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Individual differences in meditation interventions: A meta-analytic study

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Objectives. Meditation interventions typically show small to moderate effects on health and well-being, but we know little about how these effects vary across individuals. This meta-analytic study investigates the relationship between baseline participant characteristics and the outcomes of meditation.

Methods. A systematic search yielded 51 eligible studies with 7782 participants. A combination of subgroup analyses and meta-regression based on the random-effects model were used.

Results. We found that a higher baseline level of psychopathology or depression was associated with deterioration in mental health after a meditation intervention. On the other hand, participants with higher scores on interpersonal variables, motivation, medical conditions, and mindfulness showed higher levels of positive meditation outcomes. Higher well-being and stress were simultaneously associated with moderate increases in negative and positive meditation outcomes. Participant demographics, psychological traits, self-concept, and length of meditation practice did not significantly influence the response to meditation.

Conclusions. Overall, we found that meditation interventions affect participants differently, and identified some of the individual characteristics that should be considered when using meditation interventions.

Statement of contribution

The effects of participant characteristics on meditation intervention outcomes: A meta-analysis

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What is already known on this subject?

There is an universalist assumption that has been guiding studies on meditation techniques, which can be simply be stated as 'meditation works in the same way for everyone'. This assumption explains why, thus far, participant characteristics as sources of variability in the response to meditation have not been examined directly through a meta-analysis, but only briefly explored as moderating factors in meta-analyses that examine the effects of meditation on specific dependent variable in a specific population (e.g., age as a moderator of the effect of meditation on reducing trait anxiety in adults, see Khoury, Sharma, Rush, & Fournier, 2015; Orme-Johnson & Barnes, 2013; Zoogman, Goldberg, Hoyt, & Miller, 2015).

Based on these previous meta-analyses it appears that age, gender and ethnicity do not to moderate outcomes of meditation in clinical and non-clinical samples (Khoury et al., 2015; Orme-Johnson & Barnes, 2013; Zoogman et al., 2015); that the reduction in trait anxiety following meditation appears to be greater in people with high anxiety levels (Orme-Johnson & Barnes, 2013); and that people with three or more episodes of major depression responded better to Mindfulness-Based Cognitive Therapy (MBCT) than those with one or two episodes (Piet & Hougaard, 2011). However, a comprehensive analysis of participant factors in relation to the efficacy of meditation-based interventions has not been conducted before.

What does this study add?

- People with higher psychopathology are more likely to show worsening of mental health following meditation.
- People with interpersonal problems or with medical conditions are more likely to experience benefits of meditation.
- Demographics, psychological traits and self-concept do not influence the response to meditation.

Background

Meditation is generally practiced with the aim of achieving positive changes, whether physical, mental health, or of a moral-spiritual character. In reality, the effectiveness of meditation practices varies among individuals; while many reap benefits and become dedicated long-term practitioners, others sense no noticeable effects or might even experience unwanted, unpleasant, or adverse effects (Cebolla, Demarzo, Martins, Soler, & Garcia-Campayo, 2017; Van Dam et al., 2018; Farias, Maraldi, Wallenkampf, & Lucchetti, 2020; Lindahl, Fisher, Cooper, Rosen, & Britton, 2017; Schlosser, Sparby, Vörös, Jones, & Marchant, 2019). In 1977, the American Psychiatric Association issued a statement on meditation strongly recommending the need to undertake research that evaluates the possible usefulness, indications, and contraindications of meditation (American Psychiatric Association, 1977). Over 40 years have passed, and we still have not achieved a body of research allowing us to tell which type of individuals may benefit the *most* and the *least* from meditation interventions.

One example of the wide-reaching problems driven by the lack of insight into individual differences in meditation research concerns its clinical implications. Meta-analyses focusing on mindfulness-based interventions (MBIs) have shown that patients with some psychiatric conditions using these techniques experience a level of symptom reduction equivalent to that of other evidence-based treatments, such as psychotherapy or biomedical treatment (Goldberg et al., 2018; Hofmann & Gomez, 2017; Veehof, Trompetter, Bohlmeijer, & Schreurs, 2016). Despite this evidence, the British National

Institute for Health and Care Excellence recommends MBIs in only two specific cases: for individuals with a history of three or more episodes of depression (Pilling et al., 2009), and for treating fatigue in patients with multiple sclerosis (Perry et al., 2014). This rather restrictive recommendation is understandable as the majority of current evidence is based on reports of mean group changes, but it pays no attention to how individuals might react differently to MBIs or other meditation-based practices. For instance, even if high-quality randomized controlled trials with anxious samples show moderate effect sizes of meditation on anxiety, there would still be many participants within each trial that show no reductions in anxiety where we would not be aware of why that is so. If there is variability in the valence and intensity of meditation effects across individuals, the task at hand is to assess this variability so clinicians and therapists know when and with whom to use these techniques and when to avoid them.

As it happens with other types of psychological interventions, there are three groups of characteristics that are likely to lead to variability in responses to meditation interventions: participant, intervention, and teacher characteristics (Baer, Crane, Miller, & Kuyken, 2019). The focus of this paper is on participant characteristics because there has been no comprehensive analysis of participant factors in relation to the efficacy of meditation-based interventions. Participant characteristics as sources of variability in the response to meditation have not been examined directly through a meta-analysis, but only briefly explored as moderating factors in meta-analyses that examine the effects of meditation on the specific dependent variable in a specific population (e.g., age as a moderator of the effect of meditation on reducing trait anxiety in adults, see Khoury et al., 2015; Orme-Johnson & Barnes, 2013; Zoogman et al., 2015) or in a non-quantitative form as a narrative review of 26 studies (Buric, Brazil, & van Mulukom, 2021). These previous studies provide limited conclusions regarding variability in meditation responses. For instance, the meta-analyses suggest that age, gender, and ethnicity did not moderate various outcomes of meditation in clinical and non-clinical samples (Khoury et al., 2015; Orme-Johnson & Barnes, 2013; Zoogman et al., 2015). This is partially in congruence with a narrative review that found the females respond better to meditation interventions, but there is no relationship between other demographic variables and meditation outcomes (Buric et al., 2021). Another meta-analysis found that the reduction in trait anxiety following meditation was greater in people with high anxiety levels (Orme-Johnson & Barnes, 2013), similar to a review that found that people who are more anxious generally tend to respond better to meditation interventions (Buric et al., 2021). Finally, a meta-analysis found that people with three or more episodes of major depression responded better to mindfulness-based cognitive therapy than those with one or two episodes (Piet & Hougaard, 2011). Buric et al. (2021) reached a similar conclusion and also identified several other sources of variability in meditation responses. More specifically, Buric et al. (2021) suggested that people with higher expectations of meditation tend to respond better to meditation interventions and that people with more severe medical conditions also tend to respond better. Finally, they also found indications that there might be some genetic predispositions that make some people more prone to experience better responses to meditation interventions. While these previous studies are certainly noteworthy, they do not provide numerical comparisons of different participant characteristics that could aid in predicting how a person might respond to meditation. The topic is quickly becoming of greater relevance as clinical practice recognizes the importance and urgency of developing interventions that are tailored to the individual's needs (i.e., are personalized) (Cuthbert & Insel, 2013), particularly in populations that tend to be less responsive to the established interventions (Brazil, van Dongen, Maes, Mars, & Baskin-Sommers, 2018). The central idea behind

personalized medicine is to move beyond the one-size-fits-all principle. One way in which we can move meditation research in the direction of individualized treatment is to first explore carefully how participant characteristics might affect meditation interventions.

Aims of the study

Our first aim was to examine the relationship between participant characteristics and responses to meditation through a series of meta-analyses. Thus, our focus is different from previous meta-analyses that have examined whether meditation works as an intervention across different populations (e.g., Khoury et al., 2015; Orme-Johnson & Barnes, 2013; Sedlmeier et al., 2012; Zoogman et al., 2015) or from non-quantitative reviews (Buric et al., 2021). To carry out these meta-analyses, we identified studies of meditation-based interventions that measured at least one variable pertaining to participant characteristics and reported how these characteristics were linked to meditation outcomes. As there is a lack of theory that would guide the selection of outcomes in meditation studies, this leads to wide variability in the selection of outcome variables. To run such meta-analyses, all outcome variables have to be split into positive and negative (i.e., as having a positive or negative impact on mental health) because any participant characteristic could have one kind of association with negative outcomes, and a different association with positive outcomes. For instance, participants' baseline depression levels could be highly associated with a change in stress scores following meditation intervention, but less associated with a change in sleep quality scores.

Based on previous studies described above, we expected to find that demographic variable had no effect on positive or negative outcomes of meditation. Furthermore, we expected that participants with higher trait anxiety or with higher depression levels would experience a more positive impact from meditation. We did not have further specific hypotheses about other participant characteristics and their effect on meditation outcomes, as many of these characteristics were still unknown and the present study was the first to systematically explore the literature to uncover them.

Our second aim was to test for moderators of the relationship between participant characteristics and meditation outcomes. We included six moderators: sample size, sample type, research design, study quality, meditation type, and length of meditation. The first four moderators were chosen based on the results of previous meta-analyses focusing on meditation, which often show smaller effect sizes in studies with larger samples, in non-clinical samples, in randomized controlled trials, and in studies of high methodological quality (Sedlmeier et al., 2012). The remaining two moderators were chosen because the effect sizes often vary for different types of meditation and different lengths of meditation interventions (Kok & Singer, 2017), thus we wanted to test these moderators in the context of participant characteristics and meditation. We also examined the methodological rigor of the studies included in our analyses given that concerns have been raised about the methodological quality of meditation studies (Chiesa & Serretti, 2009; Goyal et al., 2014).

Methods and materials

Selection of studies

We searched the databases Psych INFO, MEDLINE, PsycARTICLES until March 2019 using the following search terms: (meditation OR mindfulness) AND (moderator OR

predictor OR individual differences OR interaction). The search was limited to titles and abstracts. To locate studies that were not detected with the initial database search, we contacted 58 experts to enquire if they were familiar with additional studies that met our eligibility criteria, and we hand-searched references of the 79 articles that met our eligibility criteria (Figure 1). Following the removal of duplicates, 2000 records were screened. A total of 51 articles met the following inclusion criteria:

- The sample contained participants that were 18 years of age or older.
- Both clinical and non-clinical samples were allowed.
- There should be at least 10 participants per group (Hedges, 1985).
- Studies had to include a meditation intervention, baseline measures of participants' characteristics, and at least one meditation outcome.
- All types of meditation or meditation-based interventions that included meditation as a core component were eligible.
- Research designs could be experimental or quasi-experimental.
- Articles should have been published in English in peer-reviewed journals.

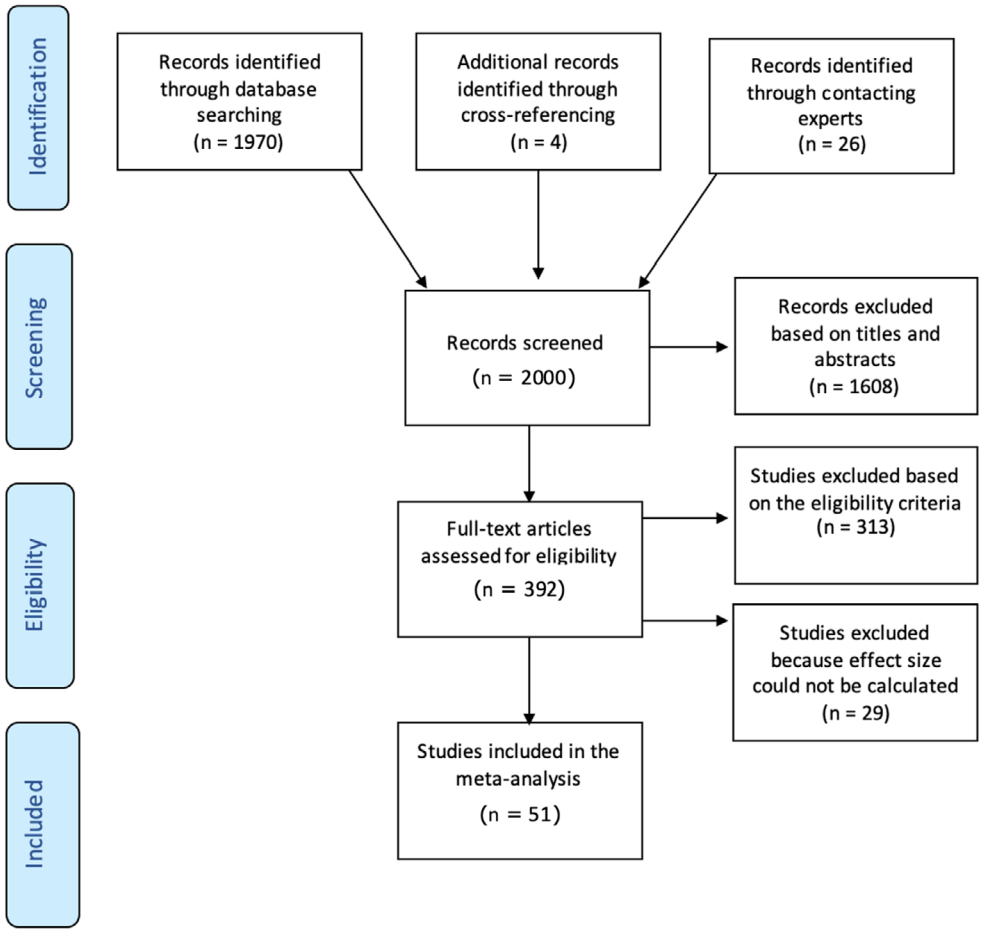

Figure 1. PRISMA flowchart.

Exclusion criteria:

- Meta-analyses, review papers, commentaries, doctoral theses, and conference proceedings.
- Studies that only used non-standardized tasks and/or questionnaires.
- Studies with outcomes that cannot be categorized as having a positive or negative impact on mental health.

Quality assessment

We assessed the methodological quality of the studies using the National Institutes of Health Study Quality Assessment Tools: Quality Assessment of Controlled Intervention Studies and Quality Assessment Tool for Before–After (Pre–Post) Studies with No Control Group (National Heart, Lung and Blood Institute, 2014). Each tool consists of 8–14 questions that are answered with *yes, no,* or *not reported/cannot determine/not applicable*, where the latter two suggest a potential flaw in the study design or implementation. The questions examine components of internal validity, such as if the study used random sequence generation, included blinding of outcome assessment, or showed selective reporting of statistical results. We had to modify two out of three quality assessment tools, as some items were not applicable to meditation research. Specifically, in the Quality Assessment of Pre–Post Studies with no Control Group, we excluded two items: *Were outcome measures of interest taken multiple times before the intervention and multiple times after the intervention (i.e., did they use an interrupted time-series design)?* and *if the intervention was conducted at a group level (e.g., a whole hospital, a community, etc.) did the statistical analysis take into account the use of individual-level data to determine effects at the group level?* In the Quality Assessment of Controlled Intervention Studies, we excluded one item: *Were study participants and providers blinded to treatment group assignment?* because it is dubious whether one can truly blind participants to a meditation intervention (Davidson & Kaszniak, 2015). The responses were coded as 1 if the answer was *yes* or as 0 if the answer was *no* or *not reported*.

Study characteristics

There was a total of 7782 participants across 51 articles (full references of included articles can be found after the references cited in the text, and the extracted data can be found in Table 1). Studies showed moderate-quality based on the National Institutes of Health study quality assessment tools (see Table 2). The median length of meditation interventions was 56 days. Out of the 51 included studies, mindfulness meditation was used in 68% of the studies, while 14% of the studies employed transcendental meditation, and other techniques (mainly compassion or breathing meditations) were used in 18% of studies. Furthermore, 56% of the studies had pre–post design studies without a control group, while 44% were randomized controlled trials. Randomized controlled trials used active control groups in 58% of cases, which included psycho-education or various forms of attention control, such as reading or listening to a story. Healthy adults were examined in 56% of the 51 eligible studies. The most common clinical populations were patients with chronic medical conditions, such as cancer, hypertension, or arthritis (24%). The most prevalent mental disorders were anxiety (18%) and depression (18%), followed by substance abuse (14%), and studies that targeted more than one mental disorder (14%).

Table 1. Summary of the results of all studies included in the meta-analysis showing authors of each study, examined participant characteristic and outcomes of meditation, effect size (ES) converted to Pearson's r, sample size, research design type, sample type, meditation type and length, and study quality estimated with tools by National Institutes of Health (ranging from 0 to 1)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
Azam et al. (2016)	Having headache	Heart-rate variability	.37	77	RCT	Healthy adults	Loving-kindness meditation	1	.83
Brotto et al. (2015)	Trait anxiety	Change score in pain	.02	63	Non-RCT	Women with vulvodynia	Group training that includes mindfulness, cognitive-behavioural therapy, and pain education	56	.70
	Depression	Change score in pain	.13	60	Non-RCT	Women with vulvodynia	Group training that includes mindfulness, cognitive-behavioural therapy, and pain education	56	.70
	Number of comorbid conditions	Pain induced by a cotton swab at 6 mo follow-up	−.18	69	Non-RCT	Women with vulvodynia	Group training that includes mindfulness, cognitive-behavioural therapy, and pain education	56	.70
	Sexual distress	Change score in pain	.05	63	Non-RCT	Women with vulvodynia	Group training that includes mindfulness, cognitive-behavioural therapy, and pain education	56	.70
Cohn & Fredrickson (2010)	Social support received	Continued meditation practice at 8 weeks	.19	95	RCT	Healthy adults	Loving-kindness	365	.69
	Daily positive emotions during the week before learning meditation	Continued meditation practice at 8 weeks	.24	95	RCT	Healthy adults	Loving-kindness	365	.69
Cordon Brown & Gibson (2009)	Insecure attachment	Drop-out rate	.29	131	Non-RCT	Healthy adults	Mindfulness-based stress reduction	75	.90
Crandall et al. (2019)	Intentions to practice mindfulness and subjective norms	Practicing mindfulness	.30	85	Non-RCT	Healthy adults	Provisional selection among many mindfulness exercises within an app (The Smiling mind app)	14	.90
	Perceived behavioural control	Practicing mindfulness	.06	85	Non-RCT	Healthy adults	Provisional selection among many mindfulness exercises within an app (The Smiling mind app)	14	.90

Continued

Table 1. (*Continued*)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
	Age, gender, employment status	Practicing mindfulness	.02	85	Non-RCT	Healthy adults	Provisional selection among many mindfulness exercises within an app (The Smiling mind app)	14	.90
Crescentini et al. (2014)	Implicit religiousness/ spirituality	Implicit religiousness/ spirituality	.40	30	Non-RCT	Healthy adults	Mindfulness group training based on Theravada traditions and mindfulness-based stress reduction	70	.50
Day et al. (2016)	Expectations/motivation	Pain interference	.34	21	RCT	Chronic headache pain	Mindfulness-based cognitive therapy	56	.54
	Expectations/motivation	Home practice	.15	21	RCT	Chronic headache pain	Mindfulness-based cognitive therapy	56	.54
Delmonte (1981)	Age	Deciding to learn meditation after tm lecture	.25	94	Non-RCT	Healthy adults	Transcendental meditation	16	.60
	Expectations	Deciding to learn meditation after tm lecture	.33	64	Non-RCT	Healthy adults	Transcendental meditation	16	.60
	Perceived self	Deciding to learn meditation after tm lecture	.32	70	Non-RCT	Healthy adults	Transcendental meditation	16	.60
Delmonte (1985)	Expectations (positive rationale group)	Skin conductance	.42	40	Non-RCT	Healthy adults	Transcendental meditation	1	.70
Delmonte (1988)	Extraversion	Becoming a regular meditator at 12mo	.02	37	Non-RCT	Outpatients with psychosomatic and neurotic symptoms	Transcendental meditation	104	.70
Dobkin et al. (2017)	Not depressed	Stress	.30	63	Non-RCT	Patients with various chronic illnesses	Mindfulness-based stress reduction	56	.70
	Not depressed	Coherence (average comprehensibility, manageability, meaningfulness,	.10	63	nNon-RCT	Patients with various chronic illnesses	Mindfulness-based stress reduction	56	.70
Felleman et al. (2016)	Gender	PTSD severity	.16	116	Non-RCT	PTSD veterans	Mindfulness-based stress reduction	56	.80

Continued

Table 1. (*Continued*)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
	PTSD severity	PTSD severity	.19	116	Non-RCT	PTSD veterans	Mindfulness-based stress reduction	56	.80
Gawrysiak et al. (2016)	Distress tolerance	Perceived stress	.32	327	Non-RCT	Healthy adults	Mindfulness-based stress reduction	56	.90
Greenberg et al. (2018)	Self-compassion	Change in depression symptoms	−.02	13	RCT	Patients with depression	Mindfulness-based cognitive therapy	56	.62
Greeson et al. (2011)	Having a religious affiliation	Change in depression symptoms	−.04	279	Non-RCT	Healthy adults	Mindfulness-based stress reduction	56	.90
Greeson et al. (2015)	Having a religious affiliation	Change in depression symptoms	.01	322	Non-RCT	Healthy adults	Mindfulness-based stress reduction	56	.90
	Age	Change in depression symptoms	−.04	322	Non-RCT	Healthy adults	Mindfulness-based stress reduction	56	.90
	Mindfulness	Change in depression symptoms	.19	322	Non-RCT	Healthy adults	Mindfulness-based stress reduction	56	.90
	Mental functioning	Change in depression symptoms	.19	119	Non-RCT	Healthy adults	Mindfulness-based stress reduction	56	.90
Geschwind et al. (2012)	Number of depressive episodes	Depression symptoms HSRD scale	.21	260	RCT	Adults with history of depression	Mindfulness-based cognitive therapy	56	.77
Heide et al. (1980)	Hypnotic responsivity	Trait anxiety	.20	58	RCT	Healthy adults	Mantra meditation	7	.77
	Hypnotic responsivity	Perceived benefit from meditation	.19	58	RCT	Healthy adults	Mantra meditation	7	.77
Herdt et al. (2012)	Therapist's assessment of the patients' motivation	Number of attended sessions	.43	51	Non-RCT	Psychiatric patients	Mindfulness-based cognitive therapy	63	.80
	Having participated in group therapies earlier	Completed sessions 1–3	.21	74	Non-RCT	Psychiatric patients	Mindfulness-based cognitive therapy	63	.80
Hülsheger et al. (2015)	Age	Work hours	−.13	140	RCT	Healthy adults	Self-trained mindfulness based on mindfulness-based stress reduction and mindfulness-based cognitive therapy	10	.46
	Age	Sleep duration	.00	140	RCT	Healthy adults	Self-trained mindfulness based on mindfulness-based stress reduction and mindfulness-based cognitive therapy	10	.46

Continued

Table 1. (*Continued*)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
	Age	Mindfulness	−.06	140	RCT	Healthy adults	Self-trained mindfulness based on mindfulness-based stress reduction and mindfulness-based cognitive therapy	10	.46
	Trait mindfulness	Mindfulness	.19	140	RCT	Healthy adults	Self-trained mindfulness based on mindfulness-based stress reduction and mindfulness-based cognitive therapy	10	.46
	Sleep duration	Sleep duration	.23	140	RCT	Healthy adults	Self-trained mindfulness based on mindfulness-based stress reduction andmindfulness-based cognitive therapy	10	.46
Jazaieri et al. (2016)	Low social anxiety	Social anxiety during MBSR	.30	47	RCT	Patients with social anxiety disorder	Mindfulness-based stress reduction	56	.54
Kabat-Zinn & Chapman-Waldrop (1988)	Gender in pain cohort	Completing the program	.12	500	Non-RCT	Patients with stress or pain-related conditions	Mindfulness-based stress reduction	56	.60
	Type of pain/stress diagnosis	Completing the program	.14	784	Non-RCT	Patients with stress or pain-related conditions	Mindfulness-based stress reduction	56	.60
	Gender (total population)	Being a no-show vs being a drop-out	.06	784	Non-RCT	Patients with stress or pain-related conditions	Mindfulness-based stress reduction	56	.60
Kharlas & Frewen (2016)	Mindfulness	Distress during meditation	−.12	508	Non-RCT	Healthy adults	A single session of mindfulness imagery practice	1	.60
	Mindfulness	Visual imagery during meditation	.13	508	Non-RCT	Healthy adults	A single session of mindfulness imagery practice	1	.60
	Sensory imagery	Distress during meditation	.01	508	Non-RCT	Healthy adults	A single session of mindfulness imagery practice	1	.60
	Sensory imagery	Pleasantness during meditation	.25	508	Non-RCT	Healthy adults	A single session of mindfulness imagery practice	1	.60
Lee & Bowen (2015)	Conscientiousness	Curiosity	.01	63	Non-RCT	Prisoners with addiction disorders	Mindfulness group training based on mindfulness-based stress reduction	56	.70
Logie & Frewen (2015)	Curiosity	Negative affect during referential processes	.15	70	RCT	Healthy adults	A single session of mindfulness via an audio recording (focused attention)	1	.69

Continued

Table 1. (*Continued*)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
	Curiosity	Positive affect during referential processes	.14	70	RCT	Healthy adults	A single session of mindfulness via an audio recording (focused attention)	1	.69
Ly et al. (2014)	Low depression symptoms	Depression symptoms	.40	37	RCT	Patients with major depressive disorder	Mindfulness training via an app (focused attention)	56	.92
Mak et al. (2018)	Discomfort with emotion	Well-being	.04	2161	RCT	Healthy adults	Mindfulness training via an app (focused attention)	28	.85
	Ambiguity tolerance	Well-being	.03	2161	RCT	Healthy adults	Mindfulness training via an app (focused attention)	28	.85
	Gender	Well-being	.04	2161	RCT	Healthy adults	Mindfulness training via an app (focused attention)	28	.85
	Religion	Well-being	.00	2161	RCT	Healthy adults	Mindfulness training via an app (focused attention)	28	.85
	Discomfort with emotion	Distress	.05	2161	RCT	Healthy adults	Mindfulness training via an app (focused attention)	28	.85
	Ambiguity tolerance	Distress	.03	2161	RCT	Healthy adults	Mindfulness training via an app (focused attention)	28	.85
	Gender	Distress	.00	2161	RCT	Healthy adults	Mindfulness training via an app (focused attention)	28	.85
	Religion	Distress	.00	2161	RCT	Healthy adults	Mindfulness training via an app (focused attention)	28	.85
Michalak et al. (2016)	Childhood abuse	Depression change in meditation group (observer rated)	−.29	26	RCT	Patients with chronic depression	Mindfulness-based cognitive therapy	56	.61
Nguyen-Feng et al. (2016)	History of interpersonal violence	Worry	−.33	314	RCT	Healthy adults	Three 20-minute pre-recorded mindfulness exercises via a web (focused attention)	1	.61
Nguyen-Feng et al. (2017)	History of interpersonal violence	Depression, anxiety, stress	−.11	147	RCT	Healthy adults	Pre-recorded mindfulness training via a web (focused attention)	28	.77
Oken et al. (2018)	Gender Age Education	Health-related quality of life	.01	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based cognitive therapy, one-on-one with a trained instructor	42	.69
	Depression	Health-related quality of life	−.08	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based Ccognitive therapy, one-on-one with a trained instructor	42	.69

Continued

Table 1. (*Continued*)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
	Mental health, affect, sleep quality	Health-related quality of life	.00	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based cognitive therapy, one-on-one with a trained instructor	42	.69
	Life stressors	Health-related quality of life	.14	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based cognitive therapy, one-on-one with a trained instructor	42	.69
	Perceived stress	Health-related quality of life	.01	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based cognitive therapy, one-on-one with a trained instructor	42	.69
	Neuroticism	Health-related quality of life	.18	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based cognitive therapy, one-on-one with a trained instructor	42	.69
	Expectancy	Health-related quality of life	−.09	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based cognitive therapy, one-on-one with a trained instructor	42	.69
	Self-efficacy	Health-related quality of life	−.09	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based cognitive therapy, one-on-one with a trained instructor	42	.69
	Mindfulness	Health-related quality of life	.00	121	Non-RCT	Stressed adults	Mindfulness based on mindfulness-based cognitive therapy, one-on-one with a trained instructor	42	.69
Pace et al. (2010)	Affect	Amount of practice (high vs low)	.36	30	Non-RCT	Healthy adults	Compassion meditation	42	.80
	Affect	Amount of practice (high vs low)	.50	30	Non-RCT	Healthy adults	Compassion meditation	42	.80
Pace et al. (2009)	IL-6	Amount of practice (high vs low)	.14	30	Non-RCT	Healthy adults	Compassion meditation	42	.80
	Gender	Amount of practice (high vs low)	.12	61	RCT	Healthy adults	Compassion meditation	42	.85
	Depressive symptoms	Amount of practice (high vs low)	.07	61	RCT	Healthy adults	Compassion meditation	42	.85
Park & Park (2012)	Self-directedness	Heart-rate variability	−.10	58	Non-RCT	Healthy adults	Paced breathing	1	.80

Continued

Table 1. (*Continued*)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
	Harm avoidance	Heart-rate variability	−.08	58	Non-RCT	Healthy adults	Paced breathing	1	.80
Prins et al. (2014)	Pain catastrophizing	Rating pain during painful stimuli	.26	51	RCT	Healthy adults	A single session of pre-recorded mindfulness (focused attention and open monitoring)	1	.62
Reich et al. (2014)	Lymphocyte subsets	Fatigue	.32	17	RCT	Breast cancer patients	Mindfulness-based cognitive therapy	42	.77
Rohsenow Smith et al. (1985)	Anxiety	Anxiety difference	.58	36	RCT	Adults with heavy drinking problems	Cognitive-affective stress management	1	.23
	Irrational beliefs	Anger difference	.52	36	RCT	Adults with heavy drinking	Cognitive-affective stress management	1	.23
	Social support	Anxiety difference	.13	36	RCT	Adults with heavy drinking	Cognitive-affective stress management	1	.23
	Alcohol consumption	Anxiety difference	.52	36	RCT	Adults with heavy drinking	Cognitive-affective stress management	1	.23
	Locus of control	Anxiety difference	.32	36	RCT	Adults with heavy drinking	Cognitive-affective stress management	1	.23
	Mood	Anxiety difference	.67	36	RCT	Adults with heavy drinking	Cognitive-affective stress management	1	.23
Rojiani et al., 2017	Women	Negative affect	.31	77	Non-RCT	Healthy adults	Mindfulness from Buddhist or Daoist traditions (focused attention and open monitoring)	84	.70
	Men	Mindfulness	.67	77	Non-RCT	Healthy adults	Mindfulness from Buddhist or Daoist traditions (focused attention and open monitoring)	84	.70
Roos et al. (2017)	Substance use severity	Number of substance use days	.10	80	Non-RCT	Substance use disorders	Mindfulness-based relapse prevention	56	.92
	Depression	Number of substance use days	.05	80	Non-RCT	Substance use disorders	Mindfulness-based relapse prevention	56	.92
	Anxiety	Number of substance use days	−.07	80	Non-RCT	Substance use disorders	Mindfulness-based relapse prevention	56	.92
Rosenzweig et al. (2010)	Type of pain diagnosis	Psychological distress	.33	133	Non-RCT	Patients with chronic pain	Mindfulness-based stress reduction	56	.70

Continued

Table 1. (*Continued*)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
	Type of pain diagnosis	Quality of life	.26	133	Non-RCT	Patients with chronic pain	Mindfulness-based stress reduction	56	.70
Sass et al. (2013)	Low discomfort with emotion	Psychological distress	.58	24	Non-RCT	Healthy adults	Mindfulness based on mindfulness-based stress reduction and mindfulness-based cognitive therapy	56	.70
Seer & Raeburn (1980)	Diastolic blood pressure	Responding to treatment	.40	41	RCT	Patients with hypertension	Transcendental meditation	5	.61
	Feeling relaxed	Responding to treatment	.44	41	RCT	Patients with hypertension	Transcendental meditation	5	.61
Shapiro et al. (2011)	Mindfulness	Rumination	−.50	30	RCT	Healthy adults	Mindfulness-based stress reduction	56	.69
	Mindfulness	Mindfulness	.29	30	RCT	Healthy adults	Mindfulness-based stress reduction	56	.69
Smith (1978)	Trait anxiety	Trait anxiety	.22	19	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Trait anxiety	Continued practice of meditation for 6 months	.10	22	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Age	Trait anxiety	.09	19	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Gender	Continued practice of meditation for 6 months	.16	22	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Considered therapy	Trait anxiety	−.24	19	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Considered therapy	Continued practice of meditation for 6 months	.30	22	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Self-concept (averaged)	Trait anxiety	−.13	19	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Self-concept (averaged)	Continued practice of meditation for 6 months	.06	22	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Social desirability	Trait anxiety	.10	19	RCT	Adults with anxiety	Transcendental meditation	180	.85
	Social desirability	Trait anxiety	−.01	19	RCT	Adults with anxiety	Transcendental meditation	180	.85
Takahashi et al. (2005)	Novelty seeking	Heart-rate variability	−.06	20	Non-RCT	Healthy adults	Other types of meditation	1	.50
Tamagawa et al. (2015)	Anxiety	Class attendance	.26	38	Non-RCT	Distressed breast cancer patients	Mindfulness-based cancer recovery	56	.80
	Married/cohabitating vs single	Home practice	.20	38	Non-RCT	Distressed breast cancer patients	Mindfulness-based Ccancer recovery	56	.80
	Depression	Meditation home practice	.09	38	Non-RCT	Distressed breast cancer patients	Mindfulness-based cancer recovery	56	.80

Continued

Table 1. (*Continued*)

Authors	Participant characteristics	Outcomes	ES	Sample size	Design type	Sample type	Meditation type	Meditation length (days)	Study quality
	Social support	Meditation home practice	.10	38	Non-RCT	Distressed breast cancer patients	Mindfulness-based cancer recovery	56	.80
	Months since cancer diagnosis	Meditation home practice	−.05	38	Non-RCT	Distressed breast cancer patients	Mindfulness-based cancer recovery	56	.80
	Low self-esteem	Class attendance	.03	38	Non-RCT	Distressed breast cancer patients	Mindfulness-based cancer recovery	56	.80
	Repressive/defensiveness	Class attendance	−.02	38	Non-RCT	Distressed breast cancer patients	Mindfulness-based cancer recovery	56	.80
	Low well-being	Class attendance	.05	38	Non-RCT	Distressed breast cancer patients	Mindfulness-based cancer recovery	56	.80
Watier & Dubois (2016)	Low mindfulness	Executive attention	.19	78	RCT	Healthy adults	One-session pre-recorded mindfulness (focused attention)	1	.62
Weinstein & Smith (1992)	Absorption	Somatic anxiety difference	.55	52	Non-RCT	Adults with anxiety	Focused attention meditation	1	.80
	Absorption	Focusing difference	−.53	52	Non-RCT	Adults with anxiety	Focused attention meditation	1	.80
Zalta et al. (2018)	Combat or military sexual trauma	PTSD severity	.41	191	Non-RCT	PTSD patients	Cognitive processing, mindfulness, yoga, and psychoeducation	31	.90
	Combat or military sexual trauma	Health	.22	191	Non-RCT	PTSD patients	Cognitive processing, mindfulness, yoga, and psychoeducation	31	.90
	Gender	PTSD severity	.10	191	Non-RCT	PTSD patients	Cognitive processing, mindfulness, yoga, and psychoeducation	31	.90
Zautra et al. (2008)	History of recurrent depression	Catastrophizing	.24	144	RCT	Patients with rheumatoid arthritis	Mindfulness based on mindfulness-based stress reduction and mindfulness-based cognitive therapy	56	.54
	History of recurrent depression	Pain control	.15	144	RCT	Patients with rheumatoid arthritis	mindfulness based on mindfulness-based stress reduction and mindfulness-based cognitive therapy	56	.54
Zuroff & Schwarz (1978)	Expectancy	Anxiety difference	−.26	60	RCT	Healthy adults	Transcendental meditation	63	.62
	Psychological maladjustment	Anxiety difference	.06	60	RCT	Healthy adults	Transcendental meditation	63	.62
	Locus of control	Anxiety difference	.53	60	RCT	Healthy adults	Transcendental meditation	63	.62
	Social desirability	Anxiety difference	−.20	60	RCT	Healthy adults	Transcendental meditation	63	.62

Table 2. Characteristics of the studies included in the meta-analysis (N = 51)

	Average	Median	Range	SD	Sum
Number of participants[a]	155.64	63	17–2161	510.25	7782
Length of meditation (days)	47.14	56			
Study quality	0.72	0.7			
	RCT	Non-RCT			
Research design	44%	56%			
	Clinical sample	Non-clinical Sample			
Sample type	44%	56%			
	Mindfulness	Transcendental meditation	Other		
Meditation type	68%	14%	18%		

Note. RCT: randomized controlled trial. Other types of meditation mainly included self-compassion or breathing meditation.
[a]Sample sizes varied from 17 (minimum) to 2161 (maximum), while the standard deviation was 510.25.

Studies were published between 1978 and 2018, though the majority (72%) was published in the past ten years, which suggests a growing interest in examining the effects of participant characteristics.

Procedure for data extraction and categorization

The lead author (IBu) reviewed titles, abstracts, and full texts. An extraction sheet was used to specify relevant information for each study: sample size, meditation type, meditation length, type of research design, quality assessment, examined participant characteristics, outcomes, and the relationship between participant characteristics and outcomes. Two authors (IBu and JMAD) independently extracted data on participant characteristics and meditation outcomes. Inter-rater agreement was high (r =.89) and disagreements were discussed until consensus was reached.

Data extraction yielded 99 variables for participant characteristics and 76 outcome variables (see Tables 3 and 4). Given that many sources of individual differences in mediation outcomes still remained to be uncovered, we first explored whether 'themes' could be found within the pool of extracted participant characteristic variables by clustering these variables into thematic categories. Each category consisted of at least four studies. First, we searched for broad themes that were present across most studies and were therefore relatively easy to identify, such as *well-being, psychopathology, psychological traits*, and *medical conditions*. Next, studies were added to each of these clusters until thematically different sub-clusters emerged that consisted of four or more studies each, which led to the conversion of the sub-clusters into separate thematic categories. For example, studies categorized under *anxiety* were initially part of the *psychopathology* category until, from the classification process, 4 or more studies assessing anxiety emerged. We found thirteen conceptually distinct categories of participant characteristics (Table 3). A second researcher (JMAD) also conducted the clustering independently to control for subjectivity bias. Inter-rater agreement was high (r = 0.93) and all discrepancies were settled before proceeding with the analyses.

Following this, we classified all meditation outcomes into two types: positive or negative (Table 4). They were classified as *positive* when an increase in scores reflected a positive impact on mental health (e.g., improved emotion regulation), and as *negative*

Table 3. Participant characteristics that were measured in the 51 eligible study, categorized across 13 categories

Category	Number of studies	Measured baseline participant characteristics
Psychological traits	11	Absorption, social desirability, cooperativeness, persistence, novelty-seeking, harm avoidance, reward dependence, repressive/defensiveness, hypnotic responsivity, Big Five (extraversion, neuroticism, openness to experience, conscientiousness, agreeableness), sensory imagery
Anxiety	7	State anxiety, social anxiety, trait anxiety, bodily symptoms of anxiety
Self-concept	9	Locus of control, low self-esteem, perceived self, self-concept, self-transcendence, self-directedness, self-efficacy, self-compassion, perceived behavioural control
Interpersonal	9	Positive life experiences, social support received, social support given insecure attachment, history of interpersonal violence, childhood abuse, life experience stressors, sexual trauma, combat-related trauma
Demographics	13	Age, gender, marital status, employment, education
Depression	9	Depression symptoms, history of recurrent depression, number of depression episodes, fatigue
Motivation	8	Therapist's assessment of patient's motivation, therapist's prediction of leaving preterm, expectancy, motivation for spiritual growth, considered meditation, considered therapy, attitudes about meditation, intentions to practice meditation, subjective norms
Psychopathology	4	Obsessive–compulsive behaviour, alcohol consumption, posttraumatic stress disorder severity, psychological maladjustment, severity of substance use
Mindfulness	7	Trait mindfulness, curiosity, decentering, non-judgement
Belief system	4	Irrational beliefs, spirituality, religiosity, implicit religiousness/spirituality, religious affiliation
Medical conditions	6	Headaches, length of time since cancer diagnosis, pain/stress diagnosis, diastolic blood pressure, hypertension history, number of comorbid pain conditions, baseline pain
Stress-related factors	7	Cortisol, IL-6, lymphocyte subsets, mitogen-stimulated subsets, pain catastrophizing, discomfort with emotion, sexual distress
Well-being	12	Psychological detachment from work, sleep quality, sleep duration, well-being, pain self-efficacy, minutes of physical activity per day, distress tolerance, relaxation level, mood, positive and negative affect, positive emotions, experience in group therapy, psychological functioning, physical functioning, mental health

Note. The second column represents the number of studies per category and its sum is bigger than the total number of included studies ($N = 51$) as almost all studies had outcomes that were included in more than one category.

Table 4. Outcomes of meditation interventions that were measured in the 51 eligible study, categorized as positive or negative

Category	Number of studies	Measured baseline participant characteristics
Positive outcomes	68	Heart-rate variability, meditation practice frequency at home, meditation session attendance, implicit religiousness/spirituality, religion, coherence, sleep duration, mindfulness, visual imagery (during meditation), pleasantness (during meditation), curiosity, positive affect, well-being, ambiguity tolerance, quality of life, responding to hypertension treatment, executive attention, focusing, health, pain control
Negative outcomes	62	Skin conductance, perceived pain, pain interference, drop-out rate, perceived stress, PTSD severity, depression, trait anxiety, social anxiety, somatic anxiety, work hours, distress (during meditation), distress, negative affect, discomfort with emotion, worry, fatigue, anger, frequency of substance abuse, rumination, catastrophizing,

Note. The second column represents the number of studies per category and its sum is bigger than the total number of included studies ($N = 51$) as almost all studies had multiple outcomes. An outcome is categorized as positive if its increase has a positive impact on mental health or as *negative* if its increase meant a deterioration in mental heal.

when an increase in scores meant a deterioration in mental health (e.g., increased stress). Studies with outcomes that could not be classified as positive or negative were excluded from the analyses; this led to the exclusion of two studies with EEG measures.

Finally, we considered the moderators. As three out of our six moderators were categorical, they were coded as follows: sample type was coded as 'non-clinical' or 'clinical' (samples that included only participants with a psychiatric or other medical diagnosis were considered clinical, while samples with healthy adults were considered non-clinical); meditation type was coded as 'mindfulness', 'transcendental meditation', or 'other type of meditation'; type of research design was coded as 'RCT' if the study was a randomized controlled trial or as 'non-RCT' if another experimental design was employed.

Data handling and statistical analysis

A summary of data extraction and analysis can be found in Figure 2. Following data extraction and categorization of variables, effect sizes were calculated as Pearson's *r* using Meta-Calc (Rosenberg, Adams, & Gurevitch, 2000). If there were insufficient data to calculate effect sizes in the published studies, we contacted the authors. Similarly, for studies that included statistical corrections that reduced comparability across studies (e.g., including age as a covariate in all analyses), authors were contacted to obtain original data to calculate the uncorrected effect sizes. There were 79 studies that met our eligibility criteria, but we had to exclude 28 studies because the data could not be retrieved from its authors, leaving a total of 51 studies.

When studies used different measures of the same construct (e.g., two pain scales) or of the same category (e.g., several measures within well-being; see Table 3), the effects were averaged across measures. Similarly, in studies that had several follow-ups, the effects were averaged across all post-intervention time-points. When studies included three or more groups, the meditation intervention group was compared against the

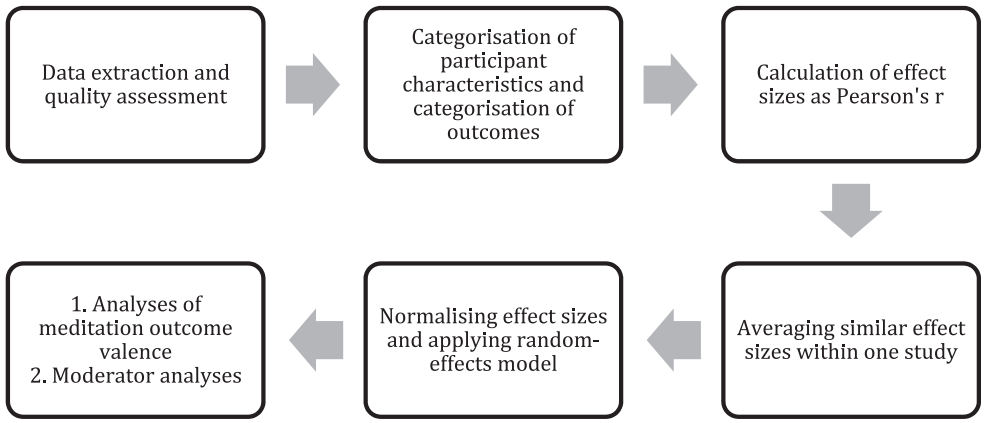

Figure 2. Schema for conducting data extraction and analysis. First, the relevant data were extracted from the 51 eligible studies and the quality of each study was rated. Second, we categorized all independent variables (i.e., participant characteristics) and dependent variables (i.e., outcome measure of meditation intervention), which resulted in thirteen categories of independent variables and two categories of dependent variables. Third, all extracted effect sizes were converted into Pearson's *r*. Fourth, multiple effect sizes within one study were averaged when they were related to the same construct or the same category, when the effect sizes represented two or more follow-ups, or when studies included three or more groups. Fifth, effect sizes were normalized through Fisher's *z* transformation and a random-effects model was applied in all analyses. Subgroup analyses were used to show the effect for each category of participant characteristics on two types of outcomes (i.e., positive and negative), and to test categorical moderators: sample type, research design, and meditation type. Finally, a meta-regression was conducted to test for continuous moderators: sample size, study quality, and length of meditation.

combination of other groups (for a similar procedure see (Hoppenbrouwers, Bulten, & Brazil, 2016)).

Effect sizes were first imported into MetaWin, normalized through Fisher's z-transformation (Rosenberg et al., 2000). Publication bias was evaluated using funnel plots combined with Rosenthal's fail-safe N approach (Orwin, 1983). A funnel plot shows the mean effect size of eligible studies converted to Fisher's z on the X-axis and standard errors on the Y-axis, along with the expected distribution of studies in the absence of bias (Sterne, Becker, & Egger, 2006). If studies were symmetrically distributed around the mean effect size, this shows there is no publication bias. Conversely, the fail-safe N indicates the number of unpublished studies with non-significant results that would be required to make the mean effect size non-significant (Egger, Smith, Schneider, & Minder, 1997). As a rule of thumb, if the fail-safe N is larger or equal to 5n + 10, where n is the number of studies, then the results are considered to be robust (Rosenberg, 2005). As this meta-analysis includes 51 studies, the fail-safe N had to be larger than 260 for the results to be considered robust. Note that a category was included in analysis only if it included a minimum of four studies.

The effects of participant characteristics on meditation outcomes were first examined with a univariate meta-analysis using a random-effects model (Rosenberg et al., 2000). Heterogeneity of scores between and within studies was assessed with the Q statistic (Cochran, 1954). The main downside of the univariate analysis is that it includes studies

with multiple effect sizes, which violates the assumption of independence of effect sizes. When the effect sizes in a meta-analysis are not independent, the estimated standard errors (SEs) on the average effect are generally under-estimated (Lopez-Lopez, Van den Noortgate, Tanner-Smith, Wilson, & Lipsey, 2017). To ensure the robustness of our results, we ran an additional analysis based on a three-level meta-analysis model using *metafor* package in R (Cheung, 2019). The three-level meta-analysis provides more information on how the heterogeneity can be decomposed into 2 levels: level 2 represents the variance of effect sizes that stem from the same study, and level 3 represents the variance of effect sizes between studies (Table S3).

In addition to testing the effects of participant characteristics on meditation outcomes, we conducted moderator analyses. Three categorical moderators were examined with subgroup analyses, while three continuous moderators were examined with meta-regression. The interpretation of the effect sizes is based on established guidelines by which the effects were considered small if r = .1, medium if r = .3, and large if r = .5 (Cohen, 2013). Significance was determined based on bootstrapped 95% confidence intervals (with 999 replications).

Results

Analyses based on thematic categories

Outcome valence: Do the effects of participant characteristics vary depending on whether mental health outcomes are negative or positive?

We tested whether each of the identified categories was linked to negative and/or positive effects on mental health after mediation. The mean effect size for participant characteristics on the negative effects of meditation was r = .12. The largest effect sizes were for stress-related factors (r = .25), well-being (r = .24), depression (r = .22), and psychopathology (r = .21), while the smallest were for demographics (r = .03), interpersonal (r = .03), and mindfulness (r = −.04) variables. Only four categories out of 12 had statistically significant effect sizes: psychopathology, well-being, depression, and stress-related factors. There were less than four studies available for medical conditions for this particular analysis, thus this variable was not examined (see Table 5).

The mean effect size for participant characteristics on the positive effects of meditation was r = .11 (*CI* 0.06, 0.15). Six out of 10 categories were significant: motivation (r = .23), medical conditions (r = .19), well-being (r = .19), interpersonal (r = .17), mindfulness (r = .15), and stress-related factors (r = .10), (see Table 5). The results were not carried out for three categories – anxiety, psychopathology, and belief system – because there were less than four studies available.

The analyses also revealed that the diversity in outcome measures was a large source of heterogeneity, as the Q statistic decreased when the data were split into studies with positive and negative outcomes (see Table 6). Therefore, although the overall analysis indicated that there was heterogeneity of effect sizes across studies, this was not the case once the total sample was divided into sub-classes based on the different types of outcomes of meditation. Rosenthal's fail-safe N was large for both positive and negative outcomes (510 and 457, respectively), suggesting that the results are robust. When we compared the outcomes of this univariate analysis with a three-level meta-analysis, this confirmed the original effect sizes and provided more insight into heterogeneity. We found that 85% of the variation in effect sizes across studies is due to heterogeneity rather than chance, which supports the choice of the random-effects model. Furthermore, we

Table 5. The results of the meta-analysis showing effect size (ES) of each category of participant characteristics on positive and negative outcomes, with corresponding 95% confidence intervals (CI)

	Negative outcomes			Positive outcomes		
Participant characteristics category	Number of ES	Mean ES	CI	Number of ES	Mean ES	CI
Psychological traits	5	.14	−.08, .37	10	.02	−.15, .15
Anxiety	5	.20	.00, .44	N/A	N/A	N/A
Self-concept	4	.29	−.08, .52	6	.05	−.06, .17
Interpersonal	6	.04	−.21, .30	4	**.17**	.11, .21
Psychopathology	4	**.21**	.07, .42	N/A	N/A	N/A
Belief system	4	.08	−.03, .35	N/A	N/A	N/A
Well-being	5	**.24**	.09, .50	8	**.19**	.09, .30
Motivation	4	.06	−.26, .41	6	**.23**	.05, .38
Depression	6	**.22**	.14.30	5	.06	−.03, .13
Stress-related factors	4	**.25**	.09, .60	4	**.10**	.03, .26
Demographics	7	.03	−.04, .11	11	.00	−.19, .11
Mindfulness	5	−.04	−.25, .13	6	**.15**	.08, .21
Medical conditions	N/A	N/A	N/A	5	**.23**	.11, .34
Overall	65	**.13**	.06, .19	63	**.11**	.06, .15

Note. N/A: analysis is not possible because less than four studies were available. Mean ES reported as Pearson's *r* with significant results marked in bold. The number of effect sizes exceeds the number of samples because more than one participant characteristic from the same category was used in some studies (e.g., gender and age belong to the demographics category). Confidence intervals are 95% and bootstrapped.

were able to identify the types of studies that have the largest percentage of variation between studies due to heterogeneity: RCTs (88%) and studies that examine positive health outcomes (85%). On the other hand, studies with non-clinical samples (59%), non-RCTs (57%), and studies that include types of meditation other than mindfulness or transcendental meditation (40%) have the largest percentage of variation within studies.

Moderator analyses: Categorical moderators

Research design: Do participant characteristics have a larger effect in randomized controlled trials? Types of research designs were coded as categorical variables to differentiate between randomized controlled trials and other research designs. The effect size in RCTs (r = .11, *CI* 0.06, 0.77) was almost identical to other study types (r = .11, *CI* 0.06, 0.15). The Q statistic was significant, indicating a large amount of heterogeneity based on study design. More specifically, there was a high amount of heterogeneity within and between the samples in RCTs, which suggests that included RCTs showed more diverse effect sizes, while studies employing a non-RCT design had less variability in the effects of participant characteristics (see Table 6). Large fail-safe numbers support the robustness of these results.

Sample type: Do participant characteristics have a larger effect in clinical or non-clinical samples? To test if participant type moderated the relationship between participant characteristics and meditation outcomes, we differentiated between clinical and non-clinical samples.

Table 6. The results of the meta-analysis showing effect sizes (ES), confidence intervals (CI), overall heterogeneity (Q), heterogeneity within studies (Q_w), heterogeneity between studies (Q_b), and fail-safe Ns for the overall analysis, subgroup analyses, and moderator analyses

	ES	95% CI	Q	Q_w	Q_b	Fail-safe N
Overall analysis	**.11**	.08, .15	**197.51**	**180.53**	16.99	2568.1
Negative outcome analysis	**.13**	.06, .19	77.85	**67.08**	10.77	417.7
Positive outcomes analysis	**.11**	.06, .15	78.39	64.83	13.56	493.1
Moderator analysis 1: research design			**220.02**	**219.96**	0.06	2873.7
RCT	**.11**	.06, .17	**124.71**	**111.20**	**13.52**	780.4
non-RCT	**.11**	.06, .15	88.80	88.62	0.18	514.6
Moderator analysis 2: sample type			**225.48**	**221.15**	**4.33**	2947.6
clinical	**.14**	.10, .19	86.51	75.85	**10.66**	909.3
non-clinical	**.08**	.03, .13	**127.59**	**127.47**	0.12	434.7
Moderator analysis 3: meditation type			**219.90**	**215.08**	4.82	2872.0
mindfulness	**.09**	.06, .13	**121.83**	**121.07**	0.75	1215.9
transcendental	**.18**	.05, .27	18.15	16.80	1.36	43.8
other	.16	−.02., .32	23.31	18.52	**4.78**	25.4
Moderator analysis 4: length of meditation	.11	.08, .14	**216.42**	**216.13**	0.07	2822.0
Moderator analysis 5: sample size	**.11**	.08, .14	**225.31**	**219.24**	**6.07**	2945.3
Moderator analysis 6: study quality	**.11**	.08, .14	**217.95**	**212.35**	**5.59**	2845.5

Note. Q statistic represents a composite measure of heterogeneity between (Q_b) and heterogeneity within studies (Q_w). Rosenthal's fail-safe N represents the required number of unpublished studies with non-significant results that would make the mean effect size non-significant, which should be over 260 in the case of a meta-analysis of 51 studies. Confidence intervals (CI) are 95% and bootstrapped. Mean ES reported as Pearson's r with significant results marked in bold.

Although the effect size was larger for studies with clinical (r = .14, *CI* 0.10, 0.19) than non-clinical samples (r = .08, *CI* 0.03, 0.13), both types showed significant effects of participant characteristics on meditation outcomes. The heterogeneity statistic was significant when studies were split based on the sample type, which suggests that the sample type was a source of heterogeneity (Table 6). The effect sizes of participant characteristics in studies with non-clinical samples varied significantly, while the effect sizes of studies with diverse clinical samples were consistent. Large fail-safe numbers support the robustness of these results.

Meditation type: Do participant characteristics have a larger effect in mindfulness meditation in comparison with other types of meditation?

Types of meditation were coded as categorical variables to differentiate between mindfulness, transcendental meditation, and other types of meditation. The lowest effect size was for mindfulness (r = .09, *CI* 0.06, 0.13), followed by other types of meditation (r = .16, *CI* −0.02, 0.32), and the largest for transcendental meditation (r = .18, *CI* 0.05, 0.28). However, participant characteristics had a significant effect on outcomes in studies that employed mindfulness or transcendental meditation, while this was not found for other types of meditation. Heterogeneity was significant only in studies that used mindfulness, while studies of transcendental meditation and other types of meditation show more consistent effect sizes, but also low fail-safe numbers, which suggests that these results are not robust (see Table 6). Additionally, the funnel plot is symmetrical (Figure 3), which suggests the absence of bias and systematic heterogeneity.

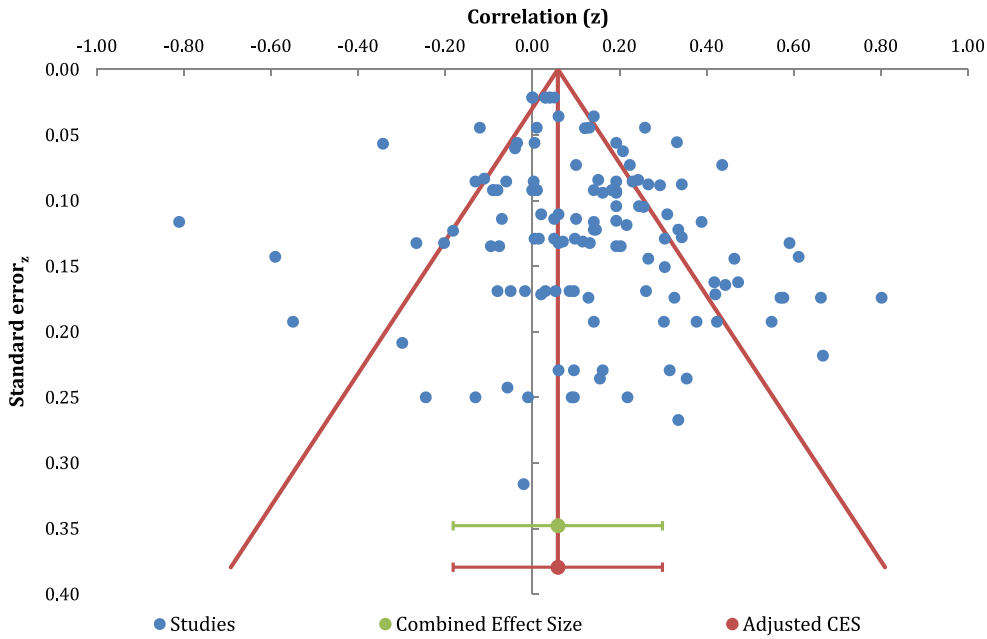

Figure 3. The funnel plot shows the overall mean effect size of eligible studies converted to Fisher's *z* on the *X*-axis and standard errors on the *Y*-axis, along with the expected distribution of studies in the absence of bias.

Moderator analyses: Continuous moderators

Meta-regression was conducted to examine three continuous moderators: sample size, length of meditation intervention, and study quality. We first tested whether sample size moderated the effect size of participant characteristics. Meta-regression confirmed that participant characteristics had a smaller effect on meditation outcomes when studies had larger samples (p = .01). Next, we investigated whether the frequency of meditation intervention or practice moderated the effect size of participant characteristics. Meta-regression results showed that the effect size of participant characteristics was not affected by the frequency of meditation practice (p = .79), which varied from 1 to 365 days. The third question concerned the moderating effect of the methodological quality of the study (for quality scores see Tables 1 and 2). Meta-regression showed that the quality of the study moderated the effects of participant characteristics on meditation response so that studies with higher quality had lower effect sizes (p = .02). Fail-safe N confirmed that the results are rigorous for all three meta-regressions, but Q statistics point to significant heterogeneity, which indicates large variability in effect sizes (see Table 6).

Discussion

The present study shows that participant characteristics play a significant role in shaping responses to meditation. Here, we focused on participant characteristics as sources of variability in responses to meditation, though we acknowledge that contextual factors, such as characteristics of the meditation teacher or group processes, can also play a role.

Our results confirmed the impact of participant characteristics on negative and positive health outcomes with two robust data analyses: a univariate and three-level meta-analysis. Psychological traits, self-concept, and demographics were the only non-significant categories in all analyses. This suggests that the response to meditation is not significantly impacted by participants' personality traits as operationalized in, for example, the Big Five theory of personality, nor to self-concept variables such as self-esteem or locus of control. In line with our findings, demographic variables have previously been found to not have a significant effect on the effect of meditation on health in clinical and non-clinical populations (Goldberg et al., 2018; Khoury et al., 2015; Sedlmeier et al., 2012).

In contrast, two categories were significantly related to meditation outcomes in all analyses: well-being and stress-related factors. We found that participants with higher baseline levels of well-being showed moderate increases for both negative and positive meditation outcomes. Similarly, participants with higher baseline levels of stress showed moderate increases in negative outcomes and small increases in positive outcomes. These results suggest that meditation has contrasting, even opposing effects for individuals with higher well-being and higher stress levels. Some authors have argued that meditation, by making one acutely aware of certain thoughts and emotions, can be a difficult process for some (Creswell, Pacilio, Lindsay, & Brown, 2014; Farias & Wikholm, 2015).

There was another unexpected and somewhat counter-intuitive result. Baseline levels of depression were only significantly related to negative outcomes. In other words, meditation practice or intervention is more likely to lead to negative outcomes for an individual reporting a higher level of depression. We need to qualify this result by looking at the individual studies that led to this result. Three out of the nine included studies in this category were conducted with participants with a diagnosis of current major depression episode (Ly et al., 2014) or a history of major depression (Geschwind, Peeters, Huibers,

van Os, & Wichers, 2012; Zautra et al., 2008), while the six remaining studies included different clinical populations that often exhibit symptoms of depression, such as chronic pain conditions (Brotto, Basson, Smith, Driscoll, & Sadownik, 2015), breast cancer survivors (Tamagawa et al., 2015), or substance use disorders (Roos, Bowen, & Witkiewitz, 2017). This suggests that it is not depression per se, but depression as a comorbid factor that might interact negatively with meditation. This claim seemingly contradicts prior meta-analytic findings showing that individuals with a current episode of depression can benefit from a meditation-based intervention (Strauss, Cavanagh, Oliver, & Pettman, 2014). However, Strauss et al. (2014) did not directly examine if there was a relationship between the extent of depression symptoms that are present before the meditation intervention and the outcomes after the intervention, thus there remains a possibility that their data would show results similar to ours if the same research question was examined. However, it is important to emphasize that we cannot conclude that the symptoms of depression necessarily get worse because only two out of the nine studies measured that, while others measured negative outcomes such as stress or substance use. Another possible explanation of the association between baseline depression levels and negative outcomes is that participants with symptoms of depression experience an initial worsening of their mental health in the early stages of meditation practice, but then experience improvements in later stages if they manage to develop high acceptance. As none of the included studies that measured depression as a participant characteristic provided data for more than 8 weeks of practice nor examined acceptance as a mediator, we currently cannot examine this.

Based on previous studies, we had a clear hypothesis that people with higher trait anxiety would be more likely to experience a more positive response to meditation. However, there were fewer than four studies available that included these data, so we were not able to confirm nor dismiss this hypothesis. Instead, we were able to find that the association between anxiety and negative outcomes was non-significant. Furthermore, there were several other categories of participant characteristics where we were not able to obtain results due to a lack of studies: interpersonal participants characteristics (regarding both positive and negative outcomes), psychopathology (and positive outcomes), belief systems (and positive outcomes), and medical conditions (and negative outcomes; see Table 5). It remains unknown how different the results of this study would be if we were able to include the additional 28 studies that met our eligibility criteria, but that failed to provide the necessary data to calculate effect sizes.

Overall, these results highlight the possibility that some individuals can react negatively to meditation. The negative effects of mind-body interventions have been an uncomfortable and neglected topic within meditation research, though recently some studies have suggested that adverse experiences in meditators have a prevalence of about 8%, which is similar to that reported for psychotherapy practice (Farias et al., 2020). The prevalence and relevance of these negative effects are potentially underestimated. Two recent meta-analyses of mindfulness-based therapeutic interventions found that only 9 trials out of 47 (19%) (Goyal et al., 2014) and 36 trials out of 231 (16%) (Wong, Chan, Zhang, Lee, & Tsoi, 2018) reported adverse effects. There are also criticisms concerning the use of unreliable methods to address these negative effects (Lindahl, Britton, Cooper, & Kirmayer, 2021), and a tendency to frame these effects as difficulties during meditation which will eventually transform themselves into positive experiences (e.g., Chen, Qi, Hood, & Watson, 2011).

Looking at the other side of the spectrum, motivation, medical conditions, and interpersonal characteristics were significantly related to only positive outcomes. These

results point at various interesting possibilities. First, it indicates that people with medical problems may particularly benefit from meditation. It would be interesting for future studies to look at the processes that potentially mediate this relationship, such as self-regulation, or detachment from anxiety related to the medical condition. Second, it shows that interpersonal characteristics play a significant role in shaping meditation outcomes. A closer look at the studies involved shows that most of them focused on negative interpersonal factors, such as abuse, violence, and sexual trauma. This is in line with some research suggesting that individuals with a history of childhood trauma are more likely to benefit from a meditation-based intervention when being treated for recurrent depression (Williams et al., 2014). Thirdly, motivational factors, such as positive attitudes and expectations of meditation, were associated with positive outcomes. This is an expected finding as it can be assumed that individuals who begin learning meditation with higher motivation and expectations of achieving benefits do actually show greater benefits. Nevertheless, this is an important result to consider, as few meditation studies have controlled for this variable. Those who have, though, have found that positive expectations of meditation outcomes play a significant role in the results of studies (Creswell et al., 2014).

We took a deeper look into the data by examining several moderators: research design, sample type, meditation type, length of meditation intervention, sample size, and study quality. The effects of participant characteristics on meditation outcomes were statistically significant concerning the type of research designs (RCTs or non-RCTs), the types of samples (clinical or non-clinical), and whether a study employed transcendental meditation or mindfulness.

The results of meta-regression showed that participant characteristics have the same effect on the outcomes of meditation regardless of the length of meditation intervention, which ranged from 1 day to 1 year. This suggests that future studies could successfully study the effects of participant characteristics using brief meditations interventions because predictors of short-term and long-term outcomes of meditation are similar. On the other hand, participant characteristics had a smaller effect on meditation outcomes when studies had larger samples and higher methodological quality.

We found that, overall, the quality of studies was moderate. The most consistent flaw across studies was the lack of transparent reporting that would enable the assessment of all aspects of study quality. It is generally recommended to adhere to the Consolidated Standards of Reporting Trials (CONSORT) that has an extension for social and psychological interventions (Montgomery et al., 2018). Developing a reporting guideline that is specific to MBIs could improve the quality of research in the field and, in turn, contribute to estimating the effectiveness of MBIs more accurately.

One critical consideration is a large amount of variation in measures of individual differences in meditation research. To deal with this, we created categories based on previous research. There are inherent ambiguities in this process; for example, some could argue that 'experience in group therapy' should not belong to the category 'well-being', but in the interpersonal category. We have dealt with this problem following standard protocols of inter-rater reliability and discussion. Further variation in meditation literature was observed while examining different types of meditation, where the majority (68%) of eligible studies used mindfulness interventions. Notably, although 70% of those studies that used mindfulness interventions were following standardized 8-week programs that are delivered in a group format (e.g., mindfulness-based stress reduction or mindfulness-based cognitive therapy), some studies used apps or other forms of self-training via pre-recorded mindfulness instructions that lasted less

than 8 weeks. It is possible that different participant characteristics would be significant across different formats of mindfulness interventions, thus this remains to be examined by future studies.

Finally, we acknowledge that this meta-analysis is the first one of its kind, which means that further work is required to validate its results and develop clear and precise clinical recommendations. One suggestion for a future meta-analysis is to include individual-level data, instead of group averages that were used here.

Conclusions

This meta-analysis has shown that participant baseline characteristics significantly influence the response to mindfulness and transcendental meditation interventions. Although more work is needed to validate these results and develop clinical recommendations, our results suggest the importance of actively monitoring the experiences of individuals undertaking meditation interventions, particularly individuals with high levels of psychopathology and depression who are more likely to experience negative outcomes of meditation.

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Conflict of interest

The authors declare that they have no conflict of interest.

Author contribution

Ivana Buric: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Visualization; Writing – original draft; Writing – review & editing. **Miguel Farias:** Conceptualization; Supervision; Writing – review & editing. **Josi Driessen:** Data curation; Formal analysis; Methodology; Validation; Writing – review & editing. **Inti Brazil:** Conceptualization; Methodology; Software; Supervision; Writing – review & editing.

Ethical approval

The manuscript does not contain clinical studies or patient data.

Open research badges

This article has earned an Open Data Badge for making publicly available the digitally-shareable data necessary to reproduce the reported results. The data is available at https://osf.io/nquwa/?view_only=53d1a09611c945cf8e115386e6898741.

Data availability statement

The data are available at the Open Science Framework website: https://osf.io/nquwa/?view_only=53d1a09611c945cf8e115386e6898741

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Supporting Information

The following supporting information may be found in the online edition of the article:

Table S1. Summary of the results of all studies included in the meta-analysis showing authors of each study, examined participant characteristic and outcomes of meditation, effect size (ES) converted to Pearson's r, sample size, research design type, sample type, meditation type and length, and study quality estimated with tools by National Institutes of Health (ranging from 0 to 1).
Table S2. Characteristics of the studies included in the meta-analysis ($N = 50$).
Table S3. Comparison of univariate and multivariate analysis showing mean effect sizes as Pearson's r, estimated heterogeneity variance (EHV) and the relative heterogeneity statistic I^2.
Figure S1. Graphical representation of the subgroup analyses results showing categories of participant baseline that are associated with negative or positive outcomes of meditation.
Figure S2. The overall effects of participant characteristics by type of outcome measures, study design, sample type, and type of meditation.