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A systematic review on the effectiveness of unstandardized mindfulness interventions in improving dietary and physical activity outcomes in healthy adults

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Abstract

Background Mindfulness-based strategies are increasingly applied outside of standardized clinical protocols to promote healthy lifestyle behaviors. No overview exists of how mindfulness-based strategies are integrated in these "unstandardized" interventions and which strategies have potential for effect. This review (i) summarizes key intervention characteristics and strategies, (ii) provides a qualitative overview of the effectiveness of unstandardized mindfulness-based strategies for promoting healthy dietary and PA behaviors, and (iii) provides an assessment of the study quality.

Methods Articles were identified using the PubMed, PsycINFO, and Web of Science online databases until 11/2024. Records were included if they applied mindfulness outside of a standardized clinical protocol among healthy adults and measured healthy dietary or PA outcomes pre- and post-intervention. Study quality was assessed using the Effective Public Health Practice Project tool.

Results Interventions ($n = 44$) inconsistently applied formal and informal mindfulness strategies and a variety of meditation exercises (e.g., body-centered or movement meditation). The findings did not provide clear evidence in favor of unstandardized mindfulness applications in promoting dietary behaviors and PA at the between-group level. Study quality was predominantly rated as 'weak' due to selection bias and lacking blinding procedures.

Discussion There exist great variations in the implementation of mindfulness strategies, low study quality, and heterogeneity in measurement, potentially explaining the lack of effects of such unstandardized interventions. To gain more insight into the effective application of mindfulness-based strategies in health promotion, higher-quality studies with robust designs as well as component studies are needed to shed light on the active ingredients of interventions.

Keywords Mindfulness, Meditation, Health behavior, Diet, Physical activity, Behavior change

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Consuming a healthy diet and engaging in physical activity (PA) are two key health-promoting behaviors [1, 2] that are associated with better mental health [3–5] and that may reduce the risk of non-communicable diseases, including heart disease, certain types of cancer, and type 2 diabetes [6, 7]. As promoting these behaviors remains a challenge, there is a need for efficient programs that encourage sustainable behavior changes. Increasingly, mindfulness-based strategies are used to encourage the adoption of such behaviors [8–11].

Mindfulness originates from traditional Eastern religious practice and has become a prominent approach in Western psychology to promote both health behaviors and mental health [12]. It is often represented as a multifaceted construct with underlying attentional and attitudinal processes [13–15]. Within the attentional component, an individual regulates the focus of their attention by bringing awareness to their present-moment environment and to their behaviors, thoughts, and feelings [13]. The attitudinal component describes the skill of responding to one's internal and external awareness with an orientation that is accepting, curious, and open [13].

Mindfulness can be cultivated through formal meditation training or through informal mindfulness exercises (i.e., those that are integrated into daily life) [16]. Formal mindfulness meditation training (e.g., body scan, sitting meditation, and mindful movement) is one key component of the standardized, clinical mindfulness-based training Mindfulness-Based Stress Reduction (MBSR) [17]. The standardized MBSR curriculum is composed of a standardized set of training sessions that teach formal exercises as well as informal mindfulness practice [18]. These standardized programs have demonstrated effectiveness in promoting various mental and behavioral health outcomes as well as quality of life in healthy adults [18–21].

Apart from standardized programs, there is a growing trend toward utilizing other, selected mindfulness-based strategies of varying durations and formats [22] to promote healthy dietary and PA behaviors. Such unstandardized mindfulness-based interventions (UMBIs) can range from one-off, brief mindfulness inductions [23, 24] to several months of mindfulness practice [25], and may vary in their application of formal and informal training. Many of those interventions lack adherence to a standardized mindfulness protocol in which a specific set of training sessions and durations (using formal mindfulness exercises and practice) is described. Throughout this paper, we therefore refer to interventions with a mindfulness component, but that do not adhere to a standardized protocol such as MBSR, as UMBIs. As UMBIs may have merits, systematic overviews are warranted to study how mindfulness-based strategies are integrated in these UMBIs and which strategies may have potential for effect.

Existing comprehensive reviews [8–10, 26] have provided insight into the combined effects of standardized and UMBIs for changing health behaviors (e.g., binge eating and emotional eating [10, 27] or enhancing PA [9]). However, caution is necessary when interpreting the effectiveness of mindfulness-based strategies across standardized and unstandardized treatment protocols, as this may lead to an overestimation of the benefits of mindfulness for changing health-promoting behaviors. It is crucial to conduct reviews specifically examining the distinct effects of unstandardized MBIs to determine whether and which MBI components can be used best to promote health behaviors. Moreover, there is a scarcity of systematic syntheses describing the effectiveness of mindfulness for promoting healthy lifestyle behaviors in healthy (i.e., non-treatment-seeking) populations. To our knowledge, one review has explicitly investigated the effectiveness of randomized controlled intuitive eating and mindful eating interventions on dietary behaviors in individuals without an eating disorder [11]. There is currently no review of solely UMBIs to promote healthy dietary and PA behaviors in healthy, non-treatment-seeking adults.

Aims and research questions

The purpose of this study was to conduct a systematic review to identify intervention characteristics and the effectiveness of diverse, UMBIs for promoting changes in healthy dietary and PA behaviors. Such a review is imperative to (i) provide insight into how unstandardized approaches to delivering mindfulness interventions are currently designed and (ii) to investigate variations in content, format, duration, and delivery settings, that are currently used to foster PA and healthy dietary outcomes. The specific aims of this review are therefore (i) to identify and summarize currently applied UMBI characteristics and components, (ii) to provide a general qualitative overview of the effectiveness of UMBIs on (a) healthy dietary intake and (b) PA behavior in healthy adults, and (iii) to provide an assessment of the study quality. With the findings of our review, we hope to contribute to a better understanding of the diversity of UMBI methods, their implementation, adaptations from standardized protocols, and opportunities for future research that aims to promote healthy dietary and PA behaviors.

Methods

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines [28]. A protocol was registered in

PROSPERO (CRD42022377663) and additional data can be found on OSF (osf.io/3jv2f).

Eligibility criteria

Reports were included if they (i) were published in a peer-reviewed journal, (ii) applied a mindfulness-based strategy or intervention component (e.g., body-centered meditation or mindful observation) outside of a standardized mindfulness-based protocol (e.g., not following the full standardized MBSR or Mindfulness Based Cognitive Therapy, MBCT, curriculum), (iii) targeted and separately reported on a healthy adult sample (i.e., non-treatment seeking individuals without physiological, neurodegenerative, or mental health conditions), (iv) were published in English, Dutch, or German, and (v) subjectively self-reported or objectively measured PA behavior or healthy dietary (sub-)behaviors (e.g., the consumption of fruits and vegetables, refraining from high-calorie snack intake, or compliance with dietary recommendations) at both pre- and post-test. Articles were included regardless of their employed measures of diet and PA outcomes (e.g., valid, reliable, and standardized questionnaires or non-validated single item-measures or indices) and regardless of their study design as long as a pre-test and post-test were included. Given the abundance of research on mindfulness and PA outcomes, we decided to conduct this portion of the review as an addition to Schneider et al. [9] (who combined unstandardized and standardized programs), and included suitable studies on PA published after June 2018 to avoid considerable overlap. Interventions targeting multiple health behaviors were retained regardless of date.

Reports were excluded if they (i) solely measured aerobic capacity, (ii) measured disordered eating behavior only or measured appetitive reactions to food cue exposure in a laboratory setting, (iii) conducted a therapeutic, solely acceptance-based intervention, and (iv) the article fully applied the curriculum and structure of a standardized mindfulness-based therapy intervention (e.g., MBSR or Mindfulness Based Cognitive Therapy, MBCT [29]). As the aim of this study was to investigate the effectiveness of UMBIs, articles including (multiple) singular mindfulness-based exercises drawn from a standardized program without administering a full standardized curriculum were not excluded. When multiple articles covered the same intervention, only the record with the most thorough description of the results was retained to avoid data duplication.

Information sources

Records were identified using the PubMed, PsycINFO, and Web of Science online databases, covering both psychological and multidisciplinary subjects. Manual searches were conducted on the reference lists of relevant systematic reviews [9, 10, 30, 31] for additional records. Where relevant dissertations or theses were identified, a targeted search was conducted for the corresponding publication in a peer-reviewed journal. The searches were conducted by CEP over a two-week period, from late November 2022 to early December 2022. An updated literature search was conducted to include studies published between December 2022 and the updated search in late November of 2024.

Search strategy

Search terms were developed for three concept groups: (i) mindfulness (e.g., mindful*, awareness, non-react*), (ii) PA behavior (e.g., exercise, movement, fitness), and (iii) healthy eating behaviors (e.g., energy intake, fruit intake, nutrition). In addition to the search constructs and their synonyms, Medical Subject Headings (MeSH) were included in the search on PubMed for both PA and eating behaviors. Terms were linked by Boolean operators (AND, OR) and searched in the titles and abstracts of papers to aid a focused search. The optimal search strategy was achieved through an iterative process of testing and modifying the search terms. The final search strategy was peer-reviewed by a scientific information specialist from the university library. This search strategy was then used in PubMed by CEP, who subsequently also adapted the PubMed search strategy for Web of Science and for PsycINFO considering the Thesaurus of Psychological Index Terms (see Additional file 1). No language or date limits were applied using filters. The search strategies, databases, and eligibility criteria for the updated search remained the same as those outlined in the initial search. However, filters were used in the updated search to select studies published after November 2022 to avoid substantial duplication with the prior search.

Selection of sources of evidence

Records were imported into Endnote version X9 for deduplication and transferred to Rayyan QCRI [32] for title and abstract screening. All duplicate records identified by automation tools in Rayyan and EndNote were reviewed by CEP. At the title and abstract screening stage, all records that met inclusion criteria 1–4 and that did not meet any of the specified exclusion criteria were included in the full-text screening stage.

Title and abstract screening were performed by CEP, with 10% of excluded records verified by LV and 20% verified by KB (update), respectively. These percentages were chosen to ensure a somewhat similar number of screened abstracts between the initial review and the update while maintaining feasibility. Moreover, any included abstracts that were not separately checked would undergo full-text

screening, allowing for a more thorough assessment of their eligibility. One discrepancy was discussed and solved between CEP and LV. Full-text screening was performed by CEP considering all the specified eligibility criteria. Reasons for the exclusion of all reports at the full-text stage were reviewed by LV and DdR (both 100% agreement for initial and updated full-text screening).

Data charting process and data items

CEP recorded the data in a Microsoft Excel file adapted from the Cochrane Effective Practice and Organisation of Care's (2017) data collection form [33]. Information was extracted regarding study characteristics (title, year of publication, authors, geographical location, design), outcomes and measures (behavior category, mindfulness and behavioral measurement tools), population (sample size, description, age, gender composition), intervention characteristics (level and method of administration, number of sessions, session length, content), and statistical information where available (means, standard deviations, effect sizes).

To gain insight into the utilized intervention components, mindfulness-specific exercises were coded in line with the proposed framework of meditation clusters by Matko and Sedlmeier [34]. This framework was previously applied to study the efficacy of meditation techniques used by MBIs regarding the cognitive, socio-emotional, and academic skills of children [35]. We additionally identified Behavior Change Techniques (i.e., active components of an intervention designed to alter behavior regulation; BCTs) that were administered as part of the intervention. These active components were coded according to BCT clusters using Michie et al.'s [36] Behavior Change Technique Taxonomy. We used this combination of frameworks to be able to describe the intervention components based on well-established and validated taxonomies.

Synthesis of results

Descriptive statistics for study and intervention characteristics were calculated using SPSS version 28. The results of the studies were described qualitatively and compiled in two summary tables. Because not all UMBIs reported effect sizes or sufficient information to calculate effect sizes, we classified studies in a qualitative way, as showing an "improvement", "no effect," or a "decline" at the within- and between-group level. An intervention was deemed to show an "improvement" when there was a statistically significant favorable post-test difference in the health behavior (i.e., more engagement in PA, more fruit consumption, lower sugar intake) or mindfulness in comparison to the control group or baseline assessment [37]. This "improvement" was determined from p-values ($p < .05$) and any other available information provided in the respective texts or additional materials. An UMBI was classified as showing "no effect" when there were no significant within or between group differences in health behavior or mindfulness. Studies were coded as showing a "decline" when there was a significant unfavorable difference between baseline and follow-up or between groups in the health-promoting behavior or mindfulness. The total number of behavioral outcomes showing an "improvement" are presented as frequencies to make an estimate about the overall direction of the effect. In this study, we defined evidence of effectiveness across studies as ≥ two thirds of the studies reporting an improvement on the specific outcome(s). The results of within- and between-group analyses are presented separately.

Risk-of-bias assessment

Study quality was assessed using the Effective Public Health Practice Project (EPHPP) tool for quantitative studies [38]. We chose this instrument as it can be used for studies with different research designs. The tool includes 20 assessment items across eight components: selection bias, study design, confounding variables, blinding, data collection methods, participant dropout, intervention integrity, and analyses. Following the scoring instructions, overall study quality was scored as weak (two or more components rated as weak), moderate (one weak component rating), or strong (absence of weak ratings). All risk-of-bias criteria were assessed independently by CEP and NCB (97.3% agreement) as well as by CEP and KB for the update (94.4% agreement). Discrepancies were resolved in discussion between CEP and NCB/KB and in consultation with AO and DdR. The results are displayed as a weighted bar plot showing the distribution of risk-of-bias judgments. Detailed ratings per study can be found on OSF (osf.io/3jv2f).

Results

Study selection

The research strategy brought up 9,909 unique records that were screened for their eligibility. We excluded 209 of the 241 reports at the full-text stage as they did not measure dietary behavior or PA, did not administer a mindfulness-based strategy, included populations with chronic health conditions or adolescents, administered a full, standardized MBI, or were an undesired publication type (see Fig. 1). After the full-text review, 32 unique studies were included in this review. The updated search identified 3,558 unique records in the three databases (see + in Fig. 1). Of these additional records, 12 met the inclusion criteria and were added to the synthesis.

In 16 of the records, both healthy dietary behavior and PA behavior were targeted. Seven articles exclusively

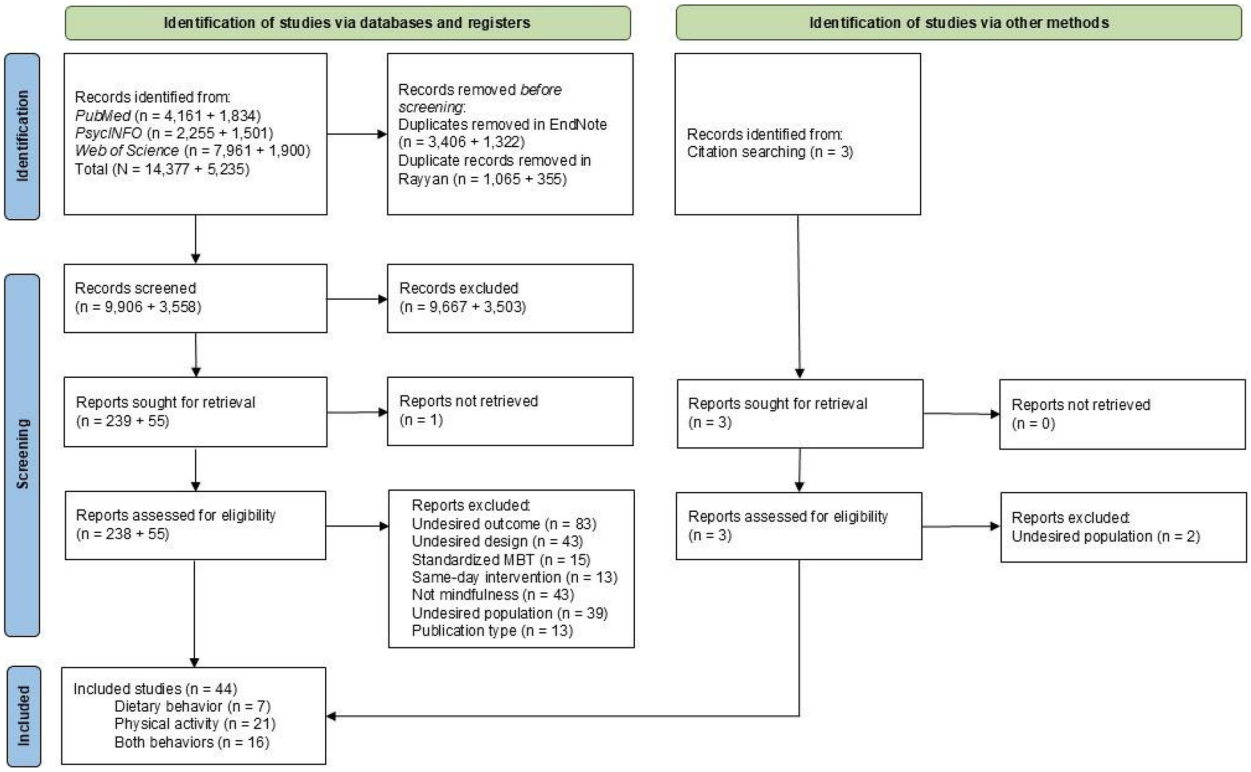

Fig. 1 PRISMA flowchart describing the identification, screening, and inclusion of articles. Note. "+" indicates records identified during the update Nov 2024

reported healthy dietary behavior, and 21 focused explicitly on physical activity outcomes. The study characteristics are described per targeted behavior(s) to gain insight into potential differences between programs with one versus multiple relevant behavioral outcomes.

Study characteristics

Studies focusing exclusively on healthy dietary behaviors ($n=7$) analyzed a total of 516 participants, with 268 in a mindfulness-based condition. Mostly young or middle-aged females made up the sample (M*%female*=90.4 [SD=15.8]; M*age*=33.6, [SD=13.1]; 14.9% attrition [SD=19.6]). Studies were conducted in North America ($n=4$), Europe ($n=2$) or Brazil ($n=1$) and predominantly used a randomized controlled design ($n=6$).

Across the studies targeting PA ($n=21$), 1,686 participants were analyzed, including 903 in a mindfulness-based condition. Samples predominantly consisted of either young or middle-aged females (M*%female*=78.1 [SD=12.9]; M*age*=36.8, [SD=13.4]). The attrition rate in the mindfulness condition was on average 19.9% [SD=18.4]. The majority of studies were conducted in the USA ($n=17$; 77.3%) and reported a randomized controlled design ($n=13$).

Of the studies measuring both behaviors ($n=16$), 1,231 participants were analyzed, of whom 688 were allocated to a mindfulness-based condition. Young or middle-aged females made up the majority of the samples (M*%female*=75.9 [SD=22.2]; M*age*=43.6, [SD=11.3]). In the mindfulness condition, the average attrition rate was 27.9% [SD=23.7]. The majority of the studies were carried out in the USA ($n=11$; 68.8%) and reported a single group pre-post design ($n=9$).

Intervention components

The seven interventions targeting only healthy dietary behaviors employed formal mindfulness (i.e., a traditional contemplative approach practiced at designated times) or a combination of formal and informal mindfulness practice (i.e., mindfulness practice integrated into daily activities). These interventions utilized mostly body-centered meditation (e.g., body scan). All seven programs applied behavior change strategies (most commonly emotion regulation), with an average of 1.8 BCT clusters ([SD=1.1]; range 1–4). The targeted meditation types and BCT clusters with their frequencies are presented in Table 1. Interventions were predominantly administered in a group setting and lasted an average

Table 1 Summary of intervention characteristics

	Healthy Eating		Physical Activity		Both Behaviors	
	Bibliography No	***%***	***Bibliography No***	***%***	***Bibliography No***	***%***
Intervention Group Size (Analyzed)						
< 10	-	0	[39]	5	-	0
10–24	[39]	14	[40–47]	38	[25, 48–52]	38
25–49	[53–57]	71	[58–62]	24	[63–67]	31
50–100	[68]	14	[69–73]	24	[74–76]	19
> 100	-	0	[77, 78]	10	[79, 80]	13
Study Design						
RCT/CCT	[53–57, 68]	86	[42, 44, 45, 58, 59, 61, 62, 69–73, 78, 81]	67	[25, 49, 52, 66, 79, 80]	38
Two group pre-post	[39]	14	[40, 43, 46, 60]	19	-	0
Single group pre-post	-	0	[41, 47, 77]	14	[48, 50, 51, 63–65, 67, 74–76]	63
Program Duration						
< 1 week	[53]	14	-	0	[67, 74]	13
1–3 weeks	-	0	[44, 46, 59, 61, 77, 81]	29	[64, 75]	13
4–6 weeks	[39]	14	[62, 71–73]	19	[49, 51, 63, 79]	25
7–9 weeks	[55, 57]	29	[40–43, 45, 47, 60, 69, 70, 78]	48	[52, 66, 80]	19
> 10 weeks	[54, 56, 68]	43	[58]	5	[25, 48, 50, 65, 76]	31
Program Duration						
Group	[39, 54, 55]	43	[42, 45, 60, 69, 70, 73, 77]	33	[25, 49–51, 64, 65, 79]	44
Individual	[53, 56]	29	[44, 46, 47, 58, 59, 61, 62, 71, 78, 81]	48	[63, 66, 67]	19
Combined setting	[57, 68]	29	[40, 41, 43, 72]	19	[48, 52, 74–76, 80]	38
eHealth/mHealth component	[53, 56]	29	[40, 42, 44, 46, 47, 58, 59, 62, 71, 73, 78, 81]	57	[48, 51, 63, 66, 67, 76]	38
39Mindfulness Practice						
Formal	[53, 55, 57]	43	[40–44, 60, 62, 71, 73, 81]	48	[52, 66, 67]	19
Informal	-	0	[61, 69]	10	[50, 79]	13
Formal & informal	[39, 54, 68]	43	[45, 58, 59, 70, 72, 77]	29	[25, 48, 49, 63–65, 74–76, 80]	63
Unclear	[56]	14	[46, 47, 78]	14	[51]	6
Meditation Cluster						
Affect-centered meditation	[39, 68]	29	[40, 45, 58]	14	[25, 50, 66]	19
Body-centered meditation	[54, 55, 57, 68]	57	[40–44, 47, 58–61, 69–73, 81]	76	[25, 48, 49, 52, 63–67, 74, 75, 79, 80]	81
Contemplation	[55]	14	-	0	-	0
Mantra meditation	-		[40]	5	-	0
Meditation with movement	[54, 56]	29	[43, 45, 47, 58–60, 69, 70, 72, 77]	48	[25, 49, 50, 52, 63–65, 74, 75, 80]	63
Mindful observation	[54, 57, 68]	43	[40, 44, 45, 58, 59, 70, 71, 73, 77]	43	[25, 63, 76, 79]	25
Visual concentration	[53]	14	-	0	-	0
Unclear	[56]	14	[46, 62, 78]	14	[51]	6
BCT Clusters						
Shaping knowledge	[56, 68]	29	[41, 43, 58–61, 70, 78]	38	[25, 48–51, 64, 65, 74]	50
Repetition and substitution	[39]	14	[60]	5	[48, 50, 51, 64, 65, 80]	38
Regulation	[39, 54, 55, 57]	57	[40, 60, 69, 81]	19	[48, 49, 66]	19
Feedback and monitoring	[56]	14	[41, 43–45, 72, 78]	29	[25, 50, 51]	19
Goals & planning	[56, 68]	29	[41, 43, 69, 78]	19	[25, 50, 76, 80]	25
Associations	[39, 53]	29	[61, 71]	10	-	0
Self-belief	-	0	[41]	5	[25]	6
Social support	-	0	[41, 43]	10	[25, 51, 64, 80]	25
Identity	-	0	-	0	[80]	6

CCT controlled clinical trial, *RCT* randomized controlled trial, *BCT* Behavior Change Technique

of 11.2 weeks [SD = 6.6]. Most studies had sessions that lasted around 2 h.

The 21 studies targeting PA predominantly made use of formal mindfulness practice or a combination of formal and informal strategies (see Table 1). Most studies utilized body-centered meditation, mindful observation or meditation with movement (e.g., yoga) to promote mindfulness. Most programs incorporated BCT clusters (most commonly shaping knowledge and feedback/monitoring), with an average of 1.3 [SD = 1.4] clusters (range = 0–5). Programs lasted 6 weeks on average [SD = 2.8]. Half of the interventions were administered in an individual setting with varying session lengths (from individually chosen app use time up to a total of 24 h of practice time). In addition to certified yoga and mindfulness teachers or a staff member delivering the intervention, more than half incorporated an audio file, videos, or an app.

The 16 combined studies predominantly targeted mindfulness in a group or combined setting, employing both formal and informal meditation practice. Most studies administered body-centered meditation or meditation with movement (see Table 1). Eleven of the 6 programs included a BCT (most commonly shaping knowledge), with an average of 1.9 BCT clusters ([SD = 1.7]; range = 0–5). On average, combined programs lasted 7.5 weeks [SD = 6.2], with practice time varying from individually chosen in-app time up to 5 h of daily practice.

Results of individual studies

Health behaviors were categorized into subgroups based on the targeted behavioral outcomes, as reported in the individual studies. A summary of study findings is presented in Table 2. Additional information on the assessment methods per study can be found on OSF (osf.io/3jv2f).

Healthy dietary behavior

Diet quality Five studies compared the effects of mindfulness on overall dietary quality [48, 55, 56, 63, 64]. Three of those studies found significant improvements in the intervention group from pre- to post-test. One study comparing mindfulness to a waitlist control group found a significant between-group difference in the consumption of a balanced diet at post-test [55].

Energy intake Eight studies reported on energy intake [25, 39, 51–54, 57, 65]. Six studies found a significant decrease in calorie intake within the mindfulness group [25, 39, 51, 54, 57, 65]. One of four studies reporting the post-test results in comparison to a control group [25, 39, 53, 54] found a significant difference in calorie intake between groups at post-test [39].

Fat intake Three of the eight studies that examined within-group differences showed significant differences in fat intake from pre- to post-test in the mindfulness condition [49–51]. Of the four studies reporting a between-group design, one study indicated significant group x time effects for the consumption of high-fat meats and low-fat ice cream but not for opting for low-fat sweets [49]. No significant between-group differences were observed at post-test for fat intake [53, 54] or the consumption of low-fat products [55].

Fruit and vegetable intake Combined fruit and vegetable intake was assessed in six studies [49, 53, 66, 67, 76, 79] and separately in six studies [48, 51, 57, 74, 75, 80]. Five of the studies reporting within-group changes found improvements in fruit and vegetable intake at post-test [48, 67, 74, 75, 79]. The study by Sant'Anna et al. [57] found no within-group changes in fruit intake, but significant changes in vegetable intake at post-test. Dyer et al. [74] found fruit and vegetable consumption to no longer be significantly different from baseline behavior at the additional two-month follow-up. There were no significant differences in the five studies reporting fruit and vegetable consumption between groups at post-test [49, 53, 66, 79, 80].

Sugar intake Results were mixed for sugar intake in the six studies reporting within-group changes [48, 50, 51, 53, 67, 68] Three studies reported a decrease in the intake of sugar and sugary beverages from pre- to post-test [48, 51, 67]. The remaining three studies found no differences between pre- and post-test sugar intake in the intervention group [50, 53, 68]. Two studies reported between-group changes in sugar intake: One study [53] found no significant differences in sugar intake between groups, whereas in the other [68], the intervention group ate significantly less sweets than the active control group at follow-up.

Physical activity behavior

Light-intensity physical activity Three of the seven studies found a significant increase in light-intensity PA over time [43, 47, 69]. The remaining studies found no increase in light-intensity PA behavior [42, 58, 65, 67]. Of the three studies reporting between-group changes, none found significant improvements in the intervention group compared to a control group [42, 43, 58].

Table 2 Summary of within-group and between-group changes to health-promoting behaviors and mindfulness at post-test

	Healthy Eating Behavior *Bibliography No*					**Physical Activity Behavior** *Bibliography No*		
	Balanced Diet	**Energy Intake**	**Fat Intake**	**Fruit/Vegetable Intake**	**Sugar Intake**	**Low-Intensity**	**Mixed-Intensity**	**Moderate/Vigorous**
Changes in Behavior								
Within-Group								
Significant improvement	(49,56,65)	(25,40,52,55,58,66)	(50–52)	(49 V,58,68,75,76,80)	(49,52,68)	(48,68,70)	(25,43,51[b],65,67,71, 72[b],73,75,76,78[b])	(48,60[b],68,70,77,79)
No improvement or decline	(57,64)	(53,54)	(54–56,58,66)	(50,52,54,58,67,77,81F)	(51,54,69)	(43,44↓,59,66)	(42,45,49–51[b],52,53,61–64,72[b],74,78[b],80)	(41,43,44 M,59,60[b],81Vi↓)
Summary [a]	3/5	6/8	3/8	6/13	3/6	3/7	11/27	7/13
Between-Group								
Significant differences	(56)	(40)	(50)	-	(69)	(44) ↓	(71,72[b],73)	(44 M,60[b])
No group differences	(57)	(25,53–55)	(54–56)	(50,54,67,80,81)	(54)	(43,59)	(25,43,45,46,50,53,61–63,67,72[b],74,80,81)	(41,43,44Vi,59,60[b],81Vi)
Summary [a]	1/2	1/5	1/4	0/5	1/2	0/3	3/17	2/9
Changes in Mindfulness								
Within-Group								
Significant improvement	(64,65)	(55)	(51,55)	(67,75–77)	(51,69)	(59,70)	(51,64,65,67,73,75,76)	(59,60,70,77)
No improvement or decline	-	(25)	-	(68,77)	(68)	(43,68)	(25,45,63)	(43,68,77)
Summary [a]	2/2	1/2	2/2	4/6	2/3	2/4	7/10	4/7
Between-Group								
Significant improvement in IG	-	(55)	(55)	(67)	-	(59,70)	(67,73)	(59,60,70)
No group differences	-	(25)	-	-	(69)	(43)	(25,45,63)	(43)
Summary [a]	0/0	1/2	1/1	1/1	0/1	2/3	2/5	3/4

[a] Amount of outcomes demonstrating an effect in the same, positive (health-promoting) direction

[b] Indicates multiple study outcomes within one category; IG = Intervention group; "Improvement" refers to significant positive changes in health-promoting behavior (i.e., more fruit consumption, lower sugar intake) or mindfulness from baseline; "Within group" refers to effects on outcomes in the mindfulness condition from pre-to-post assessment.; "Between-Group" refers to effects on outcomes between the mindfulness intervention group versus a control group; ↓ = decline in health-promoting behavior; F = Fruit consumption; V = Vegetable consumption, M = Moderate physical activity; Vi = Vigorous physical activity. Dashes signify "non-applicable". Numbers in parentheses are bibliography numbers. Due to sample size limitations and lacking statistical information, [81] was omitted from this table.

Moderate- to Vigorous Physical Activity (MVPA) Twelve articles reported on MVPA. Three studies separately assessed moderate and vigorous PA engagement [43, 58, 76]. Seven of thirteen MVPA outcomes improved at the within-group level (see Table 2). Of the nine MVPA outcomes at the between-group level, improvements were found in two studies [43, 59].

Mixed-intensity physical activity Twenty-three studies did not make a distinction between light-intensity and MVPA and assessed an outcome such as the frequency of PA engagement (e.g., daily or weekly). Of the studies assessing within-group changes, 40% ($n = 11$) of the outcomes improved over time (see Table 2). Of those studies, the level of engagement in PA post-program was no longer significant at the 2- or 3-month follow-up in three of those studies [64, 74, 75]. Sixteen separate studies reported between-group differences. Three PA outcomes significantly improved at the between-group level [70–72], while the rest did not (Table 2).

Changes in mindfulness

In total, 17 of the 44 studies (38.6%) measured within-group changes in mindfulness using a validated self-report scale (Table 2). One study measured both changes in state and dispositional mindfulness [76]. At the within-group level, 66.6% ($n = 11$) of the mindfulness outcomes increased. Of note, five of the 17 studies reported changes in mindfulness using different subscales that reflect underlying mindfulness facets (e.g., non-judging). These studies reported significant changes in all mindfulness facets of the Five Facet Mindfulness Questionnaire (FFMQ) from pre- to post-test [50, 64, 66, 72, 75].

Eleven of the 44 studies evaluated between-group differences in mindfulness at the post-test (25%). Mindfulness increased significantly relative to a control group at post-test in six (54%) of the eleven studies (see Table 2).

Common intervention components of effective studies

To better understand the potential effective ingredients of the UMBIs showing a significant improvement at the between-group level (see Table 2), we compared these eight studies regarding their key intervention components. The four studies demonstrating significant improvements on different dietary behaviors (i.e., eating a balanced diet, energy, fat, and sugar intake; [39, 49, 55, 68] administered interventions that typically (i) lasted longer than six weeks with 2-h long sessions, (ii) were employed in an individual setting, (iii) did not utilize an e-health component, (iv) included both formal and informal practices, (v) practiced body-centered meditation, (vi) taught eating-specific mindfulness, and (vii) addressed emotion regulation. Three of the studies applied more than one additional BCT (shaping knowledge, repetition, goal setting, and associations). The four studies demonstrating a significant improvement in moderate and mixed PA behavior [59, 70–72] consistently administered interventions that (i) taught both meditation with movement and body-centered meditation and (ii) taught PA-specific mindfulness. These studies each applied one BCT (shaping knowledge, feedback and monitoring, or associations).

Risk of bias

Study quality was summarized into six bias categories as well as one global rating. The majority of studies were deemed "weak" ($n=32$), with the remaining studies obtaining a moderate ($n=11$) or strong ($n=1$; [58] score. Half of the studies showed great selection bias ($n=26$), and the majority lacked information on blinding procedures ($n=39$). The distribution of bias ratings per category and global rating is presented in Fig. 2. Additional information on risk of bias can be found on OSF (osf.io/3jv2f).

Discussion

This review investigated the effectiveness of UMBIs to promote healthy dietary behavior and PA. Although there were favorable changes in dietary quality and energy intake at the within-group level, there was no strong evidence for between-group differences for dietary and PA outcomes. Our review indicates that UMBIs, as applied and evaluated in the included studies, did not show evidence regarding their effectiveness in modifying dietary and PA behavior in healthy adults. Forty percent of the studies evaluated changes in mindfulness alongside behavioral outcomes, of which two-thirds found significant between-group improvements.

Intervention components

The reviewed studies inconsistently applied formal (i.e., intentional commitment to practice) and informal (i.e., practice integrated into activities in daily life) mindfulness but frequently utilized body-centered meditation or meditation with movement. Across all studies, we found great variation in the practice setting (i.e., group, individual or both) and the program duration. Although programs often contained one or multiple core components also included in standardized MBSR (i.a., body-scan, breath-focused attention, hatha yoga; Kabat-Zinn

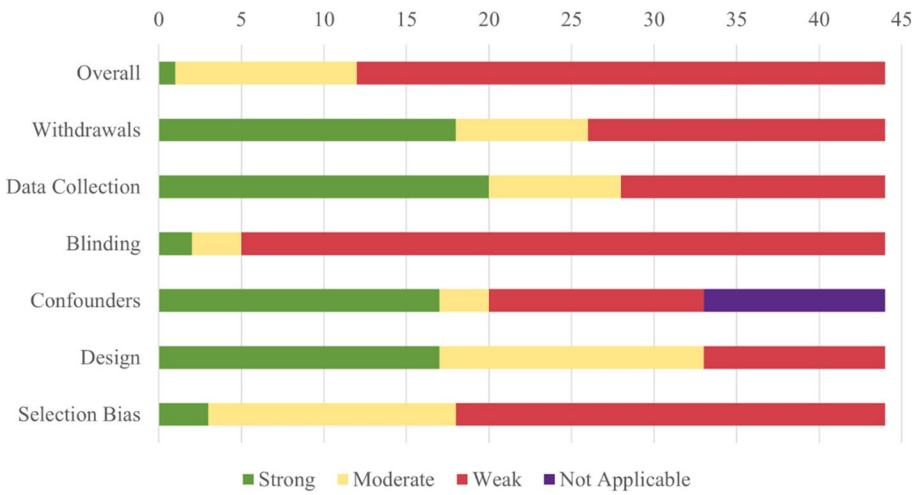

Fig. 2 Bar plots depicting the distribution of risk-of-bias judgments within each bias domain and overall judgment

[17], our findings suggest an inconsistent and diverse application of these intervention components within the studied articles. The observed heterogeneity in intervention components across articles poses a challenge to the systematic evaluation of specific mindfulness training methods in health promotion. As the rationale and selection process for specific intervention components remain unclear, there is a need for future research to evaluate and provide justification for the inclusion of specific components in UMBIs.

This review also found that the UMBIs often contained additional active ingredients related to behavior change (i.e., intervention components designed to modify the causal processes that underlie behavior regulation; Michie et al. [36]). Although addressing relevant determinants through a combination of behavior change strategies is essential for the promotion of health behaviors, the integration of UMBIs and BCTs can obscure the effects of either approach. Improvements in behavioral outcomes cannot be attributed to mindfulness alone due to the presence of such secondary intervention components (i.e., strategies that may cloud the effects of mindfulness processes). To combat the influence of secondary intervention components, Isbel and Summers [82] provide an explanatory framework for systematically targeting specific mindfulness components in longitudinal RCTs. Their model presents a standardized technique to target both attentional and non-evaluative components in the absence of unwarranted intervention components. Applying such a standardized framework may assist with the design, implementation, and isolated evaluation of mindfulness-based components.

Changes to health behaviors

The outcomes of the between-group comparisons showed that the UMBIs reviewed in the present study were ineffective in changing dietary behaviors. This is in line with a review by Grider et al. [11] that showed no significant benefits of unstandardized intuitive and mindful eating interventions on dietary intake in healthy samples. One explanation for the absence of effects may be the complexity of changing healthy eating behavior [83]. It may also be possible that (i) the intervention components were not strong enough to address the range of environmental and social-cognitive determinants of healthy dietary intake and (ii) that the UMBIs as currently implemented were not strong enough to result in changes in dietary behavior. It is also possible that (U)MBIs may have a greater potential to reduce health risk behaviors, such as increased energy intake, than a promotive behavior encouraging increased consumption of healthy foods. In our review, we observed within-group differences in both diet quality and energy intake that may support this explanation. Although there is some evidence to support the positive impact of mindfulness on various energy-balance behaviors [8, 10], it may be that its influence on behavior change is limited to certain populations, contexts, or specific behaviors, and not in the general healthy population as included in our review. Whereas health risk behaviors are often cue- or impulse-based with high arousal (e.g., environmental stimuli or internal, emotional triggers for food intake) and short-term rewards [84], health-promoting behaviors may be less likely to harbor such a component. Therefore, it is likely that reductions in health-risk behaviors (e.g., emotional eating, overeating) may benefit more from the awareness and attitudinal processes encapsulated by mindfulness than health-promoting behaviors (e.g., increasing fruit consumption) without a strong emotional trigger. It is crucial for future research to explore the potential boundaries and limitations of (U)MBIs for promoting healthy dietary behavior.

Further, although 40% of the mixed-intensity PA outcomes showed an improvement at the within-group level, our results indicate that UMBIs did not result in an improvement in PA at the between-group comparison. Although prior research suggested an association between dispositional mindfulness and PA [30], a past review found that 8/20 of the reviewed standardized and UMBIs promoted PA behavior [9]. In line with the latter finding, our results suggest that the current implementation and evaluation of UMBIs are not effective in inducing significant behavioral changes. One potential explanation for our findings may be related to the control groups' activities (e.g., standard lifestyle/health promotion intervention, loving-kindness meditation) that diminished the differences between the intervention and control groups. Second, in contrast to standardized applications of mindfulness that follow a specific set of exercises to promote mindfulness, UMBIs may target mindfulness elements less consistently. Third, due to the complex combination of inner-individual motivations, skills, and environmental factors that determine PA behavior [83], it is possible that (i) the duration of the intervention and follow-up assessments were insufficient for PA behavior changes to emerge and (ii) intervention elements did not successfully address cognitive and environmental determinants. Further longitudinal studies are warranted to investigate the relationship between psychosocial determinants of PA behavior and mindfulness elements.

Concerning the quality of evidence, most of the reviewed studies showed multiple limitations regarding the selection of participants, blinding, withdrawal, data collection tools, and the study design. Similar limitations in MBIs have previously been identified by Schneider et al. [9]. Half of the reviewed studies did not use

a randomized controlled design to examine changes in health behaviors. This is problematic, as the sole evaluation of pre-post effects potentially includes effects that may have occurred regardless of the mindfulness intervention. However, as the majority of reviewed studies did not identify improvements in health behaviors at the within-group level, there may also be limited prospects for effects at the between-group level. Considering the high risk of bias, the current evidence is insufficient to draw firm conclusions about the effectiveness of UMBIs.

Changes in mindfulness

Our findings showed a between-group improvement in mindfulness in about half of the studies that assessed mindfulness relative to a control group. This suggests that the intervention was effective in some cases but not others, potentially due to differences in intervention conditions, characteristics, or the populations studied. In the majority of studies, observed changes in mindfulness were not reflected in health behavior changes. UMBIs may thus have been insufficient for modifying (i) regular mindfulness practice behavior and/or (ii) underlying mindfulness skills linked to behavioral outcomes. This is in contrast to studies utilizing standardized MBSR that tend to target health outcomes and mindfulness more effectively [18].

It is particularly concerning that less than 40% of the reviewed studies investigated changes in mindfulness, with only 11% (i.e. 5 of all 44 studies) measuring mindfulness subscales to distinguish between awareness and attitudinal, acceptance mechanisms. Studies must evaluate the mechanisms of change involved in mindfulness to assess (i) what skills were successfully trained by the intervention and (ii) which mindfulness skills have the greatest impact on behavior change. Without employing a validated measure, researchers cannot confidently determine whether changes in behavioral outcomes were caused by mindfulness. To advance the field, it is crucial that researchers systematically investigate mindfulness practice behavior as well as changes in dispositional and state mindfulness, applying optimal measurement instruments. Future studies should apply a consistent framework of mindfulness to systematically target and test its active mechanisms. For the purpose of standardizing mindfulness in health promotion, Preissner et al. [85] proposed a conceptual model describing the process of arriving at a complete conceptualization and measurement of mindfulness components. It may be valuable to consider such a framework to make an informed decision on and to align the specific mindfulness components in one's operational definition and measurement.

Strengths and limitations

To our knowledge, this is the first review explicitly focusing on unstandardized MBIs applied to health behavior change in healthy populations. One key strength of this systematic review is its separation of health behaviors into multiple sub-behaviors. Second, due to the broad spectrum of practices applied under the term "mindfulness" [86, 87], interpreting the effectiveness of MBIs across standardized and unstandardized treatment protocols may inflate the estimated benefits of mindfulness for changing health behaviors. Our review overcame this limitation by specifically evaluating the effectiveness of unstandardized programs.

Despite these strengths, we acknowledge the following limitations: First, studies were not excluded for administering a self-compassion intervention (which includes mindfulness as a sub-facet) as opposed to purely mindfulness. A recent meta-analysis found self-compassion interventions to have a negligible impact on increasing mindfulness [88]. We still opted to retain such programs when increasing mindfulness was mentioned as one of the primary intervention targets.

Second, we excluded potentially relevant studies describing mixed samples that did not report outcomes for treatment-seeking and non-treatment-seeking adults when no distinction in the outcomes could be made for the two groups (e.g., [89]). As approximately one fifth of the adult population is estimated to have an underlying health condition [90, 91], mixed samples may have been representative of this target population. However, from the standpoint of developing tailored intervention programs to suit specific contexts and populations, we decided to focus our investigation on one specific group without severe health conditions. This is crucial because the intervention targets for populations with and without severe health conditions may vary depending on a number of factors associated with health behavior change [92]. There is a need for further fundamental research on specific health promoting behaviors to establish the effectiveness of MBIs.

Third, our review did not pool fitting studies from the previous review on PA outcomes [9] with studies published since, as this was outside the scope of the present review. As such, we acknowledge that the overview of studies could be more extensive. We also acknowledge that the comparison of intervention components conducted in this study on the small number of effective studies with different outcomes represents a rudimentary analysis. Although it offers some valuable insight into the potentially relevant intervention components, researchers should nevertheless exercise caution when interpreting these findings.

Fourth, even though we employed a systematic review approach, we did not apply full double screening and data

abstraction by two independent reviewers. Due to the vast amount of hits, it was not possible to verify all abstracts. We therefore limited this to the verification of 10% of excluded abstracts, and 20% for the update, as well as full-text verification. We cannot rule out that potentially relevant articles may have been wrongfully excluded because of this, but as that there was only one excluded record that needed discussion after the double verification of 1,670 excluded abstracts, we believe that the chance of having missed important records is minimal. Also, because of the experience of CEP with data abstraction, we believe that the risk of inaccuracy in data abstraction is low. Extracted information on study methods, intervention components, measurement, and effects was verified by a second reviewer during the risk of bias assessment. If any important information had been missed during data abstraction, it is likely that another risk of bias reviewer (NCB or KB) may have identified it. Additionally, CEP, AO, and DdR carefully reviewed the data included in the tables and ensured accuracy by monitoring the translation of data extraction documents into table format.

Implications

This review indicates a number of methodological limitations that may hinder drawing a strong conclusion on the effectiveness of UMBIs (i.e., without a standardized mindfulness framework or protocol) for promoting health behaviors. To enhance our understanding of the effectiveness of (U)MBIs in modifying healthy dietary and PA behaviors, it is crucial to carefully plan the content of such interventions. Interventions may benefit from adhering to standardized frameworks and treatment protocols as well as from incorporating established frameworks. Such guidelines can ensure the MBI is administered without secondary components that may cause changes in health behaviors in the absence of mindfulness. Further research would also benefit from explicit component or dismantling studies to shed light on what the active ingredients of (U)MBIs should be. Such studies could compare the effects of an isolated component (e.g., a certain meditation technique aiming to increase, e.g., non-evaluative/acceptance components), with a version of the intervention that excludes this component. Furthermore, considering the predominantly low study quality identified in this review, it is imperative to evaluate future interventions using robust and adequately powered between-group study designs, allowing for a rigorous assessment of their efficacy. In this regard, it is essential to measure changes in mindfulness throughout the intervention period to gain insight into the potential mechanisms underlying behavior change.

Conclusion

This review demonstrates limited evidence of the effectiveness of unstandardized mindfulness interventions (i.e., applied outside of standardized, therapeutic interventions) to promote dietary and PA behaviors. Future studies should (i) make use of randomized controlled designs with active comparison conditions, (ii) conduct component studies to shed light on the active ingredients of (U)MBIs, (iii) utilize standardized MBI protocols outlining active ingredients to promote the rigorous, systematic testing of mindfulness in the absence of secondary intervention elements, and (iv) examine changes in mindfulness components (e.g., awareness, acceptance) over time using suitable, validated measures.

Abbreviations

BCT	Behavior Change Technique
EPHPP	Effective Public Health Practice Project
MBCT	Mindfulness-Based Cognitive Therapy
MBSR	Mindfulness-Based Stress Reduction
PA	Physical activity
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
UMBI	Unstandardized mindfulness-based interventions

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

CEP: conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft, writing – review & editing; LV: investigation; NCB: investigation; KB: investigation; DdR: writing – review & editing, supervision; HdV: writing – review & editing, supervision; AO: conceptualization, supervision, writing – review & editing. All authors read and approved the final manuscript.

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Data availability

The full datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. Additional information can be found on OSF (https://osf.io/3jv2f).

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Lippke S, Nigg CR, Maddock JE. Health-promoting and health-risk behaviors: theory-driven analyses of multiple health behavior change in three international samples. IntJ Behav Med. 2012;19(1):1–13.
2. Matarazzo JD. Behavioral health: a 1990 challenge for the health sciences professions. In: Behavioral health: a handbook of health enhancement and disease prevention. Hoboken: Wiley; 1984. p. 3–40.
3. Głąbska D, Guzek D, Groele B, Gutkowska K. Fruit and vegetable intake and mental health in adults: a systematic review. Nutrients. 2020;12(1):115.
4. Kris-Etherton PM, Petersen KS, Hibbeln JR, Hurley D, Kolick V, Peoples S, et al. Nutrition and behavioral health disorders: depression and anxiety. Nutr Rev. 2021;79(3):247–60.
5. Briguglio M, Vitale JA, Galentino R, Banfi G, Zanaboni Dina C, Bona A, et al. Healthy eating, physical activity, and sleep hygiene (HEPAS) as the winning triad for sustaining physical and mental health in patients at risk for or with neuropsychiatric disorders: considerations for clinical practice. Neuropsychiatr Dis Treat. 2020;31(16):55–70.
6. Blair SN, Morris JN. Healthy hearts—and the universal benefits of being physically active: physical activity and health. Ann Epidemiol. 2009;19(4):253–6.
7. López-Suárez A. Burden of cancer attributable to obesity, type 2 diabetes and associated risk factors. Metabolism. 2019;92:136–46.
8. Ruffault A, Czernichow S, Hagger MS, Ferrand M, Erichot N, Carette C, et al. The effects of mindfulness training on weight-loss and health-related behaviours in adults with overweight and obesity: a systematic review and meta-analysis. Obes Res Clin Pract. 2017;11(5 Suppl 1):90–111. 2016/09/24 ed.
9. Schneider J, Malinowski P, Watson PM, Lattimore P. The role of mindfulness in physical activity: a systematic review. Obes Rev. 2019;20(3):448–63.
10. Warren JM, Smith N, Ashwell M. A structured literature review on the role of mindfulness, mindful eating and intuitive eating in changing eating behaviours: effectiveness and associated potential mechanisms. Nutr Res Rev. 2017;30(2):272–83.
11. Grider HS, Douglas SM, Raynor HA. The influence of mindful eating and/or intuitive eating approaches on dietary intake: a systematic review. J Acad Nutr Diet. 2021;121(4):709-727.e1. 2020/12/07 ed.
12. Chiesa A. The difficulty of defining mindfulness: current thought and critical issues. Mindfulness. 2013;4(3):255–68.
13. Bishop SR, Lau M, Shapiro S, Carlson L, Anderson ND, Carmody J, et al. Mindfulness: a proposed operational definition. Clin Psychol Sci Pract. 2004;11(3):230–41.
14. Coffey KA, Hartman M, Fredrickson BL. Deconstructing mindfulness and constructing mental health: understanding mindfulness and its mechanisms of action. Mindfulness. 2010;1(4):235–53.
15. Shapiro SL, Carlson LE, Astin JA, Freedman B. Mechanisms of mindfulness. J Clin Psychol. 2006;62(3):373–86.
16. Carrière K, Siemers N, Knäuper B. A scoping review of mindful eating interventions for obesity management. Mindfulness. 2022;13(6):1387–402.
17. Mindfulness-Based KZ, Reduction S. Mindfulness-based stress reduction. Constr Human Sci. 2003;8(2):73–83.
18. Khoury B, Sharma M, Rush SE, Fournier C. Mindfulness-based stress reduction for healthy individuals: a meta-analysis. J Psychosom Res. 2015;78(6):519–28.
19. Chiesa A, Serretti A. Mindfulness-based stress reduction for stress management in healthy people: a review and meta-analysis. J Altern Complement Med. 2009;15(5):593–600.
20. Janssen M, Heerkens Y, Kuijer W, Van Der Heijden B, Engels J. Effects of mindfulness-based stress reduction on employees' mental health: a systematic review. Ebmeier K, editor. PLoS One. 2018;13(1):e0191332.
21. Salmoirago-Blotcher E, Hunsinger M, Morgan L, Fischer D, Carmody J. Mindfulness-based stress reduction and change in health-related behaviors. J Evid Based Complement Alternat Med. 2013;18(4):243–7.
22. Allen JG, Romate J, Rajkumar E. Mindfulness-based positive psychology interventions: a systematic review. BMC Psychol. 2021;9(1):116.
23. Gill LN, Renault R, Campbell E, Rainville P, Khoury B. Mindfulness induction and cognition: a systematic review and meta-analysis. Conscious Cogn. 2020;1(84):102991.
24. Leyland A, Rowse G, Emerson LM. Experimental effects of mindfulness inductions on self-regulation: systematic review and meta-analysis. Emotion. 2019;19(1):108–22.
25. Spadaro KC, Davis KK, Sereika SM, Gibbs BB, Jakicic JM, Cohen SM. Effect of mindfulness meditation on short-term weight loss and eating behaviors in overweight and obese adults: a randomized controlled trial. J Complement Integr Med. 2018;15(2):20160048.
26. O'Reilly GA, Cook L, Spruijt-Metz D, Black DS. Mindfulness-based interventions for obesity-related eating behaviours: a literature review. Obes Rev. 2014;15(6):453–61.
27. Godfrey KM, Gallo LC, Afari N. Mindfulness-based interventions for binge eating: a systematic review and meta-analysis. J Behav Med. 2015;38(2):348–62.
28. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;29:n71.
29. Segal Z, Williams M, Teasdale J. Mindfulness-based cognitive therapy for depression. 2nd ed. New York: Guilford Publications; 2018. p. 473.
30. Sala M, Rochefort C, Lui PP, Baldwin AS. Trait mindfulness and health behaviours: a meta-analysis. Health Psychol Rev. 2020;14(3):345–93.
31. Hensley-Hackett K, Bosker J, Keefe A, Reidlinger D, Warner M, D'Arcy A, et al. Intuitive eating intervention and diet quality in adults: a systematic literature review. J Nutr Educ Behav. 2022;54(12):1099–115.
32. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Syst Rev. 2016;5(1):210.
33. Cochrane Effective Practice and Organisation of Care. Data collection form. EPOC resources for review authors. 2017. Available from: epoc.cochrane.org/resources/epoc-specific-resources-review-authors. Cited 2022 Aug 15.
34. Matko K, Sedlmeier P. What is meditation? Proposing an empirically derived classification system. Front Psychol. 2019;10:2276.
35. Filipe MG, Magalhães S, Veloso AS, Costa AF, Ribeiro L, Araújo P, et al. Exploring the effects of meditation techniques used by mindfulness-based programs on the cognitive, social-emotional, and academic skills of children: a systematic review. Front Psychol. 2021;12. Cited 2023 Jul 8.
36. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med. 2013;46(1):81–95.
37. Mergelsberg ELP, De Ruijter D, Crone MR, Smit ES, Hoving C. Active ingredients of interventions improving smoking cessation support by Dutch primary care providers: a systematic review. Eval Health Prof. 2023;46(1):3–22.
38. Effective Public Health Practice Project (EPHPP). Quality assessment tool for quantitative studies. 2009.
39. Timmerman GM, Brown A. The effect of a mindful restaurant eating intervention on weight management in women. J Nutr Educ Behav. 2012;44(1):22–8.
40. Biber DD, Rice K, Ellis R. Self-compassion training within a workplace physical activity program: a pilot study. Work. 2021;68(4):1059–67. 2021/04/20 ed.
41. Dysart A, Harden SM. Mindfulness and understanding of self-care for leaders of extension: promoting well-being for health educators and their clients. Front Public Health. 2022;10:862366. 2022/06/02 ed.
42. Nymberg P, Calling S, Stenman E, Palmér K, Hansson EE, Sundquist K, et al. Effect of mindfulness on physical activity in primary healthcare patients: a randomised controlled trial pilot study. Pilot Feasibility Stud. 2021;7(1):70. 2021/03/19 ed.
43. Friedman K, Marenus MW, Murray A, Cahuas A, Ottensoser H, Sanowski J, et al. Enhancing physical activity and psychological well-being in college students during COVID-19 through WeActive and

WeMindful Interventions. Int J Environ Res Public Health. 2022;19(7):4144. 2022/04/13 ed.
44. Garcia L, Ferguson SE, Facio L, Schary D, Guenther CH. Assessment of well-being using Fitbit technology in college students, faculty and staff completing breathing meditation during COVID-19: a pilot study. Ment Health Prev. 2023;30:200280.
45. Gonzales A, Lin JH, Cha JS. A year-long case study of multicomponent interventions to promote physical activity in office workers: a randomized control trial. Appl Ergon. 2024;120:104333.
46. Peterson NE, Thomas M, Hunsaker S, Stewart T, Collett CJ. mHealth gratitude exercise mindfulness app for resiliency among neonatal intensive care unit staff: three-arm pretest-posttest interventional study. JMIR Nurs. 2024;16(7):e54561.
47. Strehli I, Burns RD, Bai Y, Ziegenfuss DH, Block ME, Brusseau TA. Development of an online mind-body physical activity intervention for young adults during COVID-19: a pilot study. IJERPH. 2023;20(5):4562.
48. Cantisano LM, Gonzalez-Soltero R, Blanco-Fernandez A, Belando-Pedreno N. ePSICONUT: an e-Health programme to improve emotional health and lifestyle in university students. Int J Environ Res Public Health. 2022;19(15). Available from: WOS:000840212300001.
49. An E, Irwin MR, Doering LV, Brecht ML, Watson KE, Corwin E, et al. Mindfulness effects on lifestyle behavior and blood pressure: a randomized controlled trial. Health Sci Rep. 2021;4(2):e296. 2021/06/18 ed.
50. Horan KA, Taylor MB. Mindfulness and self-compassion as tools in health behavior change: an evaluation of a workplace intervention pilot study. J Context Behav Sci. 2018;8:8–16.
51. Baden MY, Kato S, Niki A, Hara T, Ozawa H, Ishibashi C, et al. Feasibility pilot study of a Japanese teaching kitchen program. Front Public Health. 2023;11.
52. Henninger SH, Fibieger AY, Magkos F, Ritz C. Effects of mindful eating and YogaDance among overweight and obese women: an exploratory randomized controlled trial. Nutrients. 2023;15(7):1646.
53. Seguias L, Tapper K. A randomized controlled trial examining the effects of mindful eating and eating without distractions on food intake over a three-day period. Nutrients. 2022;14(5):1043. 2022/03/11 ed.
54. Daubenmier J, Lin J, Blackburn E, Hecht FM, Kristeller J, Maninger N, et al. Changes in stress, eating, and metabolic factors are related to changes in telomerase activity in a randomized mindfulness intervention pilot study. Psychoneuroendocrinology. 2012;37(7):917–28.
55. Soriano-Ayala E, Amutio A, Franco C, Mañas I. Promoting a healthy lifestyle through mindfulness in university students: a randomized controlled trial. Nutrients. 2020;12(8):2450. 2020/08/23 ed.
56. Mota JF, Lopes LCC, Trottier CF, Johnson ST, Lieffers J, Prado CM. A randomized controlled trial of the effects of a web-based intervention on perceived stress and diet quality among first-year university students. Telemed Rep. 2023;4(1):327–35.
57. Sant'Anna EM, Paiva SPC, Santos RP, Rodrigues AMS, Davis NA, Nery SF, et al. Mindfulness-based program to support lifestyle modification and weight loss in infertile women: randomized controlled trial. J Psychosom Obstet Gynaecol. 2022;43(2):136–44. 2020/09/26 ed.
58. Lyzwinski LN, Caffery L, Bambling M, Edirippulige S. The mindfulness app trial for weight, weight-related behaviors, and stress in university students: randomized controlled trial. JMIR Mhealth Uhealth. 2019;7(4):e12210. 2019/04/11 ed.
59. Sala M, Geary B, Baldwin AS. A mindfulness-based physical activity intervention: a randomized pilot study. Psychosom Med. 2021;83(6):615–23. 2020/11/10 ed.
60. Balciuniene V, Jankauskiene R, Baceviciene M. Effect of an education and mindfulness-based physical activity intervention for the promotion of positive body image in Lithuanian female students. Eat Weight Disord. 2022;27(2):563–77. 2021/04/21 ed.
61. Gillman AS, Bryan AD. Mindfulness versus distraction to improve affective response and promote cardiovascular exercise behavior. Ann Behav Med. 2020;54(6):423–35.
62. Laird B, Puzia M, Larkey L, Ehlers D, Huberty J. A mobile app for stress management in middle-aged men and women (calm): feasibility randomized controlled trial. JMIR Form Res. 2022;6(5):e30294.
63. Aubert M, Clavel C, Scanff CL, Martin JC. Intervention to improve well-being, nutrition, and physical activity in adults: experimental study. JMIR Form Res. 2024;8(1):e47251.
64. Braun TD, Park CL, Conboy LA. Psychological well-being, health behaviors, and weight loss among participants in a residential, Kripalu yoga-based weight loss program. Int J Yoga Therap. 2012;22:9–22. 2012/10/17 ed.
65. Zhou YE, Jackson CD, Oates VJ, Davis GW, Davis C, Takizala ZM, et al. Refining a church-based lifestyle intervention targeting African-American adults at risk for cardiometabolic diseases: a pilot study. Open J Epidemiol. 2017;7(2):96–114. 2017/05/01 ed.
66. Huberty J, Green J, Glissmann C, Larkey L, Puzia M, Lee C. Efficacy of the mindfulness meditation mobile app "calm" to reduce stress among college students: randomized controlled trial. JMIR Mhealth Uhealth. 2019;7(6):e14273. 2019/06/27 ed.
67. Rung AL, Oral E, Berghammer L, Peters ES. Feasibility and acceptability of a mobile mindfulness meditation intervention among women: intervention study. JMIR mHealth uHealth. 2020;8(6).
68. Mason AE, Epel ES, Kristeller J, Moran PJ, Dallman M, Lustig RH, et al. Effects of a mindfulness-based intervention on mindful eating, sweets consumption, and fasting glucose levels in obese adults: data from the SHINE randomized controlled trial. J Behav Med. 2016;39(2):201–13.
69. Millstein RA, Lindly OJ, Luberto CM, Perez GK, Schwartz GN, Kuhlthau K, et al. An exploration of health behaviors in a mind-body resilience intervention for parents of children with developmental disabilities. J Dev Behav Pediatr. 2020;41(6):480–5.
70. Epel E, Laraia B, Coleman-Phox K, Leung C, Vieten C, Mellin L, et al. Effects of a mindfulness-based intervention on distress, weight gain, and glucose control for pregnant low-income women: a quasi-experimental trial using the ORBIT model. Int J Behav Med. 2019;26(5):461–73.
71. Robin N, Toussaint L, Sinnapah S, Hue O, Coudevylle GR. Beneficial influence of mindfulness training promoted by text messages on self-reported aerobic physical activity in older adults: a randomized controlled study. J Aging Phys Act. 2020;28(3):406–14.
72. Mirabito G, Verhaeghen P. Remote delivery of a koru mindfulness intervention for college students during the covid-19 pandemic. J Am Coll Health. 2022.
73. Don BP, Van Cappellen P, Fredrickson BL. Understanding engagement in and affective experiences during physical activity: the role of meditation interventions. Psychosom Med. 2021;83(6):592–601. 2021/07/03 ed.
74. Dyer NL, Borden S, Dusek JA, Khalsa SBS. A 3-day residential yoga-based program improves education professionals' psychological and occupational health in a single arm trial. Explore (NY). 2021;17(6):513–20. 2020/09/14 ed.
75. Trent NL, Miraglia M, Dusek JA, Pasalis E, Khalsa SBS. Improvements in psychological health following a residential yoga-based program for frontline professionals. J Occup Environ Med. 2018;60(4):357–67.
76. Kuehl KS, Elliot DL, DeFrancesco C, McGinnis W, Ek S, Van Horne A, et al. An innovative model to add mindfulness to total worker health training: a feasibility and acceptability trial. J Occup Environ Med. 2025;67(1):e47-53.
77. Holman SK, Folz HN, Ford B, Moore S, Moody A. Design and implementation of a pilot student wellness program at a school of pharmacy. Curr Pharm Teach Learn. 2021;13(11):1471–7. 2021/11/21 ed.
78. Baumann H, Heuel L, Bischoff LL, Wollesen B. Efficacy of individualized sensory-based mHealth interventions to improve distress coping in healthcare professionals: a multi-arm parallel-group randomized controlled trial. Sensors. 2023;23(4):2322.
79. Fredrickson BL, Arizmendi C, Van Cappellen P. Same-day, cross-day, and upward spiral relations between positive affect and positive health behaviours. Psychol Health. 2021;36(4):444–60. 2020/06/17 ed.
80. van Berkel J, Boot CR, Proper KI, Bongers PM, van der Beek AJ. Effectiveness of a worksite mindfulness-based multi-component intervention on lifestyle behaviors. Int J Behav Nutr Phys Act. 2014;27(11):9. 2014/01/29 ed.
81. Mitchell AD, Martin LE, Baldwin AS, Levens SM. Mindfulness-informed guided imagery to target physical activity: a mixed method feasibility and acceptability pilot study. Front Psychol. 2021;12:742989. Cited 2023 Jul 8.
82. Isbel B, Summers MJ. Distinguishing the cognitive processes of mindfulness: developing a standardised mindfulness technique for use in longitudinal randomised control trials. Conscious Cogn. 2017;1(52):75–92.
83. Brug J, Oenema A, Ferreira I. Theory, evidence and intervention mapping to improve behavior nutrition and physical activity interventions. Int J Behav Nutr Phys Act. 2005;2(1):2.
84. Gillebaart M, De Ridder DTD. Positioning self-control in a dual-systems framework. In: The Routledge international handbook of self-control in health and well-being. Milton Park, UK: Routledge; 2017. p. 35–46.

85. Preissner CE, Vilier L, De Vries H, Oenema A. Consistency between definitions and measurement of mindfulness in eating and physical activity behavior: a scoping review. Health Psychol Rev. 2024;18(3):574–98.
86. Lutz A, Jha AP, Dunne JD, Saron CD. Investigating the phenomenological matrix of mindfulness-related practices from a neurocognitive perspective. Am Psychol. 2015;70(7):632–58.
87. Van Dam NT, van Vugt MK, Vago DR, Schmalzl L, Saron CD, Olendzki A, et al. Mind the hype: a critical evaluation and prescriptive agenda for research on mindfulness and meditation. Perspect Psychol Sci. 2018;13(1):36–61.
88. Ferrari M, Hunt C, Harrysunker A, Abbott MJ, Beath AP, Einstein DA. Self-compassion interventions and psychosocial outcomes: a meta-analysis of RCTs. Mindfulness. 2019;10(8):1455–73.
89. Ingraham N, Eliason MJ, Garbers S, Harbatkin D, Minnis AM, McElroy JA, et al. Effects of mindfulness interventions on health outcomes in older lesbian/bisexual women. Womens Health Issues. 2016;26(Suppl 1):S53-62.
90. Clark A, Jit M, Warren-Gash C, Guthrie B, Wang HHX, Mercer SW, et al. Global, regional, and national estimates of the population at increased risk of severe COVID-19 due to underlying health conditions in 2020: a modelling study. Lancet Glob Health. 2020;8(8):e1003–17.
91. Pitcher MH, Von Korff M, Bushnell MC, Porter L. Prevalence and profile of high-impact chronic pain in the United States. J Pain. 2019;20(2):146–60.
92. de Vries H. An integrated approach for understanding health behavior; the I-change model as an example. PBSIJ. 2017;2(2). Available from: https://juniperpublishers.com/pbsij/PBSIJ.MS.ID.555585.php.

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