International Journal of EXERCISE SCIENCE

Review Article

A Systematic Review of the Effects of Meditative and Mindful Walking on Mental and Cardiovascular Health

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ABSTRACT

International Journal of Exercise Science 15(2): 1692-1734, 2022. Meditative and mindful exercise are types of physical exercise during which people pay attention, on purpose, to each new present moment without judging their experience. The goal is to apply an accepting awareness of the environment, bodily sensations, thoughts, and emotions without labeling them (e.g., good or bad). The literature centers on qigong, tai chi, and yoga, which are types of mindful exercise that improve mental and cardiovascular health. It is unclear if meditative and mindful walking also improve these health domains. To the authors' knowledge, this question has not been addressed by a published systematic review. The purpose of this systematic review without a meta-analysis was to synthesize the literature on meditative and mindful walking to determine their effects on mental and cardiovascular health. The protocol follows the PRISMA guidelines, is registered in PROSPERO (CRD42021241180), and is published elsewhere in a peer-reviewed journal. The systematic review contains 14 studies that had various populations, interventions, and outcomes. In 13 studies, the interventions statistically significantly improved scores on at least one outcome of mental or cardiovascular health (e.g., affect, anxiety, depression, distress, state mindfulness, stress, blood pressure, and six-minute walk distance). The improved outcomes should be interpreted cautiously because their clinical meaningfulness is unclear, and the studies had severe methodological limitations. Determining if meditative and mindful walking meaningfully improve mental and cardiovascular health will require randomized controlled trials that use rigorous designs, transparent protocols, and clinically meaningful outcomes that indicate physical function, mental wellbeing, morbidity, and mortality.

KEY WORDS: Mindfulness, mind-body exercise, mindful exercise, walking meditation, breathing, Buddhism

INTRODUCTION

The global population is suffering under a double burden of poor mental and cardiovascular health. In a year, nearly one-fifth of adults have a mental disorder (47). In a lifetime, the prevalence is almost one-third of adults (47). This mental burden is compounded by physical diseases of the heart and blood vessels. More adults live with disability and die because of cardiovascular diseases (CVD) than any other non-communicable disease (26, 41). Alleviating this double burden requires treatments that are cost-effective, physiologically effective, and widely accessible. Walking has all three features. It is a free and natural human activity that can be completed by most adults. Crucially, walking treats various mental and cardiovascular diseases effectively. With respect to mental disorders, walking protects against and improves depression (22), with one meta-analysis reporting that walking decreases symptoms by a large effect (standardized mean difference: -0.86 [95% CI: -1.12, -0.61]) (40). Walking is also negatively associated with anxiety and improves anxiety when completed for 6-12 weeks (22). Besides the mental benefits, walking also improves cardiovascular health. Walking increases aerobic capacity and decreases CVD risk factors such as body weight, adiposity, and blood pressure (34). After adjusting for other physical activity, walking also decreases all-cause mortality by 11% (95% CI: 4, 17%; estimate based on a dose of 11.25 metabolic equivalent hours/week) (21).

Motivated by the evidence that walking improves mental and cardiovascular health, a niche in the relevant literature has investigated whether the benefits of normal walking (i.e., traditional walking) are surpassed by the effects of meditative walking or mindful walking. The latter two types of walking are mindful exercises. There are several definitions of mindful exercise, but the one accepted for this systematic review is physical exercise that involves focusing one's attention earnestly on the inner experience (27, 28). During mindful exercise, people pay attention on purpose to each new present moment without judging their experience. In contrast, traditional exercise often involves mind-wandering without a profound inwardly directed contemplative focus. During meditative and mindful walking, the goal is to apply an accepting awareness to the internal bodily sensations, thoughts, and emotions without attaching labels such as "good" or "bad." This accepting and non-judgmental awareness can also be extended to the external environment. Meditative walking and mindful walking are similar except that, during meditative walking, people typically repeat mantras (i.e., short phrases) to maintain their awareness and focus. The rationale behind comparing traditional walking with meditative and mindful walking is that other types of mindful exercise improve mental and cardiovascular health, sometimes more than non-mindful exercise.

Literature on mindful exercise centers on qigong, tai chi, and yoga. Qigong and tai chi originated in China and are types of light exercise. Each type has many subtypes, but the common elements are deep breathing, smooth movements, assuming postures, and cultivating a focus on the present. The key difference between qigong and tai chi is that the latter began as martial arts training and involves stringing together martial movements. Qigong has fewer to no martial movements and involves less movement from one location (i.e., a person does not typically move around a room as much during qigong as during tai chi). Yoga originated in India and has sprouted many types. The most popular type in Western countries is Hatha yoga, during which people move through sequences of asanas (held postures; e.g., cat-cow pose, downward dog pose, and tree pose).

Qigong, tai chi, and yoga improve depression in various populations (51) and psychiatric symptoms in people with schizophrenia (29). In 2021, a meta-analysis reported that one session of yoga decreases anxiety slightly (a small, significant effect) (54). This result aligned with another finding that yoga reduces anxiety more than non-mindful exercises (also a small, significant effect) (45). Yoga also improves cardiovascular health (4, 7). The evidence for qigong and tai chi suggests these mindful exercises improve cardiovascular health too (17, 19, 23). Systematic reviews and meta-analyses about qigong, tai chi, and yoga continue to inform readers about their efficacy in a manner that individual studies cannot. It seems that only individual studies about meditative and mindful walking exist so far. To the author's knowledge, no published systematic review or meta-analysis has synthesized the individual studies of meditative and mindful walking. The primary purpose of the present systematic review was to determine the effects of meditative and mindful walking on mental and cardiovascular health. The secondary purpose was to evaluate the quality of the studies on meditative and mindful walking and compare their findings to those of studies about other types of mindful exercise.

METHODS

Protocol

The present systematic review was conducted as per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. All researchers adhered to the ethical standards of the International Journal of Exercise Science (36). The protocol of the systematic review is registered in the international prospective register of systematic reviews called PROSPERO (Registration Number: CRD42021241180) and is published elsewhere (11). In that published protocol, readers can read our methods in greater detail than what is given in this paper (Tables 1-3). The details explained in that publication are the Population, Intervention, Comparator, Outcomes, and Study Design (PICOS) criteria, eligibility criteria, search strategy (databases, team, techniques, and search terms), screening process, data extraction, and risk of bias assessment (11).

The present review did not include a meta-analysis because the included studies did not meet the four aspects of homogeneity required to conduct a meta-analysis (3). Specifically, the included studies differed by their 1) participants, 2) interventions and comparators, and 3) outcomes and the time frame over which the outcomes were measured. Additionally, 4) most of the included studies reported different treatment effects in different directions (3). The lack of homogeneity and meta-analysis warranted a longer results and discussion than is typical of standard systematic reviews. The results and discussion summarize the similarities and differences among the studies' populations, methods, and outcomes.

Table 1. Review question and PICOS table.

Review Question	What is the evidence for meditative and mindful walking as therapies for improving mental and cardiovascular health in adults with and without psychological disorders or cardiovascular diseases?
Population	Adults with or with no psychological disorders or cardiovascular diseases - Will extract participants' age, sex, gender, nationality, disease status, medication use, and history of meditation or mindfulness practice
Intervention	Meditative walking or mindful walking - Any form of walking with a meditative or mindful component used to reduce anxiety or depression, increase mindfulness, or improve cardiovascular risk factors - Operational definition of meditative and mindful walking: Walking with an inwardly directed mental focus and a concentration on muscular movements, body alignment, and/or breath - Will extract the frequency, intensity, type, duration, and location (e.g., indoors, outdoors) of the intervention
Comparator	Placebo or negative control in controlled studies No comparator in uncontrolled studies
Outcomes	Any beneficial or adverse changes in any quantitative measure of anxiety, depression, mindfulness, or cardiovascular health or risk - Any subjective self-reported measures of anxiety, depression, or mindfulness - Any objective cardiovascular biomarkers
Setting	Any physical environment (indoors, outdoors, urban, rural, built-up, or natural)
Study Design	Only studies with interventions, and no observational studies - Controlled or uncontrolled - Randomized or nonrandomized - Crossover design (participants complete the intervention and control arms) or parallel design (participants complete only the intervention or control arm)

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Table 2. Eligibility criteria.

Participants	Adults of any age, sex, gender, nationality, disease status, medication use, and history of meditation or mindfulness practice
Inclusion Criteria	1. The source is a published article in a peer-reviewed journal or is an unpublished or published master's thesis or doctoral dissertation 2. The source is written in English 3. The source reports the findings of an interventional study a. The intervention is any walking with a meditative or mindful component used to reduce anxiety or depression, increase mindfulness, or improve cardiovascular risk factors b. At least one reported outcome is a measure of anxiety, depression, mindfulness, or cardiovascular health
Exclusion	1. The source is not a published, peer-reviewed journal article or an unpublished or

Criteria	published master's thesis or doctoral dissertation 2. The source is written in any language other than English 3. The source reports the findings of an interventional study with an intervention or outcomes irrelevant to this systematic review a. There is a walking intervention without a meditative or mindful component b. None of the reported outcomes are a measure of anxiety, depression, mindfulness, or cardiovascular health 4. The source reports the findings of an observational study (i.e., there is no walking intervention)

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Table 3. Search strategy.

Investigators	Team A: DD and BC Team B: BB and KC Arbiter: JN	
Techniques	Search research databases for sources, including them in four stages: 1. Include sources by title 2. Include sources by abstract 3. Include sources by full text 4. Include sources from the reference lists of sources included by full text (journal articles, master's theses, and doctoral dissertations)	
Databases	Academic Search Premier, APA PsycInfo, Google Scholar, PubMed, and SPORTDiscus	
Included Types of Literature	Published, peer-reviewed journal articles; unpublished and published master's theses and doctoral dissertations	
Publication Date Range	No limit	
Intervention Search Terms	Outcome Search Terms	
"Meditative walk*" "Walk* meditat*" "Mindful* walk*" "Buddhis* walk*"	"Stress" "Anxiety" "Depress*" "Mindfulness" "Health" "Fitness" "Allostatic load" "Disease"	"Cardiovascular" "Hypertens*" "Blood pressure" "Cholesterol" "Hyperglycem*" "Blood sugar" "Insulin*"
Search Combination	((Meditative walk*) OR (walk* meditat*) OR (mindful* walk*) OR (Buddhis* walk*)) AND (stress OR anxiety OR depress* OR mindfulness OR health OR fitness OR allostatic load OR disease OR cardiovascular OR hypertens* OR blood pressure OR cholesterol OR hyperglycem* OR blood sugar OR insulin*)	

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RESULTS

The initial search for sources by title provided 2,800 hits from Academic Search Premier, APA PsycInfo, Google Scholar, PubMed, and SPORTDiscus (Figure 1). These 2,800 hits were screened to the 14 full-text sources included in the systematic review. The top reasons for screening out sources by abstracts were the sources 1) were not original research studies, 2) lacked a meditative or mindful walking intervention, or 3) provided meditation and walking separately. All 14 sources were peer-reviewed journal articles, meaning no master's theses or doctoral dissertations were identified or included. In the references of the included sources, no other sources eligible for inclusion were identified. In the Results of the present systematic review, the populations, interventions, study designs, and results of the 14 studies are reported and compared (Tables 4-8). From this point on, studies are called single-session or multi-session studies. Single-session studies reported only the acute effects of one session of meditative or mindful walking at a time (e.g., the effects of one mindful walk on stress). Multi-session studies reported the cumulative effects of more than one session of meditative or mindful walking (e.g., stress before and after 8 weeks of 3 sessions of mindful walking/week).

Unless stated otherwise, the data in the text and tables are expressed as means ± standard deviations (SD). Except for when the phrase "absolute percent increase/decrease" is used, all percent increases/decreases in outcomes are relative to baseline values. The phrase "absolute percent increase/decrease" is used to describe percent increases/decreases when the unit of an outcome is already a percent (e.g., percent body fat and flow-mediated dilation). Percent changes relative to baseline values were calculated in this way: Percent increases = ((final value - starting value) / |starting value|) × 100, and percent decreases = ((starting value - final value) / |starting value|) × 100.

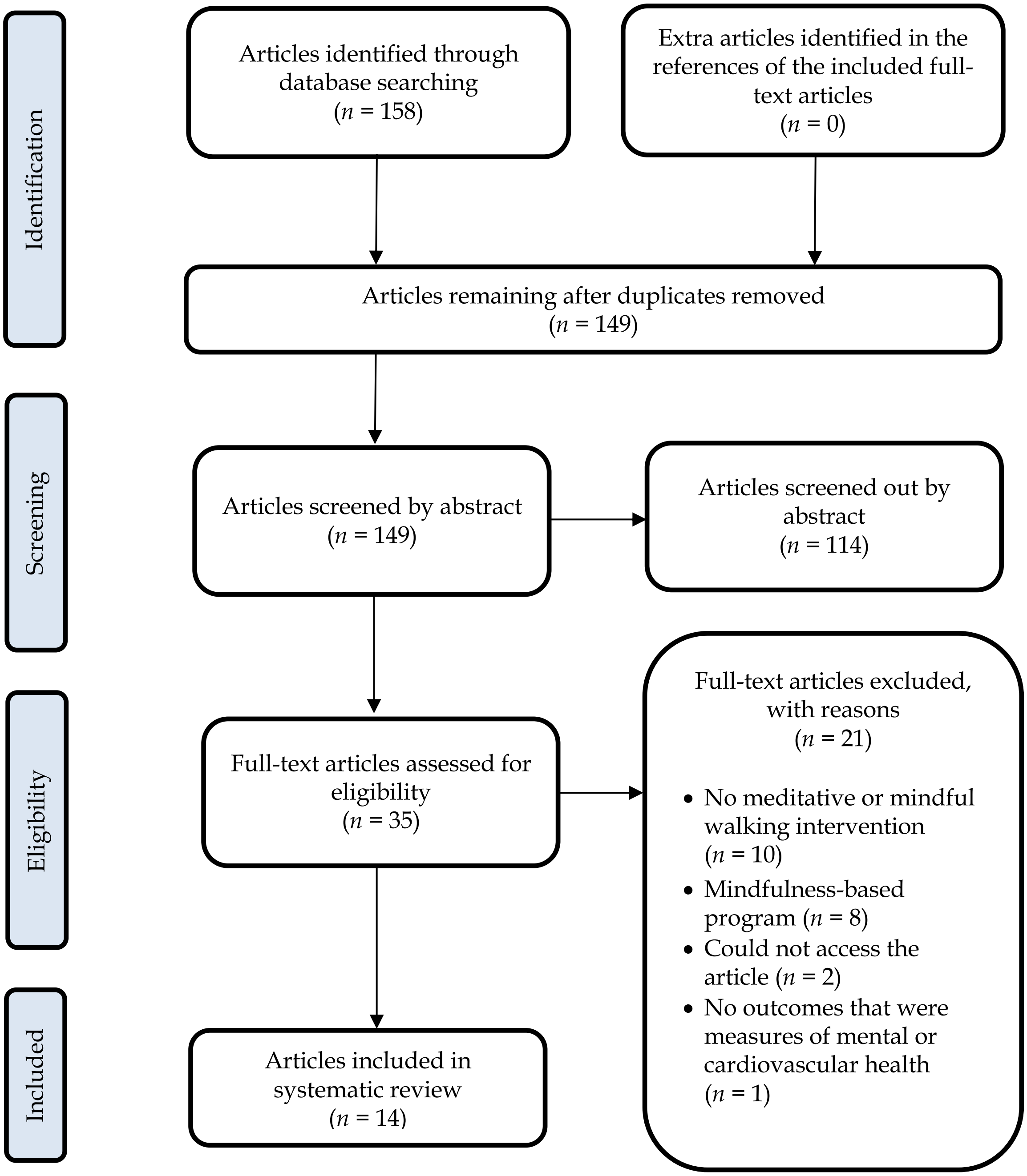

Figure 1. Flow diagram that depicts how articles were included in the systematic review.

Table 4. Design characteristics of the 14 studies included in the systematic review.

Publication Range	Origin	# Studies	Meditative Walking[a]	Mindful Walking[b]	Single-Session[c]	Multi-Session[d]	Indoors	Outdoors	Indoors & Outdoors	Indoors/ Outdoors Not Specified
2013-2021	Brazil Germany Netherlands South Korea Taiwan Thailand United States	14	6/14 (43%)	8/14 (57%)	4/14 (29%)	10/14 (71%)	6/14 (43%)	5/14 (36%)	2/14 (21%)	1/14 (7%)

Note: [a]The authors described the intervention as meditative walking or walking meditation. [b]The authors described the intervention as mindful walking, walking while practicing mindfulness, or breathing-based walking. [c]Single-session means the studies reported only the acute effects of one session of meditative or mindful walking at a time. [d]Multi-session means the studies reported the cumulative effects of more than one session of meditative or mindful walking.

Table 5. Populations sampled in the 14 studies included in the systematic review.

Populations of Apparently Healthy Adults	Populations of Adults with Diseases
Fairly physically inactive or sedentary	Chronic Obstructive Pulmonary Disease
Older adults (≥ 65 years of age)	Heart failure
Physically active	Type 2 Diabetes Mellitus
Previous meditation and mindfulness experience	Depressive symptoms
Undergraduate students with low intrinsic motivation for physical activity	Increased psychological distress
Military personnel and their family and caregivers	

Table 6. Measures of mental and cardiovascular health reported in the 14 studies included in the systematic review.

Mental Health		Cardiovascular Health	
Activation	Happiness	Aerobic Capacity	Heart Rate Variability
Affect	Health-Related Quality of Life	Blood Pressure[a]	Physical Activity[b]
Anxiety	Post-Traumatic Thoughts and Emotions	Body Fat Percentage	Six-Minute Walk Distance
Attentional Focus	Ruminative Thoughts	Body Mass Index	Blood Glycemia Variables
Brooding	Self-esteem	Flow-mediated Dilation	Blood Lipidemia Variables
Depression	Self-worth	Heart Rate	
Distress	State Mindfulness		
Emotional Awareness	Stress		
Enjoyment of Physical Activity	Trait Mindfulness		

Note: [a]Systolic and diastolic; [b]Objective (measured) and subjective (self-reported). The units and time frames in which the outcomes were measured are explained in the sections Mental Health (Single- and Multi-Session Studies) and Cardiovascular Health (Single- and Multi-Session Studies).

Table 7. Single-session studies that reported the effects of meditative and mindful walking on mental or cardiovascular health.

Authors, Year (Country)	Study Design	Participants[a]	Meditative or Mindful Walking Intervention	Mental Health	Cardiovascular Health
Ameli et al., 2021 (U.S.)	RCT, Crossover, Single session	Current and former U.S. military personnel and their family and caregivers, 18-60 y of age *n* = 12; Age = 35 ± 12 y; 75% female; 92% college-educated; 25% Asian, 25% Black; 33% White; 17% Other	Control[b]: 20-min session that included mindful walking along the Urban Road Intervention: 20-min session that included mindful walking along the Green Road Mindful walking: Walking with focused attention and present-moment orientation Setting: The Urban Road (busy campus road in a medical treatment facility) and The Green Road (a healing garden/woodland environment); Participants did not walk together	Distress: ↓ in intervention group State mindfulness: ↑ in intervention group	NR

Bigliassi et al., 2020 (Brazil)	RCT, Crossover, Single session	Apparently healthy, active adults *n* = 24; Age = 24 ± 4 y; Mass = 69 ± 17 kg; Height = 170 ± 10 cm; Active minutes = 376 ± 192 min/wk	Controls[b]: Mindlessness walking meditation and walking control Intervention: 4-6-min session of mindfulness walking meditation Mindfulness walking meditation: Walking while focusing on the feet, legs, and environment Setting: Small outdoor park on a university campus; Participants did not walk together	State mindfulness: ↑ in intervention group Affect: More positive in intervention group Perceived activation: ↓ in intervention group Perceived enjoyment: ↑ in intervention group	NR
Cox et al., 2018 (U.S.)	Non-randomized controlled study, Crossover, Single session	Undergraduate students with low intrinsic motivation for physical activity, 18-35 y of age *n* = 23; Age = 19 ± 1 y; BMI = 24.8 ± 5.0 kg · m^{-2}; 83% female; 17% Asian/Pacific Islander; 4% Black; 13% Hispanic/Latino; 4% Multi-Racial; 4% Native American/Alaskan Native; 52% White; 4% Other	Control[b]: Traditional walking Intervention: ~30-min session that included mindful walking Mindful walking: 10-min session; Walking while listening to a mindfulness script Setting: Treadmill in a university laboratory; Participants did not walk together	Attentional focus: ↑ internal focus in intervention group Positive affect: ↑ in intervention group State mindfulness of the body: ↑ in intervention group vs. control group Enjoyment: ↑ in intervention group vs. control group	NR

Shin et al., 2013 (South Korea)	Randomized, uncontrolled study, Parallel, Single session	Community-dwelling adult females, 18-25 y of age *n* = 139; Age = 20 ± 2 y; BMI = 21.4 ± 2.7 kg · m^{-2}; 45.9% religious	Interventions: 90-min sessions on four consecutive days (athletic walking in gym, athletic walking in forest, meditative walking in gym, meditative walking in forest); Each session included 35 min walking + 10 min rest + 35 min walking + 10 min rest Meditative walking: Walking while focusing on bodily sensations and breathing Setting: 100-m track (indoors) and forest (outdoors); Unclear if participants walked alone or together	Anxiety: ↓ in meditative walking group more than in athletic walking in both settings Self-esteem: ↑ in meditative walking group more than in athletic walking group in both settings Happiness: ↑ in meditative walking group more than in athletic walking group in both settings; ↑ in forest more than in gym	NR

Note: The ↑ and ↓ represent statistically significant changes/between-group differences in the measures of mental and cardiovascular health. [a]The *n* given in the table is the number of participants for which data were analyzed. [b]This study had at least one control group, none of which was a non-walking control group. Abbreviations: RCT: randomized controlled trial; U.S.: United States; y: years; min: minute(s); NR: not reported; kg: kilogram(s); cm: centimeters; wk: week(s); BMI: body mass index; m: meters.

Table 8. Multi-session studies that reported the effects of meditative and mindful walking on mental or cardiovascular health.

Authors, Year (Country)	Study Design	Participants[a]	Meditative or Mindful Walking Intervention	Mental Health	Cardiovascular Health
Srisoongnern et al., 2021 (Thailand)	RCT, Parallel, Multi-session	Adults with heart failure, 18-80 y of age *n* = 48; Age = 65 ± 12 y; 50% female	Control[b]: Aerobic exercise program Intervention: 30-40-min session of Buddhism meditative walking on ≥ 3 days/wk for six wk Buddhism meditative walking: Walking while focusing on the rhythmic swinging of the legs and mentally repeating the mantra "left" and "right" with each leg swing Setting: 5-m, straight indoor path in a hospital; Participants' homes; Participants did not walk together	Quality of life (specific to heart failure): NS	SBP: ↓ in control group DBP: NS Six-min walk distance: NS
Lin and Yeh, 2021 (Taiwan)	RCT, Parallel, Multi-session	Adults with mild-to-severe COPD *n* = 78; Age = 71 ± 8 y; BMI = 24.4 ± 4.0 kg · m^{-2}; 2.6% female; 26% college-educated; 26%	Control: Usual care Intervention: Usual care + 35-min session that included mindful walking on five days/wk for	Emotional awareness: ↑ in intervention and control groups from baseline to Wk 4, 8, and 12	Six-min walk distance: ↑ in intervention group from baseline to Wk 4, 8, and 12; Distance in intervention group > distance in

		Buddhists; 29% currently smoking; Active minutes = 195 ± 98 min/wk	eight wk (total = 40 sessions) Mindful walking: 20 min of each 35-min session; Walking while focusing on and controlling breathing Setting: Participants' homes and communities; Participants did not walk together		control group at Wk 8 and 12 HRV: NS
Shi et al., 2019 (U.S.)	RCT, Parallel, Multi-session	Sedentary adults, ≥ 18 y of age *n* = 38; Entire Sample: Age = 49 ± 14 y; BMI = 30.1 ± 7.6 $kg \cdot m^{-2}$; 87% female; 3% Asian; 18% Black; 3% Native American/Alaskan Native; 76% White; 84% college-educated; 29% had a chronic medical condition	Control: Only received biweekly emails encouraging physical activity Intervention: 60-min session that included mindful walking on one day/wk for four wk (total = four sessions) Mindful walking: 40 min of each 60-min; Walking while focusing on bodily sensations and breathing Setting: Unspecified indoor space; Participants walked both alone and together	Stress: ↓ in intervention group at Wk 4 Depression: NS Trait mindfulness: NS Health-related quality of life: NS	Self-reported weekly physical activity: ↑ in intervention and control groups Step count: NS

Lin et al., 2019 (Taiwan)	RCT, Parallel, Multi-session	Adults with mild-to-severe COPD *n* = 78; Age = 71 ± 8 y; 72% chronic exercisers; 29% currently smoking	Control: Usual care Intervention: Usual care + ~30-min session that included mindful walking on five day/wk for eight wk (total = 40 sessions) Mindful walking: 23 min of each ~30-min session; Walking while focusing on and controlling breathing Setting: Walking space not described; Participants did not walk together	Anxiety and Depression: ↓ in intervention group from baseline to Wk 4, 8, and 12 (lower in intervention group at Wk 4, 8, and 12)	NR
Yang and Conroy, 2019 (U.S.)	Uncontrolled study, Multi-session	Adults, ≥ 65 y of age *n* = 27; Age = 73 ± 6 y; 83% female; Only race reported was White (79%); 62% college-educated; 10% had a history of mindfulness or meditation	Intervention: 30-min session on eight separate days within four wk (total = 8 sessions; Sessions 2-7 included mindful walking) Mindful walking: Number of min of walking that were mindful walking increased from 0 min in Session 1 to 30 min in Session 8 Setting: Outdoor	Negative affect: ↓ pre- to post-walk State mindfulness: ↑ pre- to post-walk	NR

			arboretum; Participants did not walk together		
Shors et al., 2018 (U.S.)	RCT, Parallel, Multi-session	Adult females not engaged in a chronic exercise program or a formal meditation practice, 18-40 y of age *n* = 105; Age (median and range) = 20 (18-32) y	Controls: No training (wait-list), only mental training, and only physical training Intervention: 60-min MAP Training My Brain™ session that included meditative walking on two days/wk for six wk (total = 12 sessions) Meditative walking: 10 min of each 60-min session; Walking in a circle while focusing on the feet Setting: Group exercise room in a recreational facility; Participants walked together	Post-traumatic thoughts and emotions: ↓ in MAP Training and only mental training groups Ruminative thoughts: ↓ in MAP Training group Self-worth: ↑ in MAP Training group	NR
Gotink et al., 2016 (Netherlands)	Non-randomized controlled study, Parallel, Multi-session	Adults who had previously participated in either a MBCT or MBSR course *n* = 29; Age = 54 ± 9 y; 69% female; 70-80% college educated; 50-100% had a history of depression	Control: The period leading up to the intervention (control period and intervention period equal in length) Intervention: One-, three-, or ≥ six-day mindful walking retreats	Positive affect ↑ across the intervention Negative affect: ↓ across the intervention State mindfulness: NS Trait mindfulness: ↑	NR

			Mindful walking: Walking while paying attention to the senses, emotions, thoughts, and automatic behavioral patterns Setting: Along the river Rhine; Participants walked alone or together, depending on the study arm	across the intervention Allowing negative emotions and thoughts: NS Depression, anxiety, stress, and brooding: NS change across intervention vs. across control	
Gainey et al., 2016 (Thailand)	RCT, Parallel, Multi-session	Adults with type 2 diabetes, 40-75 y of age *n* = 23; Age = 58 ± 10 y; Mass = 66 ± 9 kg; Height = 156 ± 7 cm; BMI = 26.3 ± 4.5 kg · m^{-2}; %BF = 33 ± 8%; 83% female	Control[b]: Traditional walking Intervention: 50-min session that included Buddhist meditative walking on three day/wk for 12 wk (total = 36 sessions) Meditative walking: 30 min of each 50-min session; Walking while focusing on the feet contacting the treadmill and repeating the mantra "Budd" and "Dha" with each foot strike Setting: Treadmill in a university laboratory; Participants did	NR	SBP and DBP: ↓ in intervention group BMI and %BF: NS VO_{2max}: ↑ in intervention and control groups FMD: ↑ in intervention and control groups PWV: ↑ in intervention group ABI: NS FBG: ↓ in intervention and control groups HbA1c: ↓ in intervention group

			not walk together		TC, HDL-C, LDL-C, and HOMA-IR: NS
Prakhinkit et al., 2014 (Thailand)	RCT, Parallel, Multi-session	Adult women with mild-to-moderate depressive symptoms and normal mobility who could provide independent self-care, 60-90 y of age *n* = 40; Age = 74 ± 7 y; Mass = 57 ± 11 kg; Height = 149 ± 8 cm; BMI = 25.5 ± 4.1 kg · m^{-2}; %BF = 38 ± 8%	Controls: No walking (sedentary control) and traditional walking Intervention: 20-30-min session of Buddhism meditative walking on three day/wk for 12 wk (total = 36 sessions) Buddhism meditative walking: Full time of each session; Walking while practicing mindfulness, focusing on the rhythmic swinging of both arms, and repeating the mantra "Budd" and "Dha" with each arm swing Setting: 50-m indoor track at a university hospital; Unclear if participants walked alone or together	Depression: ↓ in intervention group	SBP: ↓ in intervention and traditional walking groups from baseline (lower in intervention group) DBP: ↓ in intervention and traditional walking groups from baseline (lower in intervention group) RHR: NS %BF: ↓ in intervention group Six-min walk distance: ↑ in intervention and traditional walking groups from baseline FMD: ↑ in intervention and traditional walking groups from baseline TC, TG, and CRP: ↓ in intervention and traditional walking groups from baseline LDL-C, IL-6, and cortisol: ↓ in intervention group

					Nitric oxide: ↑ in intervention and traditional walking groups from baseline
Teut et al., 2013 (Germany)	RCT, Parallel, Multi-session	Adults with increased psychological distress, 18-65 y of age *n* = 74; Age = 52 ± 9 y; BMI = 24.6 ± 4.8 kg · m^{-2}; 89% female	Control: Wait-list Intervention: 60-min session that included mindful walking on two days/wk for four wk (total = eight sessions) Mindful walking: 10 min of each 60-min session; Walking while focusing on bodily sensations and breathing Setting: Local streets and outdoor parks; Unclear if participants walked alone or together	Psychological distress: ↓ in intervention and control groups from baseline to Wk 4; NS differences between groups at Wk 12 Stress: ↓ in intervention group from baseline to Wk 4 and 12 Quality of Life-Physical Component: NS Quality of Life-Mental Component: ↑ in intervention group from baseline to Wk 4 and 12 Quality of life scales for mental health, vitality, and emotional role functioning: ↑ in intervention group from baseline to Wk 4 (only emotional role functioning at Wk 12)	NR

Note: Unless stated otherwise, the ↑ and ↓ represent statistically significant changes/between-group differences in the measures of mental and cardiovascular health. [a]The *n* given in the table is the number of participants for which data were analyzed. Unless indicated otherwise with the phrase "Entire Sample," the participant demographics represent the intervention group. Abbreviations: RCT: randomized controlled trial; y: years; min: minute(s); wk: week; NS: non-significant; SBP: systolic blood pressure; DBP: diastolic blood pressure; COPD: chronic obstructive pulmonary disease; BMI: body mass index; kg: kilogram(s); m: meter(s); HRV: heart rate variability; U.S.: United States; NR: not reported; MAP: mental and physical; MBCT: mindfulness-based cognitive therapy; MBSR: mindfulness-based stress reduction; cm: centimeter(s); %BF: percent body fat; VO_{2max}: aerobic capacity; FMD: flow-mediated dilation of the brachial artery; PWV:

pulse-wave velocity; ABI: ankle-brachial index; FBG: fasting blood glucose; HbA1c: glycated hemoglobin; TC: total cholesterol; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; HOMA-IR: homeostatic model assessment of insulin resistance; RHR: resting heart rate; TG: triglycerides; CRP: C-reactive protein; IL-6: interleukin-6

Mental Health (Single- and Multi-Session Studies)
Four single-session studies evaluated the effects of meditative or mindful walking on mental health and reported significant improvements (1, 5, 9, 43). Significant improvements were in affect (5, 9), anxiety (43), attentional focus (9), distress (1), enjoyment of physical activity (5, 9), happiness (43), perceived activation (5), self-esteem (43), state mindfulness (overall) (1, 5), and state mindfulness (of the body) (9).

Nine multi-session studies evaluated the effects of meditative or mindful walking on mental health (14, 30, 31, 38, 42, 44, 46, 50, 53). All studies except one (46) reported significant improvements on at least one measure of mental health, including affect (14, 53), anxiety (30), depression (30, 38), distress (50), emotional awareness (31), stress (42), post-traumatic thoughts (44), quality of life (50), ruminative thoughts (44), self-worth (44), state mindfulness (overall) (53), and stress (50).

In the following subsections, the single- and multi-session studies are collated and described in the context of each other. The measures of mental health have been grouped by how they are reported together in the literature.

Affect and Enjoyment of Physical Activity
Affect and enjoyment of physical activity were measured in arbitrary units via questionnaires at multiple time-points in the studies. Two single-session studies reported an increase in positive affect and used mindful walking as the intervention (5, 9). Participants walked while listening to a mindfulness script to direct their attention to the present moment. The scripts facilitated mindful walking sessions, which lasted 4-6 minutes (5) and 10 minutes (9), respectively. Affect was more positive after 4-6 minutes of mindful walking than after the same duration of mindless walking and traditional walking (Feeling Scale: 3.3 ± 0.2 vs. 1.7 ± 0.4 vs. 2.6 ± 0.2, $p \leq 0.018$ for mindful vs. mindless and mindful vs. traditional). Enjoyment of physical activity was also higher after mindful walking than after both controls (Physical Activity Enjoyment Scale: 96.7 ± 2.9 vs. 78.8 ± 3.7 vs. 83.4 ± 2.4, $p < 0.001$ for mindful vs. mindless and mindful vs. traditional) (5). Similarly, affect was more positive and enjoyment was higher during 10 minutes of mindful walking than during the same duration of traditional walking (Feeling Scale: 1.39 ± 1.66 vs. 0.87 ± 2.00, $p = 0.02$, $\eta_p^2 = 0.22$, moderate effect; Physical Activity Enjoyment Scale: 4.3 ± 1.1 vs. 3.8 ± 1.0, $p < 0.001$, $\eta_p^2 = 0.36$, moderate effect) (9). Collectively, these findings suggest that just 4-10 minutes of indoor or outdoor guided mindful walking increase positive affect and are more enjoyable than traditional walking. An important caveat to these conclusions is that neither the 4-6-minute walk nor the 10-minute walk was an independent intervention. Other parts of the intervention may have confounded the effects of mindful walking on affect and enjoyment. Exercise intensity may also modulate how mindful walking influences affect and enjoyment. One study allowed walking at a self-selected pace (5), and the other study required walking at

65% of participants' respective heart rate reserve (9). Future studies should evaluate interventions that comprise nothing else but mindful walking at varying intensities.

In addition to intensity, the frequency of mindful walking is also important. Two multi-session studies reported significant effects of more than one mindful walking bout on affect (14, 53). In one study, affect was measured by 18 Likert items in participants before and after a 1, 3, or 6+-day retreat that included mindful walking (14). Participants' affect data were combined across all three retreat lengths. After the retreat, participants' positive affect was higher (β = 0.91 [95% CI: 0.48, 1.33], $p < 0.001$) and negative affect was lower (β = -0.71 [95% CI: -1.08, -0.34], $p < 0.001$). An important note is that the participants already had mindfulness experience before the retreat and completed seated meditation during the retreat. These potential confounders may influence affect independently of mindful walking, underscoring the need for studies that require mindful walking as an independent intervention.

The only other multi-session study that reported affect was an 8-session study in which mindful walking took place in an outdoor arboretum (53). All eight sessions lasted 30 minutes, and Sessions 2-7 included 5-30 minutes of mindful walking. Mean negative affect after the sessions was lower than before the sessions (Patient-Reported Outcomes Measurement Information System: $p < 0.01$, d = -0.61, moderate effect). Negative affect after the sessions was negatively associated with increases in state mindfulness across the sessions (estimate ± SE: β = -0.27 ± 0.09, $p < 0.01$). The findings suggest that mindful walking lifts the mood and that being more mindful while walking lifts the mood more (53). The study took place outdoors like the studies by Bigliassi et al. (2020) and Gotink et al. (2016) that also reported greater positive affect because of mindful walking. It is worth exploring if walking setting modulates the effects of mindful walking on affect.

Attentional Focus

Attentional focus was measured in arbitrary units via a questionnaire after an intervention. One of the single-session studies reported the effects on attentional focus (9). Attentional focus was more associative during 10 minutes of mindful walking than during the same duration of traditional walking (Tammen's attentional focus scale: 20.65 ± 18.07 vs. 57.70 ± 25.38, $p < 0.001$, η_p^2 = 0.67, strong effect). This suggests participants focused more on internal stimuli and interoceptive cues (e.g., breathing, heart rate, and skeletal muscle contraction) during mindful walking than during traditional walking. Despite only one article on this topic, this finding aligns with the yoga literature (32). Thus, mindful walking may be a convenient way to recenter the attention on internal cues instead of external cues.

Distress, Stress, and Quality of Life

Distress, stress, and quality of life were measured in arbitrary units via questionnaires at multiple time-points during the studies. Distress was reported by one single-session study that had participants complete two separate 20-minute mindful walks, one in an urban area and one in a natural area (1). The urban area was a campus with buildings, sidewalks, crosswalks, and some grassy areas and trees. The natural area was a two-acre healing garden with woodlands, stones, a natural stream, and wildlife. Distress decreased after mindful walking in the natural area (Distress Thermometer: $p < 0.01$; effect size r = [Wilcoxon's z/# of observations] = 0.61, strong effect). Also, post-walk distress was lower ($p = 0.02$, $r = 0.51$, strong effect) after walking in the natural area than after walking in the urban area. A natural area may play a role in mindful walking decreasing distress. However, this role is uncertain because the only multi-session study to report distress showed mindful walking does not have to occur in a natural area to decrease distress (50).

The study by Teut et al. (2013) assigned distressed adults to a wait-list control or mindful walking intervention. The intervention was 60-minute sessions that included 10 minutes of mindful walking on city streets and in parks two days per week for four weeks. After four weeks, the intervention group was told to keep exercising alone until the end of the study (8 more weeks). At Week 4, distress had decreased from baseline in the control and intervention groups, but more in the intervention group (100-millimeter visual analog scale, intervention vs. control: -24.0 [95% CI: -31.4, -16.7] vs. -10.4 [95% CI: -17.5, -3.3], $p = 0.010$). The difference between groups was not present at Week 12 ($p = 0.562$), so the decrease in distress from mindful walking was not sustained.

The same washing out, whereby the effects of mindful walking appear to wear off, has been reported for stress. Sedentary adults completed 4 weeks of mindful walking (intervention group), while the control group only received emails that encouraged them to exercise (42). The intervention group received the same encouragement and attended one, 60-minute session per week that included 10 minutes of group mindful walking and 30 minutes of individual mindful walking. The intervention decreased stress from baseline to Week 4 (Perceived Stress Scale: β = -1.21 [95% CI: -2.41, -0.01], $p < 0.05$). This decrease was larger than the decrease in the control group ($p = 0.025$). But four weeks later at the Week 8 follow-up, the intervention group's stress did not differ from baseline ($p > 0.05$) (42). The studies by Teut et al. (2013) and Shi et al. (2019) suggest the effect of mindful walking on distress and stress may be transient. Maintaining the effects may require an ongoing mindful walking practice.

In addition to the effects possibly being transient, there may be a dose threshold after which mindful walking decreases stress. Just 1, 3, or 6+ days of a mindful walking retreat did not decrease stress in another study (14). Several weeks, a duration used in the interventions by Teut et al. (2013) and Shi et al. (2019), may be required. Further evidence for this is that the 4-week intervention by Teut et al. (2013) decreased stress from baseline to Week 4 only in the intervention group (Cohen's Perceived Stress Scale: -8.8 [95% CI -10.8, -6.8], $p < 0.001$ vs. the control group). By Week 12, stress had decreased from baseline in both the control and intervention groups, but more in the intervention group (intervention vs. control: -7.2 [95% CI -9.4, -5.0] vs. -3.8 [95% CI -5.7, -1.7], $p = 0.031$). In this case, the effect on stress was sustained at Week 12. Why stress remains lower after mindful walking in some studies by not others is unclear. Studies should implement follow-ups more frequently than just once or twice across 4-8 weeks after a mindful walking intervention. More frequent follow-ups will allow researchers to discern precisely when the effects of mindful walking on distress and stress cease.

Another commonality between the studies by Teut et al. (2013) and Shi et al. (2019) is that both studies reported quality of life. Overall health-related quality of life did not change in either study (Teut: Short Form-36 Health Survey [SF-36], $p \geq 0.05$; Shi: Mental Health Inventory-5, $p \geq 0.05$) (42, 50). However, Teut et al. (2013) reported that the SF-36-Mental Component increased from baseline to Weeks 4 and 12 only in the intervention group (Week 4: 9.1 [95% CI 6.2, 12.0], $p < 0.001$ vs. the control group; Week 12: 7.5 [95% CI 4.2, 10.8], $p = 0.021$ vs. the control group). The SF-36 scores for mental health, vitality, emotional role functioning, and social role functioning increased from baseline to Week 4 only in the intervention group (all higher than in the control group, $p < 0.05$). The increases were sustained at Week 12, but only emotional role functioning was higher than in the control group ($p = 0.027$). This study's key takeaway is that a mindful walking program decreased distress and stress while increasing facets of mental-health quality of life for at least four weeks (50). Whether mindful walking increases physical-health quality of life or overall quality of life is less promising. The same is true for meditative walking because six weeks did not increase the quality of life of people with heart failure (46).

The data from Ameli et al. (2021), Teut et al. (2013), and Shi et al. (2019) justify new studies to explore the effects of mindful walking on distress, stress, and mental-health quality of life. New studies should explore the possible effects of walking setting and minimize confounders that were present in the three studies described here: not having a traditional walking control group and having other physical exercise and/or mindfulness practices.

Perceived Activation

Perceived activation was measured in arbitrary units via a questionnaire after an intervention. In the study of 4-6 minutes of mindful walking, perceived activation (being mentally worked up) was also reported (5). Perceived activation was lower after mindful walking than after the mindless walking and traditional walking (Felt Arousal Scale: 2.3 ± 0.2 vs. 3.3 ± 0.3 vs. 2.7 ± 0.2; $p = 0.002$ for mindful vs. mindless, and $p = 0.039$ for mindful vs. traditional). Mindful walking seems to decrease perceived activation in a way that traditional walking or meditation alone does not. In one parallel-arm study, participants stretched, walked (traditional), or meditated for 10 minutes (12). After 10 minutes, perceived activation increased in the walking group (Felt Arousal Scale: pre vs. post = 1.9 ± 0.9 vs. 3.2 ± 0.9, $p < 0.001$). Perceived activation increasing after traditional walking (12) but decreasing after mindful walking (5) suggests mindfulness may reverse the typical arousal response to walking. Another area to be explored is whether mindful walking decreases a person's tendency toward low or high arousal as a general personality characteristic.

State and Trait Mindfulness

State and trait mindfulness were measured in arbitrary units via questionnaires at multiple time-points during the studies. Three single-session studies mentioned above also reported state mindfulness as either overall state mindfulness (1, 5) or state mindfulness of the body (9). Mindful walking for 20 minutes in a natural area, but not in an urban area, increased overall state mindfulness (Mindful Attention Awareness Scale, state version, lower scores denote more mindfulness based on how the authors used the scale, medians [interquartile ranges]: pre vs. post = 4.5 [3.0, 9.5] vs. 1.5 [0.0, 4.0], $p = 0.01$, $r = 0.52$, strong effect) (1). In a separate study, overall state mindfulness was higher after 4-6 minutes of mindful walking in an outdoor park than after mindless walking or traditional walking in the same setting (State Mindfulness Scale, mean ± standard error: 76.3 ± 2.0 vs. 58.5 ± 2.3 vs. 64.8 ± 1.6, $p \leq 0.025$ for mindful vs. mindless and mindful vs. traditional) (5).

Similar findings were reported for state mindfulness of the body, which was greater during indoor mindful walking on a treadmill than during traditional walking in the same setting (State Mindfulness Scale for Physical Activity, mean score per item within the body subscale: 3.1 ± 0.5 vs. 2.4 ± 0.8, $p < 0.001$, $\eta_p^2 = 0.40$, moderate effect) (9). Participants in this study listened to a mindfulness script (9), as the participants did in the study by Bigliassi et al. (2020). However, a mindfulness script may not be needed to increase overall state mindfulness because Ameli et al. (2021) only verbally instructed participants to be mindful. Cultivating mindfulness without scripts could save money and time. Additionally, determining the most effective form of instruction is important because maximizing state mindfulness may amplify the effects of mindful walking on other measures of mental health. This argument is supported by the finding that state mindfulness of the body is moderately correlated with more associative attentional focus ($r = -0.56$, $p = 0.01$) and a greater enjoyment of exercise ($r = 0.44$, $p = 0.04$) (9).

Mindfulness scripts were not used in either of the two multi-session studies that reported the effects of mindful walking on overall state mindfulness (14, 53). In one study, participants were assigned mindfulness tasks before each walk in an outdoor arboretum (53). Throughout the 8-session mindful walking program, overall state mindfulness was greater post-walk than pre-walk ($p < 0.01$, $d = 0.55$, moderate effect) (53). In the other study, participants received verbal instructions before a 1-, 3-, or 6+-day walking retreat (14). State mindfulness was reported before and after the retreat. Changes across the retreat did not differ from changes across the control period that preceded the retreat (Curiosity and Decentering subscales of the Toronto Mindfulness Scale: $p \geq 0.05$, CIs for Cohen's d included the null value 0) (14). The findings of Yang & Conroy (2019) and Gotink et al. (2016) disagree, and this may be because that latter group analyzed the data for all participants collapsed across retreat duration. In other words, the state mindfulness data were analyzed for all participants from the 1-, 3, and 6+-day retreats combined. Just 1-3 days of mindful walking may not be enough to change state mindfulness. Based on the studies in the present systematic review, we first recommend future studies report correlations between state mindfulness and other measures of mental health. It may be worth including state mindfulness as a covariate in inferential statistical analyses that test hypotheses about the effects of mindful walking on other measures of mental health. Second, researchers should measure state mindfulness with scales of state mindfulness, not trait mindfulness.

The reason for the second recommendation is that one study reported state mindfulness when the data were actually indicative of trait mindfulness. The study of 1-, 3-, or 6+-day walking retreats reported data from five Likert items as state mindfulness, but four of the Likert items were from the Five Facet Mindfulness Questionnaire, a measure of trait mindfulness. The four items point to general tendencies to focus one's attention, not a person's capacity to do so in a specific situation (i.e., state). Thus, we believe Gotink et al. (2016) reported trait mindfulness from the five Likert items. From our point of view, we conclude that trait mindfulness increased across the intervention (five Likert items: $\beta = 0.98$ [95% CI: 0.56, 1.40], $p < 0.001$) (14). In contrast to this finding, Shi et al. (2019) reported that their 4-week walking program did not change trait mindfulness (Freiburg Mindfulness Inventory) at Week 4 ($p = 0.34$) or Week 8 ($p = 0.37$) of follow-up. Two studies are not enough evidence to conclude the effects of multiple sessions of mindful walking on trait mindfulness. New studies should implement weeks-long interventions of mindful walking and compare pre- and post-intervention measurements on scale questions about general tendencies toward or away from mindfulness (i.e., trait mindfulness).

Anxiety, Depression, Happiness, and Self-Esteem

Anxiety, depression, happiness, and self-esteem were measured in arbitrary units via questionnaires at multiple time-points during the studies. Only one single-session study reported the effects of meditative walking on anxiety, happiness, and self-esteem (43). Participants completed two, 70-minute bouts of meditative walking and two, 70-minute bouts of athletic walking (all bouts also included two, 10-minute bouts of rest). One bout of each walking type was completed in a gymnasium, and the other bout was completed in a forest. In each respective setting, meditative walking decreased state anxiety by 25% and 32% (Spielberger State-Trait Anxiety Inventory-Form X1; $p < 0.05$) and increased self-esteem by 13% and 19% (Rosenberg Self-Esteem Scale, $p < 0.05$). Meditative walking in the gymnasium and forest also increased happiness by 34% and 73%, respectively ($p < 0.05$). State anxiety, self-esteem, and happiness were all changed more by meditative walking than by athletic walking ($p < 0.01$). Notably, regardless of walking type, happiness increased more in the forest than in the gymnasium (all comparisons $p < 0.05$) (43). This finding is similar to the finding by Ameli et al. (2021) on distress and the finding by Navalta et al. (2021) that sitting and traditional walking outdoors elicited greater comfort and calm in desert and forest environments than indoors and outdoors in an urban environment. Collectively, the findings of Ameli et al. (2021), Shin et al. (2013), and Navalta et al. (2021) bolster the case for future studies of meditative and mindful walking to prioritize outdoor interventions in natural areas (e.g., green areas with woodlands and foliage).

Among anxiety, self-esteem, and happiness, only anxiety has been reported in multi-session studies, often alongside depression. One 12-week study reported both anxiety and depression in people with mild-to-severe chronic obstructive pulmonary disease (COPD) who received usual care (control) or usual care plus mindful walking (intervention) (30). Participants were measured across an 8-week mindful walking intervention and a 4-week follow-up. Anxiety and depression scores decreased across 12 weeks only in the intervention group (Hospital Anxiety and Depression Scale [HADS]). The respective adjusted estimates in HADS-Anxiety and HADS-Depression were $\beta = -2.51$ [95% CI: -3.69, -1.33] ($p < 0.001$) and $\beta = -5.19$ [95% CI: -6.86, -3.53] ($p < 0.001$). The respective percent decreases from baseline to Week 12 were -57% (Mean: 3.03 → 1.29; SD not reported; $p < 0.05$) and -62% (Mean: 7.00 → 2.63; SD not reported; $p < 0.05$). At Week 12, HADS-Anxiety and HADS-Depression scores in the intervention group were 60% and 87% lower, respectively, than in the control group (both $p < 0.05$) (30). The study by Lin et al. (2019) suggests multiple sessions of mindful walking decrease anxiety and depression. However, the decreases may have come from other parts of the intervention or merely exercising regardless of the mindfulness component. The intervention group was not compared to a traditional walking control group.

These potential confounders also limited the other multi-session study to report anxiety or depression (14, 42). Anxiety and depression did not change across a 1-, 3-, or 6+-day mindful walking retreat more than across a control period before the retreat (Depression Anxiety Stress Scale-21: $p > 0.05$ and 95% CIs for Cohen's d included the null value 0) (14). Comparably, four weeks of mindful walking did not change depression by Week 4 or the follow-up at Week 8 (Brief Edinburgh Depression Scale: $p = 0.92$ and $p = 0.80$, respectively) (42). Control groups that walk but do not practice mindfulness are sorely needed.

A traditional walking control group was included in the only other multi-session study to report depression. The study compared 12 weeks of no walking, traditional walking, and meditative walking (38). Depression decreased from baseline to Week 12 only in the meditative walking group (Thai Geriatric Depression Scale: -49%, $p < 0.05$). In the same group, depression was 116% and 80% lower than in the no walking and traditional walking groups (both $p < 0.05$), respectively (38). The 12-week meditative walking intervention distinguishes this study from the study by Lin et al. (2019), who used an 8-week mindful walking intervention. Despite the difference in duration and walking type, both studies reported decreases in the intervention group's depression. More studies will need to determine the efficacy of 8-12 weeks of meditative and mindful walking in populations beyond people with COPD (30) and women over 60 years of age with mild-to-moderate depression (38). The precise location of mindful walking was not reported by Lin et al. (2019), but Prakhinkit et al. (2014) reported that meditative walking took place indoors at a university hospital. As in single-session studies, the walking setting in multi-session studies is an important variable to examine in future studies.

Emotional Awareness

Emotional awareness was measured in arbitrary units via a questionnaire at multiple time-points during one study. That one study was a single multi-session study that reported the effects of mindful walking on emotional awareness (31). Adults with mild-to-severe COPD completed usual care (control) or usual care plus mindful walking (intervention). The emotional awareness scale of interoceptive awareness decreased from baseline to Weeks 4, 8, and 12 in the control group (all $p < 0.05$) but increased from baseline to Week 4 ($\beta = 1.39$ [95% CI: 1.09, 1.70], $p < 0.0001$), Week 8 ($\beta = 1.66$ [95% CI: 1.35, 1.96], $p < 0.0001$), and Week 12 ($\beta = 1.79$ [95% CI: 1.49, 2.10], $p < 0.0001$) in the intervention group (31). This finding makes mindful walking a promising method to increase emotional awareness. However, separating the effects of mindful walking from other parts of this study's intervention is impossible.

Post-Traumatic Thoughts, Ruminative Thoughts, and Self-Worth

Post-traumatic thoughts, ruminative thoughts, and self-worth were measured in arbitrary units via questionnaires at multiple time-points during one study. As with emotional awareness, only one multi-session study reported the effects of meditative walking on post-traumatic thoughts (Post-Traumatic Cognitions Inventory), ruminative thoughts (Ruminative Responses Scale), and self-worth (Best Self Scale). The study compared the effects of a wait-list control group, only mental training (seated meditation and mindful walking), only physical training (aerobic exercise), and mental and physical training combined, called MAP Training My Brain™. Both the mental training and MAP Training decreased post-traumatic thoughts from baseline to Week 6 (p = 0.005 and $p < 0.05$, respectively). Only the MAP Training decreased ruminative thoughts ($p < 0.005$) and increased self-worth ($p < 0.05$) (44). All three outcomes were separately evaluated in a sub-sample of participants who had experienced sexual violence. In this sub-sample, only MAP Training decreased post-traumatic thoughts and ruminative thoughts and increased self-worth ($p < 0.05$) (44). Though an important contribution to the literature, this study does not offer data on the independent effects of mindful walking. To investigate these effects, a future study should compare a wait-list control group, seated meditation group, traditional walking group, and meditative walking group.

Cardiovascular Health (Single- and Multi-Session Studies)
None of the four single-session studies evaluated the effects of meditative or mindful walking on cardiovascular health (1, 5, 9, 43). This finding reveals a major gap in the literature that needs to be filled with high-quality studies. These studies would begin revealing the acute effects of one bout of meditative or mindful walking on measures of cardiovascular health. Important measures to consider are arterial stiffness, endothelial function, heart rate variability, systolic blood pressure (SBP), diastolic blood pressure (DBP), and the serum concentrations of glucose, insulin, lipids, and lipoproteins.

Four of the multi-session studies that evaluated the effects of meditative or mindful walking on mental health also evaluated the effects on cardiovascular health (31, 38, 42, 46). One separate multi-session study only evaluated the effects on cardiovascular health (13). All five studies except one (46) reported significant improvements on at least one measure in the intervention group. The significant improvements were in aerobic capacity (13), C-reactive protein (38), cholesterol (total and low-density lipoprotein) (38), cortisol (38), fasting blood glucose (13), glycated hemoglobin (13), flow-mediated dilation of the brachial artery (13, 38), interleukin-6 (38), nitric oxide (38), percent body fat (38), pulse-wave velocity (13), self-reported physical activity (42), six-minute walk distance (31, 38), SBP and DPB (13, 38), and triglycerides (38).

In the following subsections, the multi-session studies are collated and described in the context of each other. The measures of cardiovascular health have been organized into subsections.

Exercise Capacity, Functional Status, and Physical Activity Level
Exercise capacity was measured as maximum oxygen consumption before and after an intervention. Functional status was measured via the six-minute walk test before and after an intervention. The test provided the six-minute-walk distance (6MWD), expressed as the total meters that patients walked in six minutes around a course or corridor (the length of the pathway was 25 to 50 m, depending on the study). Physical activity level was measured as self-reported step-counts and step-counts measured via wrist-worn Fitbits before and after an intervention. Only one study reported the effects of meditative walking on aerobic capacity (13). Meditative walking was compared to traditional walking for 12 weeks. Both conditions increased maximum oxygen consumption from baseline (meditative: 28%; traditional: 15%;

within-group pre vs. post $p < 0.05$). Based on the study's report, it does not appear that the increase differed between groups ($p \geq 0.05$). Meditative walking may be equally effective at increasing aerobic capacity. If so, this mind-body modality may be better than traditional walking because the former may benefit mental health more. New studies that test this hypothesis should employ rigorous parallel designs; report both mental and cardiovascular outcomes; and match the frequency, intensity, and duration of meditative and mindful walking.

Whereas aerobic capacity indicates a person's cardiorespiratory fitness, the 6MWD indicates a person's physical function. One study reported no effect of meditative walking on the 6MWD (46), and another reported positive effects (38). Srisoongnern et al. (2021) reported six weeks of meditative walking did not change the 6MWD in adults with heart failure ($p > 0.05$). In contrast, Prakhinkit et al. (2014) reported 12 weeks of meditative walking increased the 6MWD by 84% in adults over 60 years with mild-to-moderate depression ($p < 0.05$). The opposing findings of these two studies may have been caused by them sampling different populations and using different doses of meditative walking. The participants' heart failure in the study by Srisoongnern et al. (2021) may have hampered improvements in the 6MWD. Additionally, these participants completed meditative walking for 30-40 minutes on at least three days per week for 6 weeks. Participants in the study by Prakhinkit et al. (2014) did not have heart failure and completed meditative walking for 20-30 minutes on three days per week for 12 weeks. To clarify the effects of meditative walking on the 6MWD, new studies should evaluate several doses in various populations.

Another study reported positive effects of mindful walking on the 6MWD (31). Eight weeks of mindful walking increased the 6MWD in people with COPD from baseline to Week 4 ($\beta = 22.11$ [95% CI: 1.58, 89.56], $p = 0.01$), Week 8 ($\beta = 32.71$ [95% CI: 12.68, 52.75], $p = 0.002$), and Week 12 ($\beta = 25.38$ [95% CI: 4.04, 46.71], $p = 0.02$). At Weeks 8 and 12, the distance was greater in the intervention group than the control group by 13.1% ($p = 0.03$) and 12.7% ($p = 0.04$), respectively (31). These positive effects suggest dose is important because participants walked mindfully for 20 minutes on five days per week for eight weeks. A standard practice of future studies should be quantifying the dose of mindful walking and comparing the effects to the same dose of traditional walking.

Besides aerobic capacity and the 6MWD, physical activity level has been reported as self-report and step count data (42). After four mindful walking sessions across four weeks, participants self-reported increased physical activity (Rapid Assessment of Physical Activity questionnaire; $\beta = 1.74$ [95% CI: 0.80, 2.68], $p < 0.05$). However, participants' step counts did not corroborate their self-reported increase in physical activity because the step counts did not change from baseline ($p \geq 0.05$) (42). Chronic physical activity at a light-to-moderate intensity promotes cardiovascular health (2, 37). For this reason, it is important to determine whether mindful walking causes participants to increase their physical activity level more than traditional walking. This hypothesis is worth testing because participants have reported enjoying one bout of mindful walking more than one bout of traditional walking (5, 9). To circumvent recall bias, objective measures of physical activity from accelerometers should be used together with or in place of self-reported measures.

Body Composition

Body composition was measured as percent body fat via bioelectrical impedance analyses before and after an intervention. Two studies reported conflicting effects of meditative walking on body composition. Gainey et al. (2016) reported neither 12 weeks of meditative walking nor traditional walking changed percent body fat ($p \geq 0.05$). Separately, Prakhinkit et al. (2014) reported 12 weeks of meditative walking, but not traditional walking, decreased percent body fat. Percent body fat decreased by 5% (absolute percent decrease [38% → 33%], $p < 0.05$) from baseline to Week 12 (38). The cause of these conflicting findings is not immediately clear because both studies required a similar dose of meditative walking (20-30 minutes per session, three sessions per week, 12 weeks). A potential explanation is the participants in the study by Gainey et al. (2016) were less likely to lose body fat because they had a lower percent body fat at baseline than the participants in the study by Prakhinkit et al. (2014). Another perplexing issue in the study by Prakhinkit et al. (2014) is that meditative walking decreased percent body fat but traditional walking did not. Energy expenditure should have been similar among the groups because both groups walked at the same frequency and intensity for the same duration. Follow-up studies are needed before it can be verified that meditative walking improves body composition better than traditional walking. Baseline percent body fat should be explored as a confounder in the relationship between meditative walking and percent body fat.

Blood Markers of Glycemia, Lipidemia, and Inflammation

Blood markers of glycemia, lipidemia, and inflammation were measured before and after an intervention in blood taken from the antecubital vein after an eight-hour overnight fast. The venous blood was centrifuged to separate the erythrocytes from the plasma. The plasma marker concentrations were mostly measured in a certified clinical laboratory and expressed conventionally. The effects of meditative walking on glycemia and lipidemia have been reported by two studies. Gainey et al. (2016) reported that both meditative walking and traditional walking decreased fasting blood glucose (meditative: -12%, $p < 0.05$), but only meditative walking decreased long-term glycemia measured as glycated hemoglobin (-10%; $p < 0.05$). This decrease occurred without a change in insulin resistance ($p \geq 0.05$). Follow-up studies should expand on this initial study to determine whether meditative walking truly improves glycated hemoglobin better than traditional walking. A physiological mechanism should be sought because it is unclear why an equal dose of traditional walking did not similarly decrease glycated hemoglobin. Apart from the glycemic variables, Gainey et al. (2016) reported that meditative walking did not improve total cholesterol, high-density lipoprotein cholesterol (HDL-C), or low-density lipoprotein cholesterol (LDL-C) (all $p \geq 0.05$). Contrary to this finding, Prakhinkit et al. (2014) reported both traditional walking and meditative walking decreased total cholesterol (meditative: -9%, $p < 0.05$) and triglycerides (meditative: -27%, $p < 0.05$). Only meditative walking decreased LDL-C (meditative: -12%, $p < 0.05$).

The conflicting findings could have been caused by the different study populations. Prakhinkit et al. (2014) studied people without any cardiovascular diseases or type 2 diabetes. The unimproved blood lipids reported by Gainey et al. (2016) may have been because the participants were taking oral medications for type 2 diabetes. The specific medications were not reported, and certain diabetes medications affect blood lipid concentrations. Future studies should evaluate the effects of meditative walking on glycemia and lipidemia in different populations and whether these effects are modulated by the concurrent use of medications.

Besides glycemia and lipidemia, markers of inflammation (e.g., C-reactive protein and interleukin-6) and stress (cortisol) suggest cardiovascular health and risk. Only Prakhinkit et al. (2014) reported inflammatory and stress markers. Both traditional walking and meditative walking decreased C-reactive protein from baseline (meditative: -25%, $p < 0.05$), but only meditative walking decreased interleukin-6 (-22.2%, $p < 0.05$) and cortisol (-1.6% absolute percent decrease [11.9 → 10.3%]) from baseline (both $p < 0.05$) (38). This single study is not enough evidence to conclude that meditative walking decreases inflammation and physiological stress more than traditional walking. Nonetheless, the mindfulness applied during meditative walking may bring a sense of mental calm and clarity not achieved via traditional walking. A calmer and more accepting headspace may translate into lower physical inflammation and stress. Testing this hypothesis will require new studies that report together measures of mindfulness, mental calm, mental stress, inflammation, and physical stress.

Blood Pressure and Arterial Function

Blood pressure was measured before and after an intervention. The measurement method was not specified, but the SBP and DBP were expressed conventionally as mmHg. Arterial function was measured via flow-mediated dilation (FMD) of the brachial artery in millimeters or percent and via brachial-ankle pulse-wave velocity (PWV) in centimeters per second before and after an intervention. Both SBP and DBP were reported by three studies of meditative walking. Srisoongnern et al. (2021) reported six weeks of meditative walking did not decrease SBP or DBP ($p \geq 0.05$). In contrast, Gainey et al. (2016) reported 12 weeks of meditative walking but not traditional walking decreased SBP and DBP by 12% and 8%, respectively ($p < 0.05$). Similarly, Prakhinkit et al. (2014) reported 12 weeks of meditative walking decreased SBP and DBP by 7% and 8%, respectively ($p < 0.05$). In this study, 12 weeks of traditional walking also decreased SBP and DBP, but both SBP and DBP were lower in the meditative walking group at Week 12 ($p < 0.05$). The two studies in which meditative walking decreased SBP and DBP (13, 38) were twice as long as the study that showed no effect of meditative walking (46). Meditative walking may take more than six weeks before having significant effects on blood pressure. To determine whether meditative walking affects SBP and DBP differently than traditional walking, new studies should explore interaction effects between walking type and time (i.e., how long someone has been walking traditionally in the study).

Two of the three studies that reported decreases in SBP and DPB also reported improvements in either FMD of the brachial artery or brachial-ankle PWV. Improvements in the respective outcomes are increases in FMD and decreases in PWV. Gainey et al. (2016) reported meditative walking and traditional walking increased FMD similarly by 4.9% and 4.6%, respectively (absolute percent increases, $p < 0.05$). Only meditative walking decreased PWV (-10%, $p < 0.05$). In line with the finding of Gainey et al. (2016), Prakhinkit et al. (2014) reported a 5.7% and 3.8% increase in FMD because of meditative walking and traditional walking, respectively (absolute percent increases, $p < 0.05$). Nitric oxide, a potent vasodilator produced by endothelial cells that line the arteries and capillaries, was also increased by 225% and 178% by meditative walking and traditional walking, respectively (38). The FMD and nitric oxide improving with both types of walking suggest that walking in itself, not the meditative part, causes the improvements. However, PWV only improving with meditative walking suggests that the meditative part may cause some of the improvement in arterial function. Future studies that compare meditative walking and traditional walking should match the frequency, intensity, and duration of walking completed by both groups. The groups should have similar health statuses, physical activity levels, and arterial function at baseline. Also, the statistical analyses that compare the groups should include baseline FMD, PWV, and nitric oxide as covariates. These features of the study design and statistical analysis plan will help identify whether meditation synergizes with walking to improve arterial function more than traditional walking.

Risk of Bias in the Included Studies

The risk of bias should be considered. Two studies were uncontrolled (43, 53), meaning they are inherently at risk of selection bias and cannot indicate whether meditative or mindful walking improves mental or cardiovascular health more than no walking. In the eight studies that were randomized controlled trials (RCTs) with a parallel design (13, 30, 31, 38, 42, 44, 46, 50), their risk of bias was assessed across five domains (Domains 1-5) by using the revised Cochrane Risk of Bias Tool for Randomized Trials (RoB 2) tool (49). Seven of the eight studies had some concerns or a high risk of bias (Figure 2). These ratings were mostly caused by the randomization process not being concealed from the researchers, the researchers not being blind to the participants' groups, and the studies apparently lacking a pre-specified statistical analysis plan. The risk of bias in the two RCTs that had a crossover design (1, 5) was assessed across six domains (Domains 1-5 and Domain S) by a preliminary and supplementary tool to the RoB 2 tool, called the RoB 2 for Crossover Trials (49). Like the RCTs with a parallel design, both crossover trials had some concerns or a high risk of bias (Figure 3) because of the randomization process and the researchers not being blinded to the participants' groups. The risk of bias in the two non-randomized controlled studies (9, 14) was assessed across seven domains (Domains 1-7) using the Risk of Bias in Non-randomized Studies - of Interventions (ROBINS-I) tool (48). Both studies had a serious risk of bias because of the ratings in most domains except the classification of the interventions and selection of the reported results (Figure 4). In summary, 11 of the 12 controlled studies had a concerning risk of bias. Collectively, these 11 studies and the two uncontrolled studies constitute weak evidence that meditative or mindful walking improve mental or cardiovascular health.

Author and Year	D1: Randomization Process	D2: Deviations from the Intended Interventions	D3: Missing Outcome Data	D4: Measurement of the Outcome	D5: Selection of the Reported Results	Overall
Srisoongnern et al., 2021	+	+	+	+	+	+
Lin and Yeh, 2021	+	+	+	+	!	-
Shi et al., 2019	-	+	+	-	!	-
Lin et al., 2019	+	+	-	+	+	-
Shors et al., 2018	!	!	+	-	!	-
Gainey et al., 2016	-	+	!	!	!	-
Prakhinkit et al., 2014	!	+	+	!	!	!
Teut et al., 2013	+	+	+	+	!	!

- + Low risk
- ! Some concerns
- - High risk

Figure 2. Risk of bias in the eight randomized controlled trials that had a parallel design, assessed across five domains (Domains 1-5) by using the revised Cochrane Risk of Bias (RoB 2) tool for trials that have a parallel design. D: Domain

Author and Year	D1: Randomization Process	DS: Period and Carryover Effects	D2: Deviations from the Intended Interventions	D3: Missing Outcome Data	D4: Measurement of the Outcome	D5: Selection of the Reported Results	Overall
Ameli et al., 2021	!	+	+	+	+	+	!
Bigliassi et al., 2020	!	+	+	+	-	!	-

\+ Low risk
! Some concerns
\- High risk

Figure 3. Risk of bias in the two randomized controlled trials that had a crossover design, assessed across six domains (Domains 1-5 and Domain S) by using the revised Cochrane Risk of Bias (RoB 2) tool for trials that have a crossover design. D: Domain

Author and Year	D1: Confounding	D2: Selection of Participants into the Study	D3: Classification of the Interventions	D4: Deviations from the Intended Interventions	D5: Missing Outcome Data	D6: Measurement of the Outcome	D7: Selection of the Reported Results	Overall
Cox et al., 2018	Serious	Moderate	Low	Low	Low	Serious	Low	Serious
Gotink et al., 2016	Moderate	Serious	Low	Moderate	Serious	Serious	Low	Serious

Figure 4. Risk of bias in the two non-randomized controlled studies, assessed by using the Cochrane Risk of Bias in Non-randomized Studies - of Interventions (ROBINS-I) tool. Risk of bias in each domain is rated as Low, Moderate, Serious, Critical, or No Information. D: Domain

DISCUSSION

The purpose of the present systematic review was to determine the effects of meditative and mindful walking on mental and cardiovascular health. To achieve this purpose, 14 studies from five online repositories for peer-reviewed journal articles were identified and evaluated by using a methodologically rigorous and replicable protocol. The review's main finding was that meditative and mindful walking may improve mental and cardiovascular health. However, these improvements must be interpreted cautiously because of the limitations of the included studies. Moreover, the meaningfulness of the improvements is unclear. The main finding and important caveats are explained in the next three subsections.

Effects on Mental and Cardiovascular Health

Of the studies reporting measures of mental health, all four single-session studies (1, 5, 9, 43) and eight of the nine multi-session studies (14, 30, 31, 38, 42, 44, 50, 53) reported significant improvements. Significant improvements are interesting to researchers but not inherently meaningful to participants. Therefore, how meaningful the improvements are to participants should be determined. A concept intended to capture this meaningfulness is the minimal clinically important difference (MCID) (20, 33). Researchers and clinicians establish MCIDs to make sense of observed changes in outcomes because of an intervention. An MCID is an estimate of the smallest change in an outcome that actually or practically improves the health or lives of a particular group. The best MCIDs are decided with input from the people themselves so that the MCIDs reflect the size of a change that matters to them. The value of MCIDs is that they go beyond statistics to gauge the true value of changes in outcomes. For example, in one study, a decrease in SBP of 1 mmHg after an intervention may be statistically significant but not meaningfully change the participants' health or life. An MCID for SBP asks, "what is the minimum decrease in SBP after an intervention that actually improves the health or lives of a given population?"

Population-specific MCIDs have not been established for most of the measures of mental health in the present review. However, three of the measures have relevant MCIDs that were exceeded because of meditative or mindful walking. First, in adults who smoke but have normal spirometry and no unstable diseases, the MCID on the State-Trait Anxiety Inventory (STAI) has been established as ~10 points (8). One study that sampled adult females (smoking status not reported) reported that from pre- to post-walk, meditative walking in a gymnasium and forest decreased the mean STAI-Form X score by over 10 points (43). Thus, one bout of meditative walking may meaningfully reduce anxiety. Second, in people with COPD, the MCIDs for the Hospital Anxiety and Depression Scale (HADS) subscales HADS-Anxiety and HADS-Depression have both been established as a ~1.50 (~20%) decrease from baseline (39). Another study reported that mindful walking in people with COPD decreased the mean scores on both subscales from baseline by more than 1.50 points and 20% (30). These decreases in anxiety and depression are meaningful. Third, in people with chronic musculoskeletal pain and comorbid anxiety and/or depression, the MCID for the Short Form-36 (SF-36) Mental Health subscale has been established as ~9 points (24). One study reported that mindful walking in adults with psychological distress increased scores on the SF-36 Mental Health subscale from baseline to Week 4 by 9.1 points and to Week 12 by 7.5 points (50). Adults with increased psychological distress do not match the population for which the MCID was established. However, the improved SF-36 Mental Health scores may be meaningful. The meaningfulness of the other measures of mental health is not clear.

Overall, the evidence of meditative and mindful walking improving mental health is promising but limited by a small quantity of studies that have a high risk of bias. The evidence of other mindful exercises is limited by the same problem. A 2021 meta-analysis evaluated the effects of a single session of mindful exercise (qigong, tai chi, or yoga) on anxiety (54). The standardized mean effect size for yoga decreasing anxiety was small at 0.32 (95% CI: 0.16, 0.48, $p = 0.0002$), and no conclusions could be drawn about qigong or tai chi because of the limited number of studies and their high risk of bias (54). The efficacy of yoga reducing anxiety more than non-mindful exercises was supported by a separate 2020 meta-analysis that reported a standardized mean difference of -0.45 (95% CI: -0.81, -0.09, $p = 0.01$) (45). However, when qigong and yoga studies were pooled and compared against non-mindful exercises, anxiety did not differ (p = 0.18) (45). In 2018, another meta-analysis of seven studies examined the effects of mindful exercises (qigong, tai chi, and yoga) and purely physical exercise in people with schizophrenia (29). Based on just two studies deemed to be low-quality evidence, mindful exercises improved psychiatric symptoms more than purely physical exercise (mean difference on the Positive and Negative Syndrome Scale: -8.94 [95% CI: -14.53, -3.35, $p < 0.05$) (29). Separately, a 2008 systematic review without a meta-analysis of 12 studies examined the effects of mindful exercises (n = 6 studies) and non-mindful exercises (n = 6 studies) on depression scores in adults (51). The mindful exercises were qigong, tai chi, and yoga, and the non-mindful exercises were aerobic exercise, walking, pram walking, jogging, and other unspecified exercises. The review's qualitative synthesis showed that five of the six studies of mindful exercises and all six studies of non-mindful exercise improved depression scores, suggesting both mindful and non-mindful exercises are efficacious (51). Comparative efficacy could not be determined quantitatively by a meta-analysis because of the included studies' heterogeneous populations, interventions, and measures and methodological limitations. Fourteen years after this 2008 systematic review, the same issue hinders the present 2022 systematic review and precludes a meta-analysis about the effects of meditative and mindful walking.

The literature about the effects of meditative and mindful walking on mental health is also in a similar state as the literature about the effects of traditional walking on mental health. A 2018 scoping review evaluated studies and systematic reviews about the effects of walking on anxiety, depression, self-esteem, psychological stress, and other mental health outcomes (22). The review concluded that the evidence of walking improving mental health is developing but not definitive. The largest evidence base is for walking consistently improving depression scores. The evidence base for walking improving anxiety is less conclusive, but studies have shown negative associations between walking and anxiety scores and acute walking interventions to decrease anxiety (22). Similar improvements in depression and anxiety occurred after the meditative and mindful walking interventions described in the present systematic review. However, firmer conclusions about the improvements will require a meta-analysis once more studies are conducted with similar populations, interventions, and measures of depression and anxiety.

Unlike the measures of mental health, the measures of cardiovascular health are relatively easier to interpret for meaningfulness. In one study in the present review, meditative walking decreased SBP from the Hypertension Stage 2 category (≥ 140 mmHg) to the Hypertension Stage

1 category (130-139 mmHg) (13, 52). Meditative walking also decreased DBP from the Hypertension Stage 1 category (80-89 mmHg) to the Elevated category (< 80 mmHg) (13, 52). In another study, meditative walking decreased SBP from the Elevated category (120-129 mmHg) to the Normal category (< 120 mmHg) (38, 52). These decreases may meaningfully reduce the risk of cardiovascular diseases if sustained long-term (52). The potentially hypotensive effects of meditative and mindful walking over traditional walking deserve more attention.

The ability of meditative and mindful walking to increase the six-minute walk distance also deserves more attention. The MCID for the six-minute walk distance has been established as 14.0-30.5 meters across diverse populations (6), 25 meters in people with COPD (18), 22-42 meters in adults with lung cancer (15), and 17.8 meters in older Asian adults with frailty and a fear of falling (25). In one study in the present review, usual care supplemented with mindful walking increased the distance from 388 ± 114 meters to 418 ± 123 meters (a 30-meter improvement) among Taiwanese adults with COPD (31). In another study, meditative walking increased the distance in older Thai women with depressive symptoms from 164 ± 13 meters to 302 ± 18 meters (a 138-meter difference) (38). These increases exceed the MCID for people with COPD and older Asian adults. But walking, not mindfulness, likely caused the increase in distance because mindful walking did not increase the distance more than traditional walking (38). However, this conclusion is based on one study, so more studies are needed to determine if meditative or mindful walking improve the distance more than traditional walking.

Regarding the other measures of cardiovascular health, too few studies in the present review showed that meditative or mindful walking improve aerobic capacity, percent body fat, FMD, PWV, glycemia, lipemia, or inflammation at all or more than traditional walking. Thus, definitive conclusions cannot be drawn, and more studies are needed. Researchers should especially address the lack of studies that evaluate the cardiovascular effects of one session of meditative and mindful walking.

Limitations of the Included Studies

In summary, the significant improvements in mental and cardiovascular health because of meditative and mindful walking seem congruent with the literature about other mindful exercises. However, the improvements reported by the studies included in the present review should be interpreted cautiously. The primary reason for interpreting the improvements cautiously is that the included studies rarely implemented meditative or mindful walking in an intervention without other physical exercises, seated meditation, or discussions about the intervention between the participants and researchers. These extraneous parts the intervention potentially confounded the relationship between meditative and mindful walking and mental and cardiovascular health. It cannot be stated definitively whether the meditative or mindful walking part of the intervention caused the improvement in mental or cardiovascular health.

The secondary reason for interpreting improvements cautiously is that the included studies had a moderate-to-high risk of bias. The studies were often limited by not having any control groups or at least a non-walking control group and not blinding the participants or researchers to group allocation. These limitations may have introduced selection bias, response bias, and confirmation bias. First, selection bias may have been present if some participants' measured or unmeasured baseline characteristics predisposed their mental or cardiovascular health to improve regardless of the intervention. People who participate in studies of meditation or mindfulness may already view these practices favorably. These favorable views may lead participants to report positive perceptions and experience elevated physiological responses. Without a control group and random allocation, it is unclear if mental or cardiovascular health improved because of the intervention, confounders, or random chance. Second, response bias may have biased the mental health data. Participants may have reported improved mental health on the questionnaires to please the researchers or meet their expectations that meditative and mindful walking would help. Third, because some of the studies did not blind the researchers to participants' groups, confirmation bias may have altered researchers' behavior toward participants in the meditative or mindful walking groups. Though unintentionally and subtly, the researchers may have primed participants receiving the intervention to feel calmer or happier and try harder on the measures of cardiovascular health. Thus, confirmation bias could have distorted the data for outcomes such as affect, anxiety, depression, enjoyment, blood pressure, heart rate, six-minute walk distance, and maximal oxygen consumption. Collectively, these biases preclude drawing valid inferences about the effects of meditative and mindful walking in the studies' target populations.

Another factor that precludes drawing valid inferences from the included studies relates to their statistical analyses. Most of the studies did not conduct an intent-to-treat analysis to account for the potential bias introduced by participants' not complying with the protocol (i.e., missing sessions) or withdrawing from the study. Analyzing only the data from the participants who completed the study may have produced biased estimates of the true effect of meditative or mindful walking (e.g., the beta coefficients and mean differences between pre- and post-intervention time points).

Besides interpreting the significant improvements cautiously, readers should consider whether the improvements are meaningful. Only three studies reported effect sizes to describe the magnitude of significant improvements as standardized pre-post or between-group differences (1, 9, 53). The effect sizes described the magnitude of improvements in positive affect, negative affect, attentional focus, distress, enjoyment of exercise, and state mindfulness (1, 9, 53). A fourth study reported effect sizes for some non-significant outcomes but not for the significant improvements in positive affect, negative affect, or trait mindfulness (14). The remaining studies in the present review that reported significant improvements did not report effect sizes (5, 13, 30, 31, 38, 42–44, 50). Some of these studies reported beta coefficients that suggest the magnitude of the effect of the intervention on the outcome. However, beta coefficients are statistical estimates and not inherent indicators of meaningfulness. The meaningfulness of improvements is determined by whether they are clinically relevant or important to the participants.

Notably, MCIDs in the sampled populations have not been established for many of the measures of mental health used in the studies. These MCIDs are needed to ascertain the meaningfulness of the improvements. Therefore, MCIDs in populations that are targeted for studies of meditative and mindful walking should be established. To the authors' knowledge, relevant

MCIDs do not exist for measures such as the Feeling Scale, Felt Arousal Scale, Geriatric Depression Scale, Perceived Stress Scale, Physical Activity Enjoyment Scale, or Rosenberg Self-Esteem Scale. It is also unclear if improved scores on the Five Facet Mindfulness Questionnaire, State Mindfulness Scale, or State Mindfulness Scale for Physical Activity are clinically relevant or important to the participants. The benefits of mindful walking will be clearer once MCIDs for more measures of mental health are available.

Limitations of the Present Review

Alongside the limitations of the included studies, readers should consider the limitations of the present systematic review. First, the search terms and search combinations of this review were not evaluated by a science librarian. Science librarians are important resources when searching for, organizing, and analyzing articles during a systematic review (16). The current systematic review did not seem to be affected by the lack of a science librarian because no new articles were included from the references of the 14 studies we included initially. Second, this review did not include a meta-analysis. However, doing so would have been inappropriate because the included studies did not meet the four aspects of homogeneity required to conduct a meta-analysis (3). Conducting a valid meta-analysis requires the included studies to meet four aspects of homogeneity: 1) similar participants, 2) the same interventions and comparators, and 3) the same outcomes recorded over the same time frame. Also, 4) most of the included studies must report similar treatment effects that are in the same direction (mostly positive or mostly negative effects) with overlapping confidence intervals (3). The included studies of meditative and mindful walking were clinically and methodologically heterogeneous. Across studies, participants differed by age, biological sex, race, ethnicity, nationality, height, weight, BMI, and health and disease status. The interventions also differed by the type of meditative and mindful walking and the frequency, intensity, and duration of walking. Few of the included studies evaluated the same measures of mental and cardiovascular health, so the studies did not report the same treatment effects in the same direction. Because the included studies did not meet the four aspects of homogeneity required for a meta-analysis, conducting a valid meta-analysis was not possible.

The third and fourth limitations of the present review are language bias and publication bias. The review only included published journal articles written in English. Articles written in English are more likely to report positive study findings than articles not written in English (3). The articles included in the present review were not used in formal tests of publication bias. Such tests would not be useful because the articles described studies with different interventions and outcomes. These differences mean the articles do not describe a discrete meditative or mindful walking intervention for which there may be publication bias toward positive findings for a particular outcome. If in the future a meta-analysis analyzes the effects of a discrete meditative or mindful walking intervention on a particular outcome, formal tests of publication bias would be warranted.

The fifth limitation of the present review is that studies of labyrinth walking were omitted. Labyrinth walking is a unique form of meditative and mindful walking along a winding path to facilitate calm, insight, mindfulness, and occasionally spirituality. Labyrinth walking is a niche within a niche that should be considered separately (i.e., labyrinth walking is a subsection of the meditative and mindful walking literature within the broader walking literature). We recommend that interested readers view a relevant literature review (10) published recently by the first author of the present review.

Recommendations for Future Research

The first recommendation is that future research about meditative and mindful walking should minimize bias introduced because of the study design and statistical analysis. To minimize selection bias, studies should randomly allocate participants to at least one control group and the intervention group. To minimize confirmation bias, the researchers who collect and analyze the outcome data should be blinded to participants' groups. Preferably, future studies will have a non-walking control group, traditional walking group, and meditative or mindful walking group. This design would allow the studies to show whether meditative or mindful walking interventions improve mental and cardiovascular health more than no intervention or traditional walking. In studies with a parallel design, participants in the meditative or mindful walking group should not know about the other groups so that they do not report improvements on subjective measures merely because they think the intervention should help (i.e., response bias). In studies with a crossover design, participants should complete the traditional walking arm before the meditative or mindful walking arm. Not randomizing the arms may introduce bias because of confounders associated with life circumstances during the arms (e.g., disease severity, family dynamic, and work stress). However, requiring the traditional walking first would reduce the risk of participants applying mindfulness techniques during traditional walking (i.e., carryover effect). Once the planned number of participants have completed all the arms in either a parallel or crossover study, the data should be analyzed for all participants who were randomized by using an intent-to-treat analysis in addition to the per-protocol analysis. This analysis will reduce bias in the estimates of the treatment effects because of participants' non-compliance, swapping treatment arms, or withdrawing from the study. Alongside statistical point estimates with p-values to show significance, researchers should report measures of precision (e.g., 95% CIs) and effect size (e.g., Cohen's d or ηp^2). The meaningfulness of these effect sizes should be considered in relation to participants' function, morbidity, and mortality. Using measures of mental health with population-specific MCIDs should be prioritized. For measures without population-specific MCIDs, new MCIDs should be established.

The second recommendation is also intended to ascertain the significance and meaningfulness of meditative and mindful walking by itself. Fulfilling this purpose requires an intervention of only meditative or mindful walking instead of combining it with extraneous physical and mental exercises such as stretching, calisthenics, seated meditation, and group discussion. These exercises may confound the relationship between meditative and mindful walking and mental and cardiovascular health. When implementing only meditative or mindful walking, it would be interesting to determine whether the effects depend on conducting the practice indoors or outdoors and independently or in a group. These characteristics of the intervention should be reported explicitly in future studies.

In summary, the purpose of the present systematic review was to determine the effects of meditative and mindful walking on mental and cardiovascular health. Among the 14 included studies, the target populations, interventions, and outcome measures varied considerably. Most of the studies (13 of 14) showed that their interventions statistically significantly improved scores on at least one measure. However, readers should interpret these improvements cautiously because of the methodological limitations of the studies and the unclear meaningfulness of the improvements. The key takeaway is that meditative and mindful walking is a promising type of mindful exercise for improving mental and cardiovascular health. Determining the value of this type of exercise will require methodologically rigorous randomized controlled trials that report detailed explanations of their interventions and key prognostic measures of participants' function, morbidity, and mortality. Improvements on these measures should be evaluated for meaningfulness by considering the change in scores relative to population-specific MCIDs. Relevant MCIDs should be established where they do not exist. Significant improvements alone are not sufficient evidence to conclude that meditative and mindful walking meaningfully improve mental and cardiovascular health.

ACKNOWLEDGEMENTS

The authors express great thanks to Drs. Jennifer Pharr and Graham McGinnis at the University of Nevada, Las Vegas, for their valuable feedback on drafts of this paper when it was still a manuscript.

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