reliable intervention trials are essential to dispel preexisting biases and elucidate the role of MBI in schizophrenia. To quantify its effects more precisely and consistently, we recommend additional RCTs and follow-up assessments and physiological measurements. In future research, more attention should be paid to the standardization and control throughout the entire MBI process to enhance our comprehension of the effects and mechanisms underlying MBI.

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Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

All analyses were based on previously published studies, thus no ethical approval and patient consent are required.

CRedit authorship contribution statement

Keke Qin: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft. **Yong Yu:** Data curation, Investigation, Methodology, Resources, Software, Writing – original draft, Supervision, Validation, Writing – review & editing, Data curation, Formal analysis, Methodology, Validation, Writing – original draft,

Conceptualization, Investigation, Project administration, Software. **Huiling Cai:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization. **Jiahong Li:** Resources, Software, Supervision, Validation, Visualization, Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization. **Jingyuan Zeng:** Resources, Software, Supervision, Validation, Visualization. **Huolan Liang:** Software, Supervision, Validation, Visualization.

Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary materials

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