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Review

Mindfulness-based stress reduction for healthy individuals: A meta-analysis

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ABSTRACT

Background: An increasing number of mindfulness-based stress reduction (MBSR) studies are being conducted with nonclinical populations, but very little is known about their effectiveness.
Objective: To evaluate the efficacy, mechanisms of actions, and moderators of MBSR for nonclinical populations.
Data sources: A systematic review of studies published in English journals in Medline, CINAHL or Alt HealthWatch from the first available date until September 19, 2014.
Study selection: Any quantitative study that used MBSR as an intervention, that was conducted with healthy adults, and that investigated stress or anxiety.
Results: A total of 29 studies ($n = 2668$) were included. Effect-size estimates suggested that MBSR is moderately effective in pre–post analyses ($n = 26$; Hedge's $g = .55$; 95% CI [.44, .66], $p < .00001$) and in between group analyses ($n = 18$; Hedge's $g = .53$; 95% CI [.41, .64], $p < .00001$). The obtained results were maintained at an average of 19 weeks of follow-up. Results suggested large effects on stress, moderate effects on anxiety, depression, distress, and quality of life, and small effects on burnout. When combined, changes in mindfulness and compassion measures correlated with changes in clinical measures at post-treatment and at follow-up. However, heterogeneity was high, probably due to differences in the study design, the implemented protocol, and the assessed outcomes.
Conclusions: MBSR is moderately effective in reducing stress, depression, anxiety and distress and in ameliorating the quality of life of healthy individuals; however, more research is warranted to identify the most effective elements of MBSR.

Introduction

Stress is prevalent in modern society and has become a significant global health problem [1,2]. Research suggests that high levels of stress can negatively affect both physical and mental health and are found to be associated with autoimmune diseases [3], migraines [4], obesity [5], muscle tension and backache [6], high cholesterol [7], coronary heart disease [8], hypertension [9], and stroke [10].

In the last decade, interest in research investigating mindfulness-based interventions has increased substantially [11]. Even though a consensus about an unequivocal operational definition of mindfulness is lacking so far [12,13], one of most commonly employed definitions of mindfulness was provided by Jon Kabat-Zinn who suggests that mindfulness could be described as a moment to moment awareness that is cultivated by purposefully paying attention to the present experience, with a non-judgmental attitude [14]. Interventions utilizing mindfulness techniques have shown efficacy for treating a variety of mental disorders and in coping with physical or medical conditions, including, among others, chronic pain [15], fatigue [16], stress [17,18], cancer [19], heart disease [20], type 2 diabetes [21], psoriasis [22], and insomnia [23].

Mindfulness-based stress reduction (MBSR) [24] is a well-established mindfulness training that has shown to reduce stress, depression, and anxiety [25,26]. MBSR teaches individuals to observe situations and thoughts in a nonjudgmental, nonreactive, and accepting manner. MBSR provides training in formal mindfulness practices, including body scan, sitting meditation, and yoga. MBSR seeks to change the individual's relationship with stressful thoughts and events by decreasing emotional reactivity and enhancing cognitive appraisal [27]. The standard MBSR

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curriculum is conducted in an 8-week structured group format, which includes weekly 2.5-hour group sessions in addition to a 6-hour daylong retreat.

Although initially developed for chronic pain, MBSR has reported positive results among an array of clinical and nonclinical populations, including cancer, health care professionals, continuing education students, and college undergraduates [28–30]. Chiesa et al. [28] were the first to systematically investigate the usefulness of MBSR in healthy individuals. They concluded that MBSR provided a significant nonspecific moderate to large effect on the reduction of stress in comparison with no-treatment controls. However, there were significant methodological limitations and only 10 studies were included in the analysis. Eberth and Sedlmeier [30] conducted a meta-analysis of 38 controlled studies on the effects of mindfulness meditation on psychological well-being among a nonclinical population. Among the 38 studies, 17 used MBSR, the results suggested moderate effects in reducing stress and negative emotions and in increasing well-being. However, the meta-analysis included only studies that were published before March 2010, had some methodological limitations (e.g., it did not implement PRISMA criteria and it did not include a quality measure), failed to determine moderators of the observed effects, did not investigate the role of mindfulness in the effectiveness of the interventions, and did not investigate long-term effects of MBSR.

A more recent qualitative systematic review examined the effects of MBSR on stress management in nonclinical populations in 17 trials dating between January 2009 and 2014 [29]. The outcomes suggested positive effects on both psychological and physiological measures without quantifying these effects. Overall, the current state of the literature suggests the need for a more systematic quantifiable summarization of the effects, mechanisms of actions, and moderators of MBSR for nonclinical populations. Therefore, we conducted a comprehensive effect-size analysis with the following objectives: (1) to quantify the effect size of MBSR for psychological variables (i.e., anxiety, depression, stress, distress, and burnout) in healthy individuals; (2) to investigate and quantify the role of mindfulness in MBSR; and (3) to explore moderator variables.

Methods

Power analysis

Assuming an average sample size of 25 individuals per group (on the basis of previous meta-analyses, e.g., 31), a small to moderate effect size of 0.3 (on the basis of previous meta-analyses comparing mindfulness to other active treatments, e.g., psycho-education; 31), and a large heterogeneity among the studies (as MBSR studies differ from each other in their design, implementation, and included outcomes), for a power of 80%, 15 studies comparing MBSR to an active treatment will be needed. For a power of 90%, 18 or 19 studies will be needed [32]. For within-group (e.g., pre–post) and between-group comparisons (e.g., comparing mindfulness to a waitlist), effect sizes were found to be moderate to large (e.g., 31), reducing as a result the number of required studies to 11 for a power of 80% and to 14 for a power of 90% [32].

Eligibility criteria

Any study examining MBSR interventions among healthy adults (i.e., over 18) was eligible for inclusion in the meta-analysis. Studies were excluded if they (1) did not evaluate the intervention or implemented a qualitative design; (2) did not sample healthy participants; (3) did not include stress and/or anxiety measures; (4) utilized other stress reduction strategies; or (5) did not include sufficient data to compute the effect size.

Information sources

Studies were identified by searching Medline, CINAHL and Alt HealthWatch for papers from the first available date until September 19, 2014. All papers were thoroughly verified and only English language papers corresponding to the selection criteria listed above were included in the analyses.

Search

We used the search terms mindfulness-based stress reduction, and MBSR combined with intervention or program.

Study selection

Eligibility assessment was performed in a non-blinded, standardized manner by the first author and was reviewed by the second author. Disagreements between reviewers were resolved through discussions, and in a few instances the authors of the original studies were contacted for clarifications or for asking for missed data in order to compute effect sizes. In one case, the authors were unable to provide the required data and the corresponding paper was excluded.

Data collection process

We developed an electronic data extraction sheet, pilot-tested it on five randomly-selected studies, and refined it accordingly. Data collection was conducted in September, 2014. When duplicate reports were identified for the same data, only the latest ones were included.

Data items

Information was extracted from each trial based on: (1) the characteristics of the trial (including the year of publication, design, randomization, blinding, therapist qualifications, number of participants, type of outcome measures, and follow-up time in weeks); (2) the characteristics of the intervention (including target population, length of treatment in hours, length of assigned home practice in hours, and treatment setting); (3) the characteristics of the comparison group, in controlled studies (including the number of participants, type of control, type of treatment, and length of treatment); and (4) the characteristics of participants (including mean age, percentage of males, and attrition rate).

Risk of bias in individual studies

To minimize the influence of data selection, we included data pertaining to all available psychological outcomes (i.e., anxiety, depression, stress, distress, and burnout), and quality of life. We also included data pertaining to potential mechanisms of action (i.e., mindfulness, compassion, spirituality/empathy measures). We included data from the last follow-up, when such data were available.

We also included a study quality score, which was comprised of items based on Jadad's criteria [33] and others pertaining to mindfulness. The included items are adherence of the treatment to the standard MBSR protocol (i.e., not using a modified, light, or over the phone/web version); administration of measures at follow-up; use of validated mindfulness/compassion measures; training of therapists/facilitators (i.e., psychologists, trainees in psychology, or social workers); and the mindfulness training/experience of therapists/facilitators (i.e., formal training in MBSR). For controlled studies, the items included whether participants were randomized between the treatment and control groups, whether participants in both groups spent an equal amount of time in treatment, and whether evaluators or experimenters were blind regarding the treatment/control conditions and/or participants were blind regarding the study's hypotheses. For all binary items

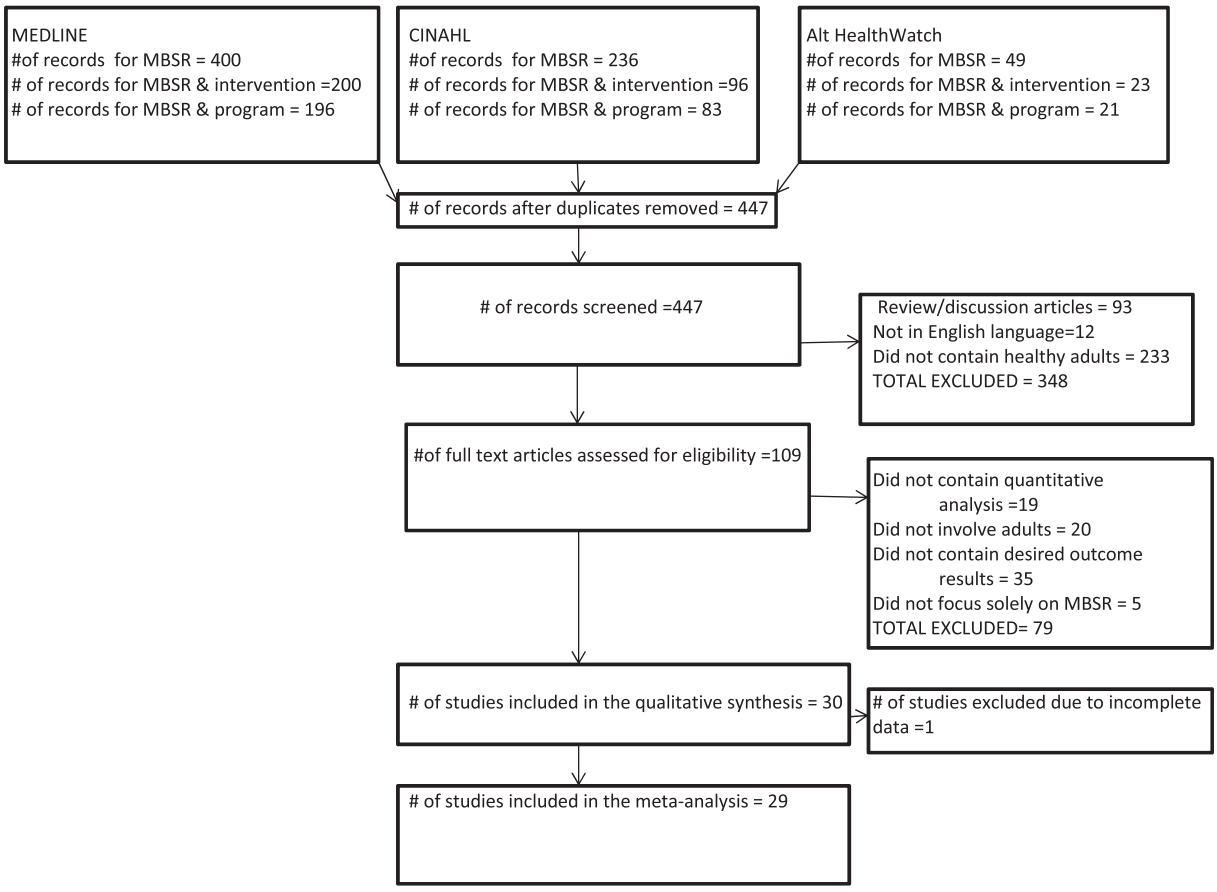

Fig. 1. Flow diagram of the study selection process.

(i.e., true or false), a value of 1 was assigned if the item was true and a value of 0 if it was false. For the study design, pre–post studies were assigned a value of 0; studies with a waitlist, no-treatment, or drop-out control group were assigned a value of 1; studies with an active treatment control group were assigned a value of 2. This rating reflects the strength of the study design and was used in previous meta-analyses (e.g., [31,34]). For blinding, non-blinded studies were assigned a value of 0; single-blind studies were assigned a value of 1; and double-blind studies were assigned a value of 2.

The inter-rater agreement was assessed by comparing the ratings of the first author (B.K.) to the ratings of the fourth co-author (C.F.), who received a written document including specific instructions on rating the studies and one-hour training about the rating procedure.

Summary measures

The meta-analyses were performed by computing standardized differences in means. We completed all analyses using Microsoft Excel 2010 and Comprehensive Meta-Analysis, Version 2.2.057 [35].

Synthesis of results

Effect sizes were computed using means and standard deviations (*SD*) when available. In the remaining studies, the effect sizes were computed using other statistics such as *F*, *p*, *t*, and χ^2. In within-group analyses, when the correlations between the pre- and post-treatment measures were not available, we used a conservative estimate ($r = .7$) according to the recommendation by Rosenthal [36]. For all studies, Hedge's *g*, its 95% confidence interval (95% CI), and the associated *z* and *p* values were computed. To calculate the mean effect size for a group of studies, individual effect sizes were pooled using a random effect model rather than a fixed effect model, given that the selected studies were not identical (i.e., did not have an identical design nor targeted a similar population).

For all studies groups, the mean Hedge's *g*, the 95% confidence interval (95% CI), and the associated *p*-values were computed. We systematically assessed the heterogeneity among studies using I^2 and the chi-squared statistic (Q). I^2 measures the proportion of heterogeneity to the total observed dispersion, and it is not affected by low statistical power. Higgins et al. [37] suggested that an I^2 of 25% might be considered low, a 50% is considered moderate, and a 75% is considered high.

Risk of bias across studies

To assess publication bias, we computed the fail-safe *N* [36] and we constructed a funnel plot.

Additional analyses

According to the objectives of this meta-analysis, we conducted meta-regression analyses. The aim of meta-regression analyses is to assess the relationship between one or more variables (moderators) and the pooled effect size. In this meta-analysis, we included only pre–post results and we investigated six moderators: (1) study quality score, (2) treatment length (as defined in the MBSR protocol), (3) duration of home practice (as indicated in the protocol), (4) mean age of participants, (5) year of publication, and (6) therapist training/experience. We also conducted a meta-regression analysis of the relationship between the changes in mindfulness and compassion outcomes combined (due to the

Table 1
Description and effect size analyses of the efficacy of the selected studies.

Study	Type of participants (*N*)	M. age	% female	Tx group (*n*)	Comp. group (*n*)	Rnd. ass	% att	Tx hrs	Clinical measures (Mind. measures)	Pre–post *g* (gm)	Fup (wks)	Pre-Fup *g* (gm)	Cntrl *g* post (gm)	Cntrl *g* fup	Sc
Astin [17]	Patients enrolled in long-term psycho-therapy (28)		Tx = 91.67, Cntrl = 100	SRRP (14)	Cntrl (14)	Yes	32.1	16 + HP	SCL-90-R; SCI; INSPIRIT	–	24–36	–	1.42	–	5
Barbosa et al. [46]	Graduate healthcare students (31)	Tx = 26.6, Cntrl = 24.6	Tx = 92.3, Cntrl = 93.3	MBSR (16)	Cntrl (15)	No	9.6	28 + HP	BAI; JSPE; MBI	0.26	3	0.31	0.46	0.37	3
Bazarko et al. [47]	Nurses employed in large healthcare organization (41)	52.2	100	MBSR (41)	N/A	N/A	12.2	17 + HP	PSS; CBI; BSS; JSPE; (SCS)	0.74 (1.05)	8	0.75 (1.22)	–	–	3
Bergen-Cico et al. [48]	Undergrad students enrolled in health courses and addictive behavior courses (119)	Tx = 21.5, Cntrl = 21.1	Tx = 80, Cntrl = 72	MBSR (72)	Cntrl (47)	No	–	10	STAI-T (KIMS; PHLM; SCS)	0.11 (0.17)	–	–	0.22 (0.28)	–	3
Birnie et al. [49]	Healthy individuals from community (104)	47.4	68.6	MBSR (104)	N/A	N/A	51	12 + HP	IRI; SOSI; POMS; FACIT-Sp (SCS; MAAS)	0.55 (0.76)	–	–	–	–	2
Cohen-Katz et al. [50]	Hospital employees (27)	46.0	100	MBSR (14)	WL (13)	Yes	7.4	26 + HP	MBI; BSI; (MAAS)	0.65 (0.97)	12	0.54 (1.08)	0.77	–	7
Cordon et al. [51]	Participants enrolled in MBSR programs with different attachment styles (185)	Tx 1 = 49.57, Tx 2 = 47.07	Tx 1 = 79; Tx 2 = 79	MBSR (Tx 1 secure = 86; Tx 2 insecure = 99)	N/A	N/A	24.9	28 + HP	ECR-R; PSS	0.79	–	–	–	–	2
De Vibe et al. [52]	Medical and psychology students (288)	23.8	76	MBSR (144)	Cntrl (144)	Yes	3.8	15 + HP	GHQ12; MBI; PMSS; SWB; (FFMQ);	0.27 (0.20)	–	–	0.41 (0.16)	–	6
Demarzo et al. [53]	Healthy university students (23)	20.7	78.3	MBSR (23)	N/A	N/A	–	28	PSS; WHOQOL-BREF	0.71	–	–	–	–	1
Flook et al. [54]	Public elementary school teachers (18)	Tx = 46.7, Cntrl = 38.50	88.9	MBSR (10)	WL (8)	Yes	–	26 + HP	SCL-90-R; MBI-ES; CLASS; (FFMQ; SCS)	0.49 (0.62)	–	–	0.61 (0.59)	–	5
Foureur et al. [55]	Midwives and nurses from two teaching hospitals (40)	–	100	MBSR (40)	N/A	N/A	30	8 + HP	GHQ-12; SOC; DASS	0.44	–	–	–	–	2
Geary & Rosenthal [56]	Academic healthcare employees (154)	Tx = 48, Cntrl = 42	Tx = 85, Cntrl = 96	MBSR (60)	Cntrl (94)	N/A	11	32	PSS; SF-36; SCL-90-R; DSES	0.84	48	0.79	0.88	0.77	4
Gold et al. [57]	Teachers from primary school (11)	Late 20s to late 50s	90.9	MBSR (11)	N/A	N/A	–	25	DASS; (KIMS)	0.95	–	–	–	–	4
Goodman & Schorling [58]	Healthcare providers (93)	–	65	MBSR (93)	N/A	N/A	–	27 + HP	MBI; SF-12v2	0.45	–	–	–	–	2
Greeson et al.	Participants enrolled in self-pay	45.0	75.3	MBSR (279)	N/A	N/A	–	27 +	DSES; SF-12v2 (CAMS-R)	0.40	–	–	–	–	3

[59]	community MBSR class (279)							HP		(1.09)					
Jain et al. [38]	Full time health students (104)	25	80.7	Tx 1 = medit. (33), Tx 2 = Relax. (35)	Cntrl (36)	Yes	22.1	10	BSI; PSOM; DER; INSPIRIT-R; M-C	0.47	–	–	–	–	7
Klatt et al. [60]	Full-time university faculty and staff (48)	Tx = 43, Cntrl = 46.5	Tx = 77, Cntrl = 86	MBSR (24)	WL (24)	Yes	6.2	6+ HP	PSS; PSQI; (MAAS)	0.41 (0.40)	–	–	0.15 (0.39)	–	4
Krusche et al. [61]	Participants in online mindfulness course (273)	47.7	78	MBSR (273)	N/A	N/A	–	–	PSS; GAD-7; PHQ-9	1.06	4	1.23	–	–	2
Martín-Asuero & Garcia-Banda [62]	Healthcare prof. seeking stress reduction (29)	41.1	83	MBSR (29)	N/A	N/A	–	28	SCL-90-R; SRLE; ECQ; PANAS	0.31	12	0.57	–	–	3
Nyklíček et al. [63]	Community residents (88)	46.1	70.6	MBSR (44)	WL (44)	Yes	9.1	20+ HP	PSS; PANAS	–	–	–	0.48	–	4
Robins et al. [64]	Community-based healthy individuals (56)	46.2	Tx = 90, WL = 76.2	MBSR (28)	WL (28)	Yes	26.8	27+ HP	DERS; ACS; RRS; PSWQ; SAES; M-C (FFMQ; SCS)	0.60 (0.91)	8	0.44 (0.92)	0.61 (0.88)	0.44 (0.92)	7
Rosenzweig et al. [65]	2nd year medical students (302)	–	–	MBSR (140)	Cntrl (162)	N/A	–	15	POMS	0.20	–	–	0.53	–	2
Shapiro et al. [68]	Undergrad students at small, private university (30)	18.7	86.7	MBSR (15)	Cntrl (15)	Yes	6.3	28	RRQ; PSS; SWB; PANAS; SWLS; ADHS; IRI; HFS (MAAS; SCS)	0.27 (0.53)	8, 48	0.37 (0.47)	0.19 (0.44)	0.23 (0.42)	6
Shapiro et al. [67]	Healthcare prof. (38)	–	–	MBSR (18)	WL (20)	Yes	22.7	16	BSI; MBI; SWLS; (SCS)	–	–	–	0.56 (1.00)	–	5
Shapiro et al. [66]	Mental health prof. (83)	29.2	88.9	MBSR (22)	Cntrl (61)	No	34.9	16	PANAS; PSS; RRQ; (MAAS; SCS)	0.72 (0.50)	–	–	0.82 (0.80)	–	5
Shapiro et al. [69]	Medical and premedical students (78)	–	56.1	MBSR (37)	WL (41)	Yes	3	18+ HP	ECRS; SCL-90-R; STAI-T; INSPIRIT	0.38	–	–	0.54	–	3
Singleton et al. [70]	Individuals enrolled in MBSR courses (14)	37.9	64.3	MBSR (14)	N/A	N/A	–	28+ HP	PWB	0.95	–	–	–	–	2
Song et al. [71]	Nursing students (50)	Tx = 19.6, WL = 19.5	>81	MBSR (25)	WL (25)	Yes	12	16+ HP	DASS-21; (MAAS)	1.07 (0.95)	–	–	0.92 (0.78)	–	5
Vieten & Astin [72]	Women in 2nd and 3rd trimesters (34)	33.9	100	MBSR (15)	WL (19)	Yes	8.8	16+ HP	PSS; CES-D; STAI; PANAS-X; ARM; (MAAS)	0.68 (0.24)	–	–	0.87 (0.51)	–	6

Note. MBSR = mindfulness-based stress reduction; prof. = professionals; M. = mean; Tx = treatment; Cntrl = control; WL = wait-list; SRRP = Stress Reduction and Relaxation Program; Medit. = meditation; Relax. = relaxation; Comp. = comparison; N/A = not applicable; Rnd. ass, = random assignment; Att = attrition; hrs = hours; HP = home practice; Mind. = Mindfulness; SCL-90-R = Symptom Checklist 90-Revised; SCI = Shapiro Control Inventory; INSPIRIT = Index of Core Spiritual Experiences; BAI = Burns Anxiety Inventory; JSPE = Jefferson Scale of Physician Empathy; MBI = Maslach Burnout Inventory; PSS = Perceived Stress Scale; CBI = Copenhagen Burnout Inventory; BSS = Brief Serenity Scale; SCS = Self-Compassion Scale; STAI-T = Spielberger State-Trait Anxiety Inventory-Trait Form Y-2; KIMS = Kentucky Inventory Mindfulness Scale; PHLM = Philadelphia Mindfulness Scale; IRI = Interpersonal Reactivity Index; SOSI = Symptoms of Stress Inventory; POMS = Profile of Mood States; FACIT-Sp = Functional Assessment of Chronic Illness Therapy-Spiritual Well-Being; MAAS = Mindful Attention Awareness Scale; BSI = Brief Symptom Inventory; ECR-R = Experiences in Close Relationship — Revised Questionnaire; GHQ12 = General Health Questionnaire; PMSS = Perceived Medical School Stress; SWB = Subjective Well-Being; FFMQ = Five Facet Mindfulness Questionnaire; WHOQOL-Bref = WHO Quality of Life-BREF; MBI-ES = Maslach Burnout Inventory — Educators Survey; CLASS = Classroom Assessment Scoring System; RVP = Rapid Visual Information Processing; SOC = Sense of Coherence — Orientation to Life; DASS = Depression, Anxiety, and Stress Scale; SF = Health Survey Questionnaire-Short Form; DSES = Daily Spiritual Experiences Scale; CAMS-R = Cognitive and Affective Mindfulness Scale—Revised; PSOM = Positive States of Mind Scale; DER = Daily Emotional Report; R = revised; M–C = Marlowe–Crowne Short Form; PSQI = Pittsburgh Sleep Quality Index; GAD-7 = General Anxiety Disorder 7-item Scale; PHQ-9 = Patient Health Questionnaire; SRLE = Survey of Recent Life Experiences; ECQ = Emotional Control Questionnaire; PANAS = Positive and Negative Affect Scale; ACS = Affective Control Scale; RRS = Ruminative Responses Scale; PSWQ = Penn State Worry Questionnaire; SAES = Spielberger Anger Expression Scale; RRQ = Reflection Rumination Questionnaire; SWLS = Satisfaction With Life Scale; ADHS = Adult Dispositional Hope Scale; HFS = Heartland Forgiveness Scale; ECRS = Empathy Construct Rating Scale; PWB = Psychological Well-Being; CES-D = Center for Epidemiologic Studies Depression Scale; PANAS-X = Positive and Negative Affect Scale — Extended; ARM = Affect Regulation Measure; *g* = Hedge's *g* of clinical outcomes; *gm* = Hedge's *g* of mindfulness and/or compassion outcomes; Fup = follow-up; wks = weeks; Sc = quality score.

limited number of studies) and the changes in clinical outcomes at pot-treatment and at follow-up.

Results

Study selection

Medline produced 400 articles, CINAHL yielded 236 publications, and Alt HealthWatch produced 40 articles. We carefully assessed the identified publications and applied the exclusion criteria, resulting in 30 publications, from which one was excluded due to insufficient data to compute the effect size. The study selection process is illustrated in detail in Fig. 1.

Study characteristics

The effect size (Hedge's g) and other characteristics for each study are shown in Table 1. The total number of participants was 2668 among them 1858 were assigned to MBSR and 810 were controls.

Most of the studies ($n = 19$) were conducted in 2010 or later, eight were conducted between 2000 and 2009 and two only were conducted prior to 2000. Students were the target of 10 studies, followed by health care professionals ($n = 9$), three among them targeted nurses. The remaining of the studies were divided among general population ($n = 4$), MBSR groups ($n = 3$), and pregnant women ($n = 1$). The majority of participants (82.68%) were young adult females (mean age = 36.80). The attrition rate was low to moderate (16.99%).

Risk of bias within studies

Table 1 presents the included studies and their quality scores. Five studies were pilots, 18 were controlled among them, 13 were randomized, 15 compared MBSR to a waitlist control, two compared MBSR to a course or seminar, and one compared MBSR to an active control treatment (i.e., relaxation training; [38]).

The majority of the studies ($n = 23$) used standard MBSR, four studies used a modified, "low-dose", or brief version of MBSR, one used a telephonic-based MBSR protocol, and one used a web-based protocol. As the protocols varied, the treatment hours varied also from six to 32 h with a mean of 20.34 h. Similarly, the assigned home practice varied from eight to 42 h with a mean of 29.28 h.

Thirteen studies used at least one validated mindfulness measure, six used a compassion measure, nine included follow-up measures (average follow-up time was 19.22 weeks), one assured an equal time between treatment and control groups, and two used blind evaluators. The quality score varied from a minimum of 1 (i.e., the lowest quality) to a maximum of 7 (i.e., the highest quality) with a mean of 3.9 ($SD = 1.76$) and a median of 4. Inter-rater agreement was high (kappa = .91).

Results of individual studies

Hedge's g values for clinical and mindfulness outcome measures, at post treatment and at the last follow-up for both within-groups (i.e., pre–post or pre-follow-up) and between-groups (i.e., MBSR versus a control group), are presented in Table 1.

Synthesis of results

The effect size (Hedge's g) for both within-group and between group analyses at the end of treatment and at the last follow-up and other characteristics for each study are shown in Table 1. Effect sizes, 95% confidence intervals, and heterogeneity (i.e., I^2 and Q) for different target populations and outcome measures at both the end of treatment and at the last follow-up are available in Table 2. Results suggest similar moderate effects in pre–post analyses ($n = 26$; Hedge's $g = .55$; 95% CI [.44, .66], $p < .00001$) and in between group analyses ($n = 18$; Hedge's $g = .53$; 95% CI [.41, .64], $p < .00001$); however heterogeneity was high in the pre–post analyses and moderate in the between-group analyses, suggesting caution in drawing definite conclusions. In within group analyses, studies conducted by a facilitator with clinical training showed higher effects ($n = 6$; Hedge's $g = .62$; 95% CI [.52, .72], $p < .00001$) than those conducted by facilitators without a clinical training ($n = 20$; Hedge's $g = .52$; 95% CI [.39, .65], $p < .00001$). The same pattern was observed for studies conducted by a facilitator with mindfulness training/experience ($n = 19$; Hedge's $g = .60$; 95% CI [.46, .74], $p < .00001$) in comparison with studies conducted by facilitators without mindfulness training/experience ($n = 7$; Hedge's $g = .43$; 95% CI [.30, .56], $p < .00001$). Heterogeneity was high in all subgroups in within-group analyses suggesting large differences between the studies and outcomes. However, heterogeneity was moderate to small in between-group analyses suggesting higher consistency among controlled studies and better indication of the true effects.

Using between group analyses, the effects were lager in non-randomized studies ($n = 5$; Hedge's $g = .59$; 95% CI [.44, .75], $p < .00001$) in comparison with randomized studies ($n = 13$; Hedge's $g = .48$; 95% CI [.36, .60], $p < .00001$). Heterogeneity was moderate to large in the first group ($I^2 = 62.24$; $Q = 10.59$) and small in the second one ($I^2 = .83$; $Q = 12.10$). The effects were also lager in studies comparing MBSR to a course or seminar, followed by studies comparing MBSR to a waitlist, and the single study comparing MBSR to relaxation training had a small effect size. Health care professionals benefited the most from the intervention, followed by general populations, and then students. Studies using the standard MBSR protocol showed a higher mean effect size ($n = 14$; Hedge's $g = .58$; 95% CI [.46, .70], $p < .00001$) in comparison with studies using modified MBSR ($n = 4$; Hedge's $g = .35$; 95% CI [.10, .60], $p < .01$), heterogeneity was small in the two groups. MBSR had the highest effects on measures of depression, followed by stress, anxiety, distress, quality of life, and burnout. Effects were maintained at the last follow-up with larger effects for mindfulness/compassion outcomes ($n = 2$; Hedge's $g = .71$; 95% CI [.22, 1.20], $p < .0005$).

Risk of bias across studies

The effect size for all pre–post analyses corresponded to a z value of 27.56 ($p < .00001$) indicating that 5114 studies with a null effect size would be needed to nullify our results (i.e., for the two-tailed p value to exceed .05). Using the Trim and Fill method, four studies would need to fall on the right of the mean effect size to make the plot symmetric (Fig. 2). Assuming a random effects model, the new imputed mean effect size was Hedge's $g = .48$ (95% CI [.35, .60]). Similar results were obtained for controlled studies, with a z value of 12.12 ($p < .00001$) and a corresponding fail-safe N of 633. Using the Trim and Fill method, five studies would also need to fall on the right of the mean effect size to make the plot symmetric, the new imputed mean effect size was Hedge's $g = .45$ (95% CI [.32, .58]). These analyses suggest that the effect-size estimates were unbiased and robust.

Additional analyses

At the end of treatment, the average pre–post effect size of clinical outcomes was positively moderated by treatment hours ($n = 25$; $\beta = .01$, $SE = .01$, $p < .05$), and assigned home practice ($n = 18$; $\beta = .01$, $SE = .01$, $p < .05$). The average pre–post effect size was not moderated by study quality score ($p = .5$, ns), mean age of participants ($p = .05$, ns), year of publication ($p = .46$, ns), or therapist training/experience ($p = .38$, ns).

The pre–post changes in effect sizes of combined mindfulness and compassion outcomes were found to correlate with the changes in effect sizes of clinical outcomes ($n = 13$; $\beta = .35$, $SE = .17$, $p < .05$) (Fig. 3), similar results were found for pre-follow-up changes ($n = 4$; $\beta = .51$, $SE = .17$, $p < .005$).

Discussion

This meta-analysis examined 29 studies using MBSR for a total of 2668 healthy participants. The results showed that MBSR is moderately effective in both within group and between group analyses. Only one study compared MBSR to an active treatment, the effect size was small but it cannot be generalized.

Even though the MBSR interventions in the studies included in this meta-analysis did not target a clinical population, moderate effects were found on multiple clinical measures including, depression, anxiety, and distress, beside a large reduction in stress and an increase in the quality of life. These results are comparable to previous meta-analyses of MBSR for non-clinical populations [28,30], previous qualitative reviews [29] and are within the range of effects of mindfulness-based treatments for clinical and nonclinical populations [31]. Standard MBSR program showed higher effectiveness than modified or shortened versions. Among the target populations who benefited the most from MBSR were healthcare professionals. Similar results were previously documented [39] and can be related to the high level of stress among healthcare professionals. In addition, the average attrition rate among participants in the selected studies (17%) was smaller than the attrition rate usually obtained in cognitive and behavioral studies (e.g., 22.5% of 1646 patients who were offered CBT in an National Health Service clinic in the UK; [40]) but is consistent with attrition rates obtained in previous meta-analyses examining mindfulness-based treatments (e.g., [31, 34]). These results suggest a higher commitment among participants to mindfulness interventions, namely MBSR.

When interpreting these findings, it is important to consider that even though all the included studies used MBSR, they varied in its implementation as some used the standard protocol while others used a more brief or lightened version with fewer sessions and with lower treatment/practice time. In addition, the studies targeted different populations, and they measured different variables using different scales. This diversity in study designs and outcomes may have been a large contributor to the observed heterogeneity in effect sizes. However, despite heterogeneity, most of the included interventions focused on

Table 2
Effect sizes and other statistics for different groups of studies at different time points.

Study design	Time point	Division criteria	Study group	Ns	*g*	95% CI	*p*	I^2 (%)	*Q*
Within-group (pre–post analyses)	End of Tx	–	All	26	.55	[.44, .66]	<.00001	89.39	235.57
		Target population	Students	10	.42	[.29, 0.55]	<.00001	85.35	61.43
			Health care professionals	7	.56	[.39, .74]	<.00001	83.96	37.40
			General population	6	.77	[.49, .94]	<.00001	89.75	48.80
		Outcomes	Anxiety	8	.55	[.19, .92]	<.005	94.31	122.93
			Depression	6	.68	[.43, .93]	<.00001	79.49	24.38
			Stress	15	.83	[.58, 1.08]	<.00001	93.75	224.00
			Distress	3	0.57	[.45, .68]	<.00001	0	.15
			Burnout	6	.39	[.14, .65]	<.005	78.28	23.02
			Quality of life	11	.44	[.31, .56]	<.00001	66.09	29.49
		Potential mechanisms of action	Mindfulness	12	.60	[.36, .85]	<.00001	89.16	101.46
			Compassion	6	.59	[.29, .89]	<.0005	83.63	30.55
			Spirituality/empathy	4	.37	[.20, .55]	<.00001	63.75	8.28
	Fwp	–	All clinical measures	8	.64	[.38, .90]	<.00001	92.11	89.64
			Mindfulness + compassion	4	.90	[.52, 1.28]	<.00001	76.05	12.53
Between-group	End of Tx	–	All	18	.53	[.41, .64]	<.00001	36.85	22.17
			Waitlist controls	15	.54	[.41, .67]	<.00001	36.82	22.16
		Control group type	Course/seminar	2	.63	[.35, .91]	<.00001	36.98	1.59
			Treatment control group[a]	1	.15	[−.16, .47]	.34, ns	–	–
		Target population	Students	9	.47	[.30, .64]	<.00001	42.50	13.91
			Health care professionals	4	.68	[.49, .88]	<.0005	13.63	3.47
			General population	2	.52	[.27, .77]	<.00001	0	.26
		Outcomes	Anxiety	6	.64	[.33, .94]	<.00001	42.51	8.70
			Depression	4	.80	[.49, 1.12]	<.00001	1.52	3.05
			Stress	9	.74	[.41, 1.07]	<.00001	74.97	31.96
			Distress	3	.62	[.42, .82]	<.00001	0	.66
			Burnout	5	.26	[.07, .46]	<.01	0	3.98
			Quality of life	4	.53	[.34, .71]	<.00001	0	2.82
		Potential mechanisms of action	Mindfulness	9	.43	[.24, .63]	<.00001	24.66	10.62
			Compassion	5	.59	[.27, .91]	<.0005	30.45	5.75
			Spirituality/empathy	2	.36	[−.08, 0.81]	.11, ns	37.79	1.61
	Fwp	–	All clinical measures	4	.47	[.24, .71]	<.00001	47.77	5.74
			Mindfulness + compassion	2	.71	[.22, 1.20]	<.005	63.25	2.72

Note. Ns = Number of studies; Tx = Treatment; Fwp = follow-up.
[a] In comparison with an active treatment.

reducing stress and results support a large reduction in stress in 15 within-groups and nine between-group studies.

One obvious question is whether MBSR also changes measures of mindfulness and compassion. Surprisingly, less than half of the studies (i.e., 45%) included a validated measure of mindfulness and/or compassion. The results showed that participants in MBSR were more mindful and compassionate at the end of the treatment, and that gains were higher at the last follow-up. In addition, there was a strong positive correlation between the changes in the mindfulness/compassion levels of the participants and the changes in their clinical outcomes. These results are consistent with previous meta-analyses [31,34], provide cumulative support for the role of mindfulness strategies in the effectiveness of MBSR, and suggest that compassion might be a complementary strategy, optimizing the mindfulness moderation of the effects. Eberth and

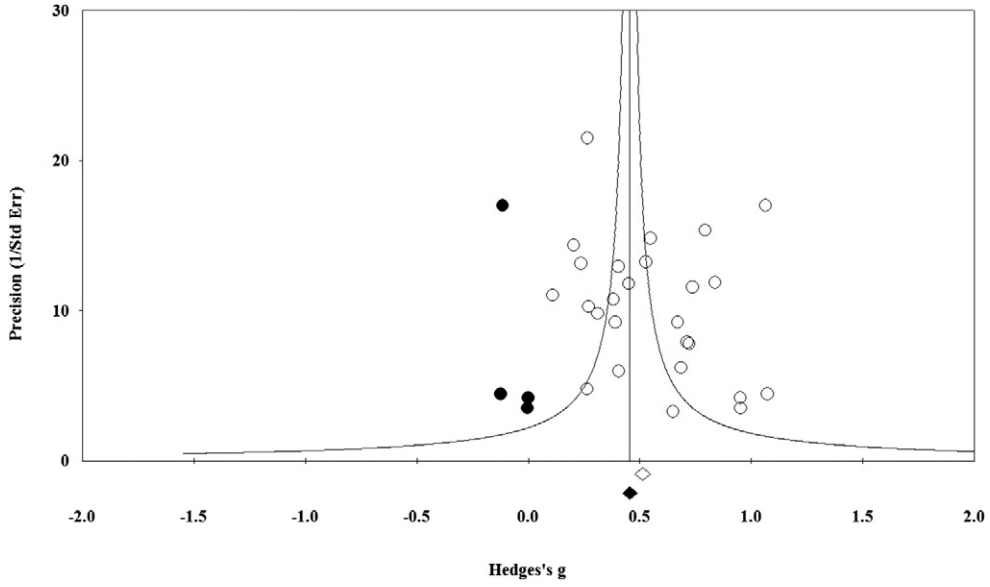

Fig. 2. Funnel plot of precision by Hedge's *g* for pre–post data. Note that in the absence of a publication bias, the studies should be distributed symmetrically with larger studies appearing towards the top of the graph and clustered around the mean effect size and smaller studies towards the bottom.

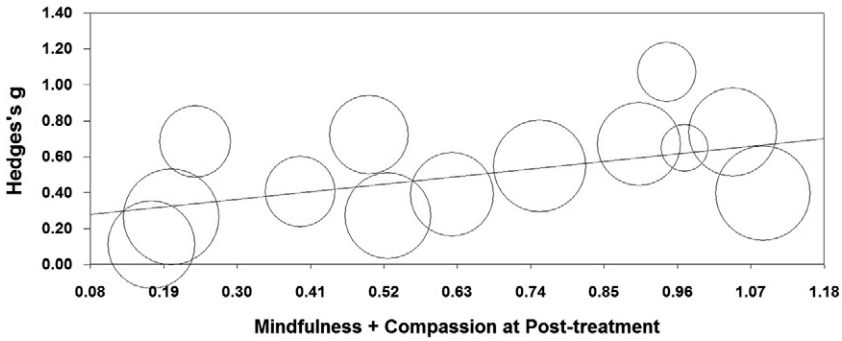

Fig. 3. Relationship between changes in mindfulness/compassion effect sizes and changes in clinical outcomes effect sizes at the end of treatment for pre–post data. The circles represent the studies; their diameter is proportional to the study weight (i.e. to the ratio of the number of participants of the specific study to the total number of participants for the present meta-analysis).

Sedlmeier [30] suggested the role of other factors in the effectiveness of MBSR namely, psychoeducation or specific expectations of participants. Future studies will need to explore the mechanisms of action of MBSR and specifically the role of mindfulness, compassion, psychoeducation, and other factors in their effectiveness.

Our results showed that the study quality score did not moderate the efficacy of MBSR. These results are consistent with previous meta-analyses [26,41,42]. However, a moderation of the study quality score was found in a previous large meta-analysis [31]. The low quality of the studies might explain the absence of moderation in the current meta-analysis. The duration of the treatment and the duration of home practice were very weak moderators for the treatment effectiveness. Previous mindfulness-based intervention studies and meta-analyses with mixed clinical and nonclinical populations found contradictory results regarding treatment duration [26,30,41,43–45], and when a significant moderation was found, it was very weak (e.g., $\beta = .01$ 31). In contrast to a previous meta-analysis [31], the facilitator's clinical and mindfulness training/experience did not moderate the effect size. However, mean effect sizes were larger in the studies conducted by a facilitator with a clinical and/or mindfulness training/experience. Other variables (i.e., mean age of participants, year of publication) were not found to be significant moderators of the clinical effects. Similar results were obtained in previous meta-analyses [26,30,31].

Among the limitations of this meta-analysis are the limited number of included studies and the high heterogeneity among some study groups, reducing as consequence the scope of the obtained results. In addition, only one study compared MBSR to an active treatment. Moreover, the assessed outcomes varied widely from study to study. Due to the limited number of available studies, we also inevitably included studies with different levels of quality, which we quantified and included in the analyses. To address our own expectancy bias, we implemented liberal selection criteria and included a variety of studies. Beside these limitations pertaining to the meta-analysis itself, many more limitations pertain to the included studies, among them are: 1) most participants were female, Caucasian and relatively young, therefore results cannot be generalized to other populations, 2) most participants were students or health care professionals, limiting the generalization of the results to other populations including participants with lower or no education, 3) only less than half of the studies included mindfulness assessment measures making it difficult for us to assess the degree of success in implementing the MBSR protocol in many of the included studies, 4) most of the studies used waiting list or nonspecific control groups making it hard for us to draw definite conclusions about the comparative effect size with active control groups such as psychoeducation or support groups, and 5) most of the studies lacked long term follow-ups (e.g. one year or more) making it difficult for us to conclude about the stability of the effects of MBSR over a longer term period following the end of the treatment program.

Despite these limitations, our results had sufficient statistical power and showed that MBSR is moderately effective. Furthermore, the findings suggest that mindfulness is a central component of the treatment effectiveness. We recommend conducting more methodologically rigorous studies to establish the efficacy of MBSR in comparison with other standard interventions and to examine and quantify moderators and mediators of effective MBSR. In addition, it is recommended that future studies include at least one validated measure of mindfulness, and one of stress, as both are central in MBSR.

These results suggest that clinicians can recommend standard MBSR programs to their patients to reduce their stress, distress, anxiety, and depression and to increase their quality of life regardless whether patients meet diagnostic criteria for a mental disorder.

Conflict of interest statement

All authors of this article had access to all study data, are responsible for all contents of the article, and had authority over manuscript preparation and the decision to submit the manuscript for publication. Authors of this article have approved the submission of the manuscript to the journal and have no competing interests. The data presented in the article is novel and has not yet been presented elsewhere.

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No official funding was provided to conduct the current meta-analysis. All authors have actively participated in preparing this manuscript. The authors have no competing interests to report. The first author (B.K.) led the meta-analysis in all its stages and worked on the data collection, analyses, and report writing, he has full access to all of the data in the meta-analysis and he takes full responsibility for the integrity of the data and the accuracy of the reported analyses. The second author (M.S.) contributed in conducting and reporting the search methodology, in double-checking the data, and in editing the manuscript. The third author (S.E.R.) contributed in writing the introduction, in collecting the raw data from different studies, and in reediting the manuscript. Finally the last author (C.F.) contributed in the inter-rating of the included studies and in giving general comments and suggestions regarding the implications of the findings.

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