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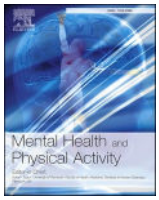

Effects of combining physical activity with mindfulness on mental health and wellbeing: Systematic review of complex interventions

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ABSTRACT

Background: Physical activity and mindfulness practice both have established psychological benefits, yet research into their interaction and combined use is sparse. This systematic review aimed to pool the evidence examining the impact of interventions that combined physical activity and mindfulness on mental health and wellbeing outcomes, and their potential mechanisms of action.

Methods: Six databases (PubMed, Scopus, EMBASE, PsychINFO, Web of Science, Cochrane Library) were searched for trials reporting interventions that included 1) physical activity and mindfulness as primary treatments, 2) comparative control condition(s), 3) an adult sample, and 4) at least one mental health or wellbeing outcome. Screening, data extraction and quality assessment were conducted by two researchers. Findings are presented narratively due to clinical and methodological heterogeneity.

Results: Out of 7682 search results, 35 trials were included. Most eligible studies had pilot or feasibility designs ($n = 19$, 54%) or small sample sizes. Combined interventions were feasible to deliver and improved psychological health relative to passive controls (25/33 outcome comparisons reported across trials). Effects on psychological health outcomes compared to active controls were mixed (12/38 comparisons favoured combination over physical activity only, 5/18 favoured combination over mindfulness only), as were results regarding physical activity engagement.

Conclusions: Interventions combining physical activity with mindfulness are effective for improving mental health and wellbeing, possibly more so than either approach alone. Further research, including larger randomised controlled trials, is required to determine effectiveness and optimal intervention parameters. Exploring mechanisms of change will clarify their effects on mental health, wellbeing, and potential for behaviour change.

1. Introduction

A robust evidence base supports the use of physical activity (PA) for improving poor mental health and wellbeing (Pedersen & Saltin, 2015; Vella et al., 2023). Reviews consistently report medium-to-large improvements in mood, stress, anxiety, and depression following engagement in PA interventions (Chan et al., 2019; Singh et al., 2023). These effects are comparable to, and in some cases greater than, current front-line pharmacological and cognitive-behavioural treatments (Singh et al., 2023). The effectiveness of PA, paired with its potential to simultaneously address physical health issues that often co-occur with mental health conditions (Launders, Kirsh, Osborn, & Hayes, 2022), has led to recognition of PA programmes as treatment options for depression in national and international guidelines (National Institute for Health and Care Excellence [NICE], 2022; World Health Organisation, 2010; Stubbs et al., 2018). Standards for treating other common mental health illnesses, including anxiety and PTSD, currently recommend PA as a preventative strategy and an adjunctive therapy (NICE, 2011). However, despite their strong evidence base, PA interventions are not consistently implemented in clinical populations (Thornton et al., 2016). Their success in research and practice is hindered by low retention rates (Stubbs et al., 2016), which often stems from the lack of psychological resources

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needed for effective engagement, such as motivation and self-efficacy (Glowacki, Duncan, Gainforth, & Faulkner, 2017).

Effective PA interventions for mental health are informed by psychological theory and provide support to individuals engaging in and sustaining PA (Thomas, Thirlaway, Bowes, & Meyers, 2020). These interventions incorporate various behavioural strategies, such as task planning, goal setting, behavioural activation, accountability mechanisms, or provide psycho-educational support with crucial psychological processes, including self-regulation, motivation, self-efficacy, locus of control, and responding to setbacks or discomfort (Glowacki et al., 2017). Such psychologically informed PA interventions have demonstrated better retention rates, greater improvements in clinical outcomes (Gourlan et al., 2016), and more robust long-term effects (Samdal, Eide, Barth, Williams, & Meland, 2017). Therefore, current evidence encourages the inclusion of psychological support targeting relevant psychosocial constructs within PA interventions for mental health and wellbeing outcomes (Arrogi, Schotte, Bogaerts, Boen, & Seghers, 2017; Gourlan et al., 2016; Thomas et al., 2020).

Mindfulness-based interventions (MBIs)—structured programs teaching mindfulness skills by promoting greater awareness and acceptance of own thoughts, feelings, and experiences (Segal, Williams, & Teasdale, 2002)—have been found to modify many psychosocial constructs that may be necessary for successful engagement in PA (see Schuman-Olivier et al., 2020 for a review and theoretical framework). As a result, the study of MBIs has recently expanded beyond traditional mental health settings (e.g., mindfulness-based stress reduction therapy for depression; Kabat-Zinn, 1982), with increasing utilisation in weight-management and health behaviour promotion (Roychowdhury, 2021; Schneider, Malinowski, Watson, & Lattimore, 2019). Previous reviews have documented the benefits of MBIs in these contexts, highlighting the potential of mindfulness training for enhancing health behaviour change outcomes, including PA engagement (Kennedy & Resnick, 2015; Schneider et al., 2019; Sohl, Birdee, & Elam, 2016).

Combining PA and MBIs in interventions may yield augmented effects relative to either component alone. The two approaches likely operate through complementary mechanisms: mindfulness training might facilitate initial engagement in PA by encouraging an accepting, non-judgemental attitude to one's potentially uncomfortable experience, and in turn, engagement in PA can boost an individual's sense of achievement and motivation to continue engaging. These effects can create a beneficial cycle of behaviour. There are also shared neuropsychological mechanisms between the two techniques, whereby engaging in both practices is likely to reinforce the 'lessons' learned and experienced benefits. Examples include better handling of stress through adaptations of the autonomic nervous system (Sun, Lu, Wang, & Tsang, 2023) and increased sense of self-efficacy (Roychowdhury, 2021). Through the collection of shared and complementary mechanisms, the cycle of mutual reinforcement between PA and mindfulness may result in additive effects, which contribute to sustained benefits not only for mental illness but also for physical health, health behaviours, social participation, productivity, and overall wellbeing (Schneider et al., 2019; Schuman-Olivier et al., 2020).

Previous research has explored combined interventions involving PA and psychotherapeutic approaches, such as cognitive-behavioural therapy (CBT). Thomas et al. (2020) reviewed their effects on mental health and wellbeing, concluding that combined interventions improved clinical outcomes over and above non-active controls (e.g., treatment as usual [TAU]), and comparably to PA interventions alone. Similarly, Bernard and colleagues' (2018) meta-analysis of interventions combining PA with CBT for adults with chronic illness found significant moderate improvements in depression, anxiety, and fatigue, but not pain, relative to non-active controls, although limited evidence for additive effects of both techniques compared to either one alone.

In contrast, the combination of mindfulness and PA has been theoretically discussed at length (e.g., Roychowdhury, 2021; Schuman-Olivier et al., 2020), but to date there are no published reviews considering their additive effects. Yin and colleagues' (2023) review compared the effects of Tai Chi, a form of Chinese martial arts pairing a mindful focus with light-to-moderate intensity exercise, to non-mindful exercise, concluding that Tai Chi may be more effective than non-mindful forms of exercise for reducing symptoms of anxiety, depression, and general distress (d = 0.20; 0.28; 0.40, respectively). However, the authors noted difficulties "quantifying mindfulness elements in Tai Chi practice", highlighting the need for dedicated research to examine the mechanisms through which mindfulness and PA interact.

This paper aimed to systematically synthesise and evaluate literature on interventions combining mindfulness-based approaches with PA. Our primary focus was on the effects of these interventions on psychological health outcomes (i.e., wellbeing and mental health), with secondary consideration of their impact on PA engagement. We aimed to understand the mechanisms of action associated with each approach and how they can be effectively combined to optimise health outcomes, which will inform future intervention development.

2. Methods

We follow the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA; Page et al., 2021), along with extensions for literature searches (PRISMA-S; Rethlefsen et al., 2021) and reviewing complex interventions (PRISMA-CI; Guise et al., 2017). The review was guided by Cochrane recommendations for systematic reviews of interventions (Higgins et al., 2022) and prospectively registered on PROSPERO (CRD42021226880). We summarise our protocol below.

2.1. Inclusion & exclusion criteria

The review considered peer-reviewed primary controlled studies reporting on psychological health outcomes of longitudinal interventions in adult populations. Interventions had to consist of eligible PA and mindfulness components, which together made up over 50% of intervention time. Supplementary content beyond PA and mindfulness was permitted, as long as the > 50% threshold was met – we report on the presence and format of such content where applicable. Full criteria are given in Table 1.

2.2. Search strategy

We systematically searched six major electronic databases (The Cochrane Library, EMBASE, PsychINFO, PubMed, Scoups, Web of Science) to identify publications with at least one keyword per category for i) physical activity, ii) mindfulness, iii) psychological health, and iv) controlled trial methodology in their title or abstract up to August 2023 (see Supplementary Section 1 for search strategy). We manually screened reference lists of relevant publications.

2.3. Screening and extraction

Search results were screened in Covidence, an online systematic review software. After removal of duplicates, titles and abstracts were independently screened for relevance by two researchers. Full texts were obtained for potentially relevant publications, and again screened by two researchers against pre-specified eligibility criteria. Reasons for exclusion were recorded and categorised. Screeners had high agreement rates (> 90% in both stages) and discrepancies were resolved in consultation with a third researcher.

One researcher extracted relevant study information from eligible trials into a pre-prepared extraction form (Supplementary Section 2). A second researcher verified the extraction against full texts.

2.4. Quality assessment

The Cochrane Risk of Bias 2 tool (Sterne et al., 2019) was used to

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
•Primary study published in a peer-reviewed journal in English language •Adult sample (mean age between 18 and 65 years), with no restrictions on medical conditions	•Review article, commentary, letter to editor, graduate thesis
•Reports a longitudinal intervention (>1 session) with physical activity **and** mindfulness components, which together make up > 50% of contact time	•Multimodal intervention where PA and mindfulness are not primary components
o Eligible physical activity components: PA interventions of any type, delivery format, activity, or intensity delivered beyond participants' baseline activity	o Athletes' usual training is not eligible as PA component because it constitutes participants' baseline activity
o Eligible mindfulness components: any mindfulness-based or mindfulness-informed interventions, including acceptance and commitment therapy (ACT), delivered in any format for any duration, which purposefully teach mindfulness principles and skills	o Mind-body interventions for which we could not determine that purposeful teaching of mindfulness principles took place (e.g., yoga, tai-chi) are not eligible for either component due to difficulty in specifying the source of effects
•Includes at least one control condition, which could be of any type (e.g., PA only, mindfulness only, attention-matched control, TAU, waitlist)	• Pre-post comparison only studies
•Outcome is any psychometrically validated measure of psychological wellbeing, mental health, self-rated health, or quality of life, whether primary or secondary outcomes of included interventions	

assess the methodological rigour of included studies. Two researchers independently rated each study on allocation procedure, blinding, protocol fidelity, data completeness, suitability of analyses and transparency of reporting, giving ratings of low, some or high risk of bias. Final quality judgements were agreed on by the wider research team.

2.5. Data synthesis

At pre-registration, and anticipating a paucity of literature with high variability in design, we declared our primary intention to adopt a narrative synthesis approach, and, in the case that it was deemed appropriate, a meta-analysis of intervention effects. We decided against conducting a meta-analysis due to a large proportion of pilot/feasibility trials in our dataset, which are not powered to detect effectiveness and can lead to inflated or unrepresentative conclusions (Beets et al., 2023). Additionally, eligible studies had high heterogeneity with respect to populations, study designs, intervention content, duration, and delivery. Therefore, a narrative synthesis with a visual summary was deemed most appropriate for the current state of the evidence (Thomson & Thomas, 2013), and a meta-analytic synthesis will be considered again when the review is updated.

3. Results

3.1. Search results

Database searches returned a total of 13,893 results, reducing to 7682 after removal of duplicates. Title and abstract screening resulted in 187 full texts for appraisal. Thirty-five trials (reported in 39 publications) met all inclusion criteria. The PRISMA diagram in Fig. 1 details

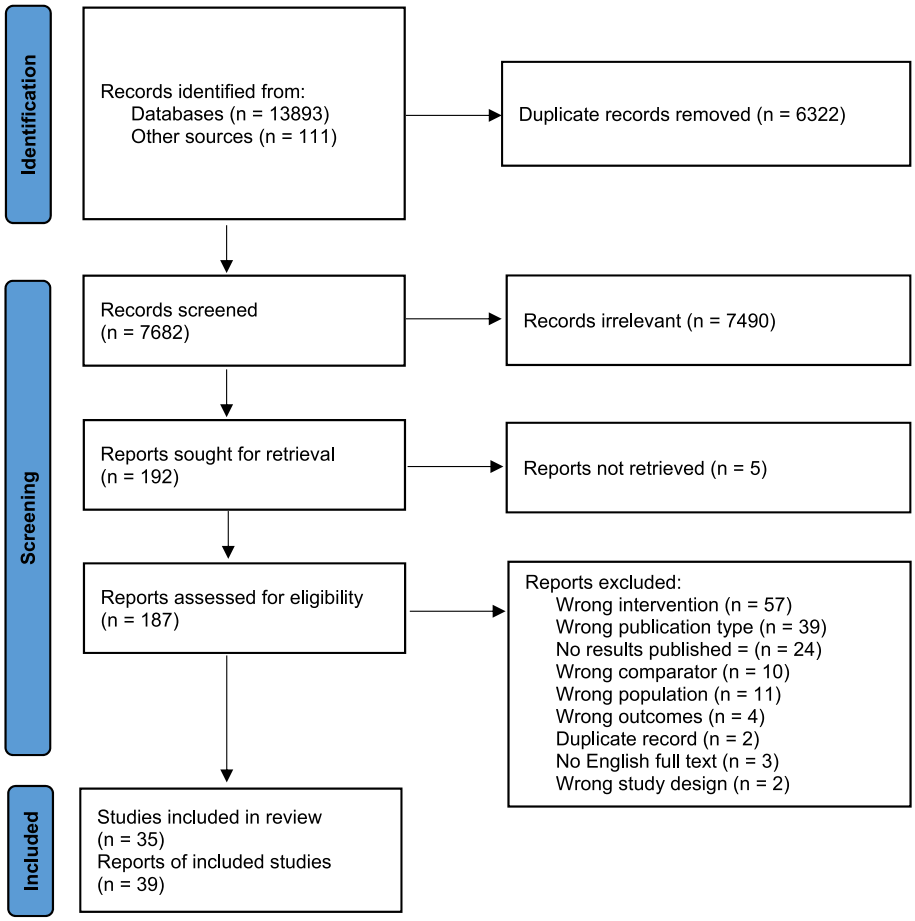

Fig. 1. PRISMA flow diagram of study selection process.

the search process.

Characteristics of included studies are summarised in Table 2. The studies included 2243 total participants, with sample sizes of 14–194 participants (median $N = 48$). Mean age was 20–65 years. Most studies recruited mixed sex samples (female participant proportions 19.1%–93.8%) and nine female-only samples.

Studies with non-clinical populations recruited students/young adults, insufficiently active adults, or groups with high stress and poor sleep. Most studied samples were clinical, however, and included cancer survivors, people living with chronic pain, and other chronic conditions. A handful of studies recruited participants with mental illness or history of trauma (such as depression, post-traumatic stress disorder [PTSD], history of addiction and sexual trauma). Reporting of participants' baseline activity levels and mindfulness experience was sparse, although populations were generally insufficiently active and not practised meditators.

With respect to study design, all were randomised controlled trials (RCTs) except five, which did not randomise allocation or failed to report it. Importantly, 19 of the 35 included trials were feasibility, pilot, or proof-of-concept studies, with one not specifying its aim and sample size calculation— leaving 15 full-scale RCTs that tested the effectiveness of combined interventions.

Comparator groups were active in 13 studies (9x PA only; 3x attention-matched; and 2x PA with attention-matched element for MBI), inactive in 11 studies (5x treatment as usual [TAU]; 6x waitlist), and 11 trials included more than one comparator arm. See Table 2 for detail.

3.2. Intervention content

Interventions varied substantially in the duration, frequency, intensity, mode of delivery, and facilitation (see Table 2). The PA component was performed in supervised groups in 14 trials, eight trials combined supervised group exercise with independent home practice (6x in-person groups; 2x online group sessions), four studies offered individual supervised appointments in combination with home practice, and nine trials had guided but entirely unsupervised PA components (5x initial one-off instructions provided in-person; 4x digital instructions).

The most prescribed type of PA was aerobic (n = 19), including nine walking interventions, two running and two dancing programmes, and non-specified aerobic activities. One trial involved resistance exercise only, whereas other interventions involved multiple exercise types or personalised the prescription to each participant. A minority of studies comprised PA psychoeducation or counselling (2x), self-monitoring with an activity monitor (1x), and one trial did not report the exercise type/intensity. Interventions were between two and 24 weeks long with a median duration of 8 weeks. The frequency of sessions ranged from 1–5x per week (except in trials with two or three total PA sessions), and the total time of PA component was between two and 30 h (mean 13.4 h).

The mindfulness component was delivered in supervised groups in most trials (n = 26; 11x in-person guidance; 1x digital facilitation), out of which 14 included independent home practice too (7x prescribed activities and durations; 7x optional home practice). Three trials offered individual supervised sessions at first, then transitioned into independent practice. Mindfulness components were entirely self-delivered in six studies, facilitated by audio guides on either audio devices or via mobile apps (3 studies each).

Ten programs referenced standardised mindfulness-based interventions when describing their mindfulness components (7x MBSR; 3x ACT). The rest contained common mindfulness meditation techniques, including focused attention, body scans and breathing exercises. In addition, 13 trials included elements of mindful walking or other movement. Two trials added mindful eating principles to the common meditation techniques. Mindfulness components were performed 1–5x per week in bouts varying from 10 min to 4 h (except in Garcia and colleagues' (2023) daily 5-min bursts), adding up to total mindfulness practice time of 4–48 h (mean 13.3 h). Reporting of mindfulness interventions was inconsistent and at times lacked detail. The majority of included interventions delivered (and described) PA and mindfulness components separately, whereas eight consisted of holistic programmes that integrated the two techniques in every session.

Thirteen trials included elements beyond PA and mindfulness components. Additional content was inconsistently reported on, with only one trial specifying its duration (1x 2-h nutritional counselling session in Johnson, Emmons, Rivard, Griffin, & Dusek, 2015, which made up 8.3% of total intervention time). Two trials reported additional elements that would have taken negligible or very little time (i.e., continuing pharmacological treatment and weekly reminder email of PA goals). Five studies provided access to resources which participants used at their will (e.g., group chats or online forums with other participants, e-diary of practice, stress reduction techniques accessible in-app), making them hard to quantify. Finally, six trials mentioned other content without specifying its duration (e.g., weekly check-in calls, a one-off psychoeducation session, or summary audio clips of intervention content). Where additional content was not quantified, we relied on its prominence in the manuscripts. We guesstimate that none of the trials' additional content made up > 20% of intervention time (see Table 2 for details).

3.3. Quality assessment

Full risk of bias assessment by domain is given in Fig. 2. Nineteen trials were rated as methodologically strong, that is, judged as having low risk of bias in all RoB2 domains except for D4 (bias arising from measurement of the outcome) – the latter was judged 'moderate' in all included studies due to the nature of self-reported outcomes in behavioural interventions. Therefore, even the methodologically stronger studies had 'moderate' overall risk of bias. Further 10 studies raised 'some concerns' in the quality assessment, mainly due to lack of randomisation (Garcia, Ferguson, Facio, Schary, & Guenther, 2023; Johnson et al., 2015), reporting only per-protocol analyses (Demmin, Silverstein, & Shors, 2022; Rabin, Pinto, & Fava, 2016; Zieff et al., 2022), or non-reporting on pre-registration/protocol and/or deviations from it (Mousavi, Molanorouzi, Shojaei, & Bahari, 2023; Norouzi, Rezaie, Bender, & Khazaie, 2023; Shors, Chang, & Millon, 2018; Spahn et al., 2013). Six trials were rated as having 'high' overall risk of bias, predominantly because of poor reporting on missing data (Daluee, Shahhabizadeh, Nasry, & Samari, 2021), omitting non-completers from the dataset (Lavadera, Millon, & Shors, 2020; Majore-Dusele, Karkou, & Millere, 2021), unequal group characteristics at baseline (Millon, Lehrer, & Shors, 2022), or non-reporting of randomisation, analysis, and deviation from protocol (Shors, Olson, Bates, Selby, & Alderman, 2014; Weng, Liao, Wang, Wang, & Yang, 2022). Effectiveness trials were generally of good quality, with 10/15 rated as methodologically strong (Casey et al., 2022; Chaharmahali, Gandomi, Yalfani, & Fazaeli, 2023; Fischer et al., 2022; Haugmark, Hagen, Provan, Smedslund, & Zangi, 2021; Henninger, Fibieger, Magkos, & Ritz, 2023; Hooker et al., 2022; Mitarnun, Mitranun, Mitarnun, & Pangwong, 2022; Mourad, Eriksson-Liebon, Karlström, & Johansson, 2022; Siripanya, Parinyanitikul, Tanaka, & Suksom, 2023; Srisoongnern et al., 2021), three moderate (Mousavi et al., 2023; Norouzi et al., 2023; Spahn et al., 2013) and two raising methodological concerns (Daluee et al., 2021; Weng et al., 2022). In the absence of meta-analysis, we were not able to determine the extent to which publication bias was present.

3.4. Feasibility and acceptability

Nineteen out of 35 included studies specified feasibility and/or acceptability in their aims. They concluded that feasibility and acceptability of interventions combining mindfulness and PA is generally high, although this was measured inconsistently (either with acceptability questionnaires or recruitment/retention rates). Six studies reported moderate feasibility, mainly due to rates of recruitment being lower

Table 2
Characteristics of included studies.

Authors	Sample	Design	Intervention: physical activity	Intervention: mindfulness training	Intervention: other	Comparator (s)	Outcome measures of interest
Casey et al. (2022) (Ireland)	$n = 175$ 70.9% female $M_{age} = 48.1$ Chronic pain	RCT	8 wks, 1 × 90 min p/w Group, in person, supervised Aerobic & resistance	8 wks, 1 × 120 min p/w Group, in person, supervised ACT focused on pain	/	PA only	Depression (PHQ-9), Anxiety (GAD-7), Health improvement (PGIC)
Chaharmahali et al. (2023) (Iran)	$n = 60$ 100% female $M_{age} = 54.4$ Knee osteoarthritis	RCT	6 wks, 4 × 60 min p/w Group, in person, supervised Resistance & balance exercise	6 wks, 4 × 20 min p/w Group, in person (wk 1) + individual, digital, self-delivered (wks 2–6) audio-guided Body scans, breathing exercises	/	PA only PA + AM	QoL (SF-36)
Daluee et al. (2021) (Iran)	$n = 60$ NR female $M_{age} = 49.6$ Haemodialysis	RCT	5 wks, 3 × 60 min p/w Group, in person, supervised Body weight exercises	5 wks, 3 × 60 min p/w Group, in person, supervised ACT & mindfulness exercises	/	M only TAU	Spiritual health (SHQ)
Demmin et al. (2022) (USA)	$n = 72$ 93.8% female $M_{age} = 39.9$ Teachers w/ high stress	Pilot RCT	6 wks, 2 × 30 min p/w Group, in person, supervised (1x/wk) + individual, digital, guided (1x/wk) Aerobic exercise	6 wks, 2 × 30 min p/w Group, in person, supervised (1x p/w) + individual, digital, guided (1x p/w) Focused attention, mindful walking	/	WL	Depression (PHQ-9) Anxiety (GAD-7) Stress (PSS-10, DTS) Wellbeing (MAP-Q) QoL (ProQOL) Rumination (RRS)
Fischer et al. (2022) (Germany)	$n = 102$ 89.2% female $M_{age} = 46.7$ Adults w/ high stress	RCT	12 wks, 1 × 45 min p/w Group, in person, supervised[a] Resistance, stretching	12 wks, 1 × 45 min p/w Group, in person, supervised[a] MBSR, mindful breathing & movement	/	PA only M only	Depression (HADS) Anxiety (HADS) Stress (PSS) QoL (SF-36) PTSD (PCL-5) Burnout (MBI)
Garcia et al. (2023) (USA)	$n = 34$ 76.5% female $M_{age} = 32.6$ University students & staff	Pilot RCT	2 wks, D NR Individual, self-delivered Self-monitoring with activity tracker (Fitbit Inspire 2)	1 wk, 7 × 5 min p/w Individual, digital, self-delivered, app-guided focused attention & breathing exercises	/	PA only	Depression (HADS) Anxiety (HADS) Wellbeing (MHC-SF) Rumination (PSWQ)
Goldstein et al. (2018) (USA)	$n = 47$ 19.1% female $M_{age} = 46.8$ Veterans w/ PTSD	Pilot RCT	12 wks, 3 × 30 min p/w Group, in person, supervised Aerobic & resistance	12 wks, 3 × 30 min p/w Group, in person, supervised MBSR, mindful breathing	/	WL	PTSD (CAPS) QoL (WHOQOL-BREF)
Haugmark et al. (2021) (Norway)	$n = 170$ 93.5% female $M_{age} = 42.5$ Fibromyalgia	RCT	12 wks, 3x NR (total) Individual, personalised PA consultation & recommendations	10 wks, 1 × 240 min p/w Group, in person, supervised (+ optional IP) Body scans, breathing exercises, mindful walking	/	TAU	Distress (GHQ-12) QoL (EQ-5D-5L) Health improvement (PGIC)
Henninger et al. (2023) (Denmark)	$n = 61$ 100% female $M_{age} = 41.9$ Inactive women w/ overweight or obesity	Pilot RCT	8 wks, 3 × 75 min p/w Group, in person, supervised Aerobic, moderate (dance), strength, balance, yoga	8 wks, 4 × 90 min (total) Group, in person, supervised Mindful eating principles & exercises	Audio clips summarising intervention content (1–2x p/w, D NR)	M only AM (education)	QoL (WHOQOL-100)
Hooker et al. (2022) (USA)	$n = 194$ 80.0% female $M_{age} = 47.0$ Adults w/ overweight or obesity	RCT	24 wks, F/D NR Individual, guided, self-delivered Aerobic, light (walking)	24 wks, 16 × 150 min (total) + 1 full day (5 h) Group, in person, supervised + encouraged IP MBSR-inspired focused attention, breathing exercises, mindful eating	/	PA + AM	Depression (PHQ-9) Anxiety (STAI) Stress (PSS) Affect (DES) Rumination (RRQ)
Johnson et al. (2015) (USA)	$n = 40$ 85% female $M_{age} = 47.3$ Healthcare professionals w/ depression	Pilot CT	8 wks, 2 × 60 min (total) Individual, personalised PA consultation & recommendations	8 wks, 1 × 150 min p/w Group, in person, supervised (+ optional IP) Body scans, breathing exercises	Nutrition counselling (1 × 120 min)	WL	Depression (PHQ-9, CESD-10) Stress (PSS-4) Anxiety (STAI)
Lavadera et al. (2020) (USA)	$n = 47$ 63.8% female $M_{age} = 24.0$ Medical students	CT	8 wks, 2 × 30 min p/w Group, in person, supervised Aerobic exercise	8 wks, 2 × 30 min p/w Group, in person, supervised	/	WL	Depression (PHQ-8) Stress (PSS)

(continued on next page)

Table 2 (*continued*)

Authors	Sample	Design	Intervention: physical activity	Intervention: mindfulness training	Intervention: other	Comparator (s)	Outcome measures of interest
				Focused attention, mindful walking			Rumination (RRS) QoL (QOLS)
Lyzwinski et al. (2019) (Australia)	$n = 90$ 67.5% female $M_{age} = 20.2$ Students wishing to lose weight	Pilot RCT	11 wks, F/D NR Individual, digital, self-delivered Type NR	11 wks, F/D NR Individual, digital, self-delivered MBSR, mindful eating exercises	Stress reduction techniques in mobile application, F/D variable	AM (self-monitoring)	Stress (PSS)
Majore-Dusele et al. (2021) (Latvia)	$n = 29$ 100% female $M_{age} = 37.8$ Chronic headaches	Pilot RCT	5 wks, 2 × 45 min p/w Group, in person, supervised Aerobic, moderate (dance)	5 wks, 2 × 45 min p/w Group, in person, supervised Body scans, sitting & walking meditation	Pharmacological treatment continued throughout, D negligible	TAU	Depression (PHQ-9, HADS) Anxiety (HADS)
Millon et al. (2022) (USA)	$n = 26$ 100% female $M_{age} = 37.8$ HIV	Feasibility CT	6 wks, 1 × 30 min p/w Group, in person, supervised Aerobic exercise	6 wks, 1 × 30 min p/w Group, in person, supervised Focused attention, mindful walking	/	WL	Depression (BDI-II) Anxiety (BAI) Stress (PSS) PTSD (PTCI) Rumination (RRS)
Mitarnun et al. (2022) (Thailand)	$n = 33$ 57.6% female $M_{age} = 61.3$ Parkinson's disease	RCT	12 wks, 3 × 30 min (supervised) + 3 × 30 min p/w (IP) Group, in person, supervised + individual, self-delivered Aerobic, light (walking)	12 wks, 3 × 30 min (supervised) + 3 × 30 min p/w (IP) Group, in person, supervised + individual, digital, self-delivered Sitting meditation, body scans	/	TAU	Anxiety (HADS)
Mourad et al. (2022) (Sweden)	$n = 109$ 61.5% female $M_{age} = 55.6$ Non-cardiac chest pain	RCT	5 wks, 1x NR (supervised) + 5 × 30 min p/w (IP) Individual, personalised PA consultations + individual, self-delivered PA of any type	5 wks, 1x NR (supervised) + 5 × 10 min p/w (IP) Individual demonstration + individual, digital, self-delivered mindfulness breathing exercises	Psychoeducation on chest pain, symptom management, safety of PA, F/D NR	AM (education + self-monitoring)	Depression (PHQ-9) QoL (EQ-VAS)
Mousavi et al. (2023) (Iran)	$n = 60$ 61.7% female $M_{age} = 39.3$ Adults w/ poor sleep	RCT	8 wks, 1 × 45 min p/w Group, in person, supervised Aerobic, moderate (bodyweight exercises, running)	8 wks, 1 × 45 min p/w Group, in person, supervised ACT-inspired exercises, focused attention, body scans, self-compassion	/	PA only M only AM (group discussions)	Depression (BDI) Anxiety (BAI)
Norouzi et al. (2023) (Iran)	$n = 50$ 59.0% female $M_{age} = 33.2$ Major depression	RCT	8 wks, 1 × 45 min p/w Group, in person, supervised Aerobic, moderate (bodyweight exercises, running)	8 wks, 1 × 45 min p/w Group, in person, supervised Focused attention, body scans, self-compassion, acceptance	/	PA only M only	Depression (BDI) Affect (DERS)
Nymberg et al. (2021) (Sweden)	$n = 88$ 72.7% female $M_{age} = 53.7$ Inactive adults	Pilot RCT	8 wks, F/D variable Individual, in person PA consultation & recommendations Type variable	8 wks, 1 × 120 min p/w (supervised) + 6 × 20 min (IP) Group, in person, supervised + individual, digital, self-delivered MBSR & MBCT techniques	/	PA only M only	Self-rated health (single-item)
Polaski et al. (2021) (USA)	$n = 38$ 68.4% female $M_{age} = 37.6$ Chronic back pain	Pilot RCT	4 wks, 5 × 30 min p/w Individual, in person, supervised + individual, self-delivered Aerobic (treadmill walking)	4 wks, 5 × 15 min p/w Individual, digital, self-delivered breathing exercises & body scans	/	AM (audiobook + rest)	Anxiety (STAI)
Rabin et al. (2016) (USA)	$n = 35$ 82.9% female $M_{age} = 33.6$ Cancer survivours	Feasibility RCT	12 wks, up to 5 × 30 min p/w Individual, self-delivered Aerobic, moderate (variable PA) + self-monitoring with activity tracker	12 wks, 4x D NR p/w Individual, digital, self-delivered breathing exercises & body scans	Weekly check-in call, D NR & online community forum, F/D variable	WL	Mood (POMS)
Rao et al. (2023) (Australia)	$n = 31$ 29.0% female $M_{age} = 60.5$ Cardiovascular disease & depression	Feasibility RCT	6 wks, 2x D NR p/w Individual, in person, supervised Personalised exercise & education (cardiac rehabilitation program)	6 wks, 1 × 20 min p/w (supervised) +6 × 20 min p/w (IP) Group, in person, supervised + individual, digital, self-delivered Breathing exercises, body scans, focused attention	/	PA only	Depression (DASS-21, HADS) Anxiety (DASS-21, HADS) Stress (DASS-21)

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Table 2 (*continued*)

Authors	Sample	Design	Intervention: physical activity	Intervention: mindfulness training	Intervention: other	Comparator (s)	Outcome measures of interest
Schröder et al. (2022) (Germany)	$n = 51$ 100% female $M_{age} = 55.8$ Breast cancer survivours	Pilot RCT	8 wks, 1 × 45 min p/w Group, in person, supervised (+ optional IP) Aerobic, light (walking)	8 wks, 1 × 45 min p/w Group, in person, supervised (+ optional IP) Breathing exercises, body scans	/	PA only	QoL (WHOQOL-BREF) Stress (PSQ)
Shi et al. (2019) (USA)	$n = 38$ 86.8% female $M_{age} = 49.3$ Inactive adults	Pilot RCT	4 wks, 1 × 30 min p/w Group, in person, supervised (+ optional IP) Aerobic, light (walking)	4 wks, 1 × 30 min p/w Group, in person, supervised (+ optional IP) Focused attention, body scans	Weekly email reminder to meet PA goals, D negligible	PA only	Depression (BEDS) Stress (PSS) QoL (MHI-5)
Shors et al. (2014) (USA)	$n = 14$ 100% female $M_{age} = 25.0$ History of abuse or addiction	Pilot CT	8 wks, 2 × 30 min p/w Group, in person, supervised Aerobic, moderate (dance)	8 wks, 2 × 30 min p/w Group, in person, supervised Focused attention, mindful walking	/	TAU	Depression (BDI-II) Anxiety (BAI)
Shors et al. (2018) (USA)	$n = 105$ 100% female $M_{age} = 20.0$ History of sexual trauma	Pilot RCT	6 wks, 2 × 30 min p/w Group, in person, supervised Aerobic, moderate (treadmill or elliptical)	6 wks, 2 × 30 min p/w Group, in person, supervised Focused attention, mindful walking	/	PA only M only WL	PTSD (PTCI) Rumination (RRS) Self-worth (BSS)
Signore et al. (2022) (Canada)	$n = 18$ 87.5% female $M_{age} = 58.2$ Inactive adults w/ prediabtetes	Pilot RCT	6 wks, 1 × 45 min (supervised) + variable IP Group, digital PA education & recommendations Type variable	6 wks, 1 × 45 min (supervised) Group, digital, guided Mindfulness & self-compassion training, incl breathing exercises	/	PA + AM	Affect (NAF)
Siripanya et al. (2023) (Thailand)	$n = 30$ 100% female $M_{age} = 45.0$ Women w/ breast cancer	RCT	12 wks, 3 × 30–40 min p/w[b] Individual, digital, self-delivered Aerobic light-moderate (walking)	12 wks, 3 × 30–40 min p/w[b] Individual, digital, self-delivered Focused attention, labelling, mindful walking	Weekly check-in call, D NR	TAU	DSQoL (QLQ-C30)
Spahn et al. (2013) (Germany)	$n = 64$ 100% female $M_{age} = 56.7$ Breast cancer survivours	RCT	10 wks, 3x D NR (supervised) + 3 × 30 min p/w (IP) Group, in person, supervised + Individual, self-delivered IP Aerobic, light (walking)	10 wks, 1 × 360 min (supervised) + variable F/D (IP) Group, in person, supervised + Individual, self-delivered IP MBSR techniques, incl body scan	Nutrition education, naturopathic self-help, F/D NR	PA only	Depression (HADS) Anxiety (HADS) DSQoL (QLQ-C30)
Srisoongnern et al. (2021) (Thailand)	$n = 48$ 45.8% female $M_{age} = 65.0$ Chronic heart failure	RCT	6 wks, 3 × 30–40 min p/w[b] Individual, in person, supervised (2 wks) + self-delivered IP (4 wks) Aerobic, light-moderate (walking)	6 wks, 3 × 30–40 min p/w[b] Individual, in person, supervised (2 wks) + self-delivered IP (4 wks) Focused attention, labelling	/	PA only	DSQoL (MLHFQ)
Torkhani et al. (2021) (France)	$n = 35$ 80.0% female $M_{age} = 43.9$ Multiple sclerosis	Pilot RCT	8 wks, 4 × 30 min p/w Individual, digital, self-delivered Various types (walking, strength, stretching, balance)	8 wks, 6 × 60 min p/w Individual, digital, self-delivered Breathing exercises, focused attention	Weekly check-in call, D NR	PA only PA + AM	QoL (EQ-5D-5L) DSQoL (MFIS, MSIS)
Weng et al. (2022) (China)	$n = 120$ 37.5% female $M_{age} = 42.7$ Type 2 diabetes & peripheral neuropathy	RCT	12 wks, 3 × 75 min p/w[b] Group, in person, supervised Aerobic, moderate intensity	12 wks, 3 × 75 min p/w[b] + 4 × 45 min p/w (IP) Group, in person, supervised + individual, digital, self-delivered IP Focused attention, breathing exercises, body scans	Online group chat with other participants, F/D variable	PA only AM (education)	DSQoL (DMQoLS)
Zheng et al. (2022) (China)	$n = 37$ 75.7% female $M_{age} = 35.3$ Chronic back pain	Pilot RCT	4 wks, 1 × 90 min (supervised) + 3 × 35 min p/w (IP) Group, in person, supervised + individual, digital, self-delivered Resistance & stretching, light-moderate	4 wks, 3 × 20 min (supervised) + F/D NR p/w (IP) Group, in person, supervised + individual, digital, self-delivered Mindfulness & self-	eDiary of practice, F/D NR	PA only	Depression (PHQ-9) Anxiety (GAD-7)

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Table 2 (*continued*)

Authors	Sample	Design	Intervention: physical activity	Intervention: mindfulness training	Intervention: other	Comparator (s)	Outcome measures of interest
				compassion training, incl focused attention			
Zieff et al. (2022) (USA)	$n = 32$ 84.4% female $M_{age} = 20.5$ High stress	Pilot RCT	4 wks, 3 × 20 min (supervised) + 1 × 60 min p/w (IP) Group, in person, supervised + individual, digital, self-delivered Aerobic, moderate (cycle ergometer) + variable IP	4 wks, 3 × 20 min (supervised) + F/D NR p/w (IP) Group, in person, supervised + individual, digital, self-delivered MBSR techniques incl breathing exercises	eDiary of practice, F/D NR	M only WL	Depression (DASS-21) Anxiety (DASS-21) Stress (DASS-21)

Note. [a] Fischer et al. (2022) trial moved to digital delivery partway due to COVID-19 restrictions. [b] Intervention integrated PA and M into the same sessions without specifying proportion of each, so reported duration represents total of both components. ACT – acceptance and commitment therapy; AM – attention-matched; BAI – Beck's Anxiety Inventory; BDI – Beck's Depression Inventory; BEDS – Brief Edinburgh Depression Scale; BSS – Best Self Scale; CAPS – Clinician-Administered PTSD Scale; CESD-10 – Center for Epidemologic Studies Depression 10; CT – controlled trial; D – duration; DASS-21 – Depression, Anxiety & Stress Scales 21; DERS – Difficulties in Emotion Regulation Scale; DES – Differential Emotions Scale; DMQOLS – Diabetes Mellitus Quality of Life Scale; DTS – Distress Tolerance Scale; EQ-5D-5L – EuroQoL 5-Level Quality of Life; EQ-VAS – EuroQoL Visual Analog Scale; F – frequency; GAD-7 – Generalised Anxiety Disorder 7; GHQ-12 – General Health Questionnaire 12; HADS – Hospital Anxiety & Depression Scale; HIV – human immunodeficiency virus; IP – independent practice; M – mindfulness; MAP-Q – Mental and Physical Training Questionnaire; MBCT – mindfulness-based cognitive therapy; MBSR – mindfulness-based stress reduction; MFIS – Modified Fatigue Impact Scale; MHC-SF – Mental Health Continuum Short Form; MHI-5 – Mental Health Inventory 5; MLHFQ – Minnesota Living with Heart Failure Questionnaire; MSIS – Multiple Sclerosis Impact Scale; NAF – Negative Affect Scale; NR – not reported; p/w – per week; PA – physical activity; PGIC – Patient Global Impression of Change scale; PHQ-9 – Patient Health Questionnaire 9; POMS – Profile of Mood States; ProQOL – Professional Quality of Life scale; PSQ – Perceived Stress Questionnaire; PSS-10 – Perceived Stress Scales 10; PSWQ – Penn State Worry Questionnaire; PTCI – Post-Traumatic Cognitions Inventory; PTSD – post-traumatic stress disorder; QLQ-C30 – EORTC Core Quality of Life Questionnaire 30; QOLS – Quality of Life Scale; RCT – randomised controlled trial; RRQ – Rumination-Reflection Questionnaire; RRS – Ruminative Response Scale; SF-36 – Short Form 36 scale; SHQ – Spiritual Health Questionnaire; STAI – State-Trait Anxiety Inventory; TAU – treatment as usual; USA – United States of America; w/ – with; WHOQOL-BREF – World Health Organisation Quality of Life scale; wks – weeks; WL – waitlist.

(Rao et al., 2023; Signore et al., 2022) or attrition higher (Demmin et al., 2022; Henninger et al., 2023; Polaski et al., 2021) than pre-specified criteria. Improving adherence to self-delivered components of the intervention was also emphasised (Nymberg et al., 2021).

3.5. Effects on psychological health

Studies' outcomes and statistical results are presented in Table 3. Psychological health outcomes generally improved over the course of combined interventions and outperformed passive controls (i.e., waitlist or TAU) in 26/36 comparisons (72%), whereas comparisons with active control conditions (including PA only, mindfulness-only and attention-matched) found mixed results: In effectiveness trials, 20/28 comparisons (71%) were not statistically different between combined and active control conditions, rising to 40/52 (77%) when pilot trials were included. No combined intervention was inferior to control conditions for any psychological health outcome.

3.6. Depression

The most studied mental health and wellbeing outcome was depression, for which 21 comparisons were reported on seven recognised measures. Depression symptoms significantly reduced in the combined intervention arm for 12/14 trials (86%; except in pilot trials by Garcia et al., 2023; Lavadera et al., 2020). Five trials—all feasibility studies—reported between-group comparisons to passive controls, and all favoured intervention condition for reduction of depressive symptoms (100%; vs. waitlist in Demmin et al., 2022; Johnson et al., 2015; Millon et al., 2022; Zieff et al., 2022; vs. TAU in Shors et al., 2014). Studies comparing to active controls found equivalent improvement in intervention and control arms (n = 12/13 [92%]: vs. PA only in Casey et al., 2022; Fischer et al., 2022; Garcia et al., 2023; Norouzi et al., 2023; Rao et al., 2023; Spahn et al., 2013; Shi et al., 2019; Zheng et al., 2022; vs. mindfulness-only in Fischer et al., 2022; Norouzi et al., 2023; Zieff et al., 2022; vs. attention-matched education group in Mourad et al., 2022; vs. PA plus attention-matched component in Hooker et al., 2022), except in Mousavi's et al., (2023) trial, where combined group outperformed both PA-only and mindfulness-only groups. Effects on depression were similar in effectiveness and pilot trials.

3.7. Anxiety

Anxiety was measured in 17 studies using five measures. Most studies determined pre-post improvement in intervention arms (n = 11/12 [92%]; including all five effectiveness trials). Compared to passive controls, intervention groups reduced anxiety most of the time (n = 1/3 [33%] vs. TAU; n = 3/4 [75%] vs. waitlist), including in the only effectiveness trial reporting this (Mitarnun et al., 2022). Active comparators again provided mixed results – combined interventions improved anxiety somewhat more than PA only (n = 4/8 [50%]; including in 2/4 effectiveness trials), but were equivalent to mindfulness-only (n = 1/3 [33%]; two effectiveness trials gave conflicting results) and attention-matched groups (n = 1/2 [50%]; effectiveness trial by Mousavi et al. [2023] found greater reductions in intervention group, whereas a pilot trial [Polaski et al., 2021] found no difference). Hooker and colleagues' (2022) effectiveness trial comparing to PA with attention-matched components also found similar effects in both groups.

3.8. Stress

Stress was third most studied with 11 results on five measures. There was agreement on combined interventions reducing pre-post levels of stress (n = 8/8 [100%]; including two effectiveness trials). Comparisons to passive controls yielded varied conclusions (combined interventions favoured in 3/4 [75%] waitlist pilot trials but not in the only effectiveness trial comparing to TAU [Haugmark et al., 2021]). Seven studies, out of which five were pilots, reported between-group effects relative to active controls: combined interventions were favoured over 1/4 PA-only groups (25%; with effectiveness trial [Fischer et al., 2022] finding no differences), delivered stress reduction similar to mindfulness-only (n = 0/2; 0%), and reduced stress relative to attention-matched self-monitoring in the per-protocol analysis only (but not in intention to treat analysis; Lyzwinski, Caffery, Bambling, & Edirippulige, 2019). Effectiveness trial by Hooker et al. (2022) also found no stress reduction over and above PA with attention-matched component.

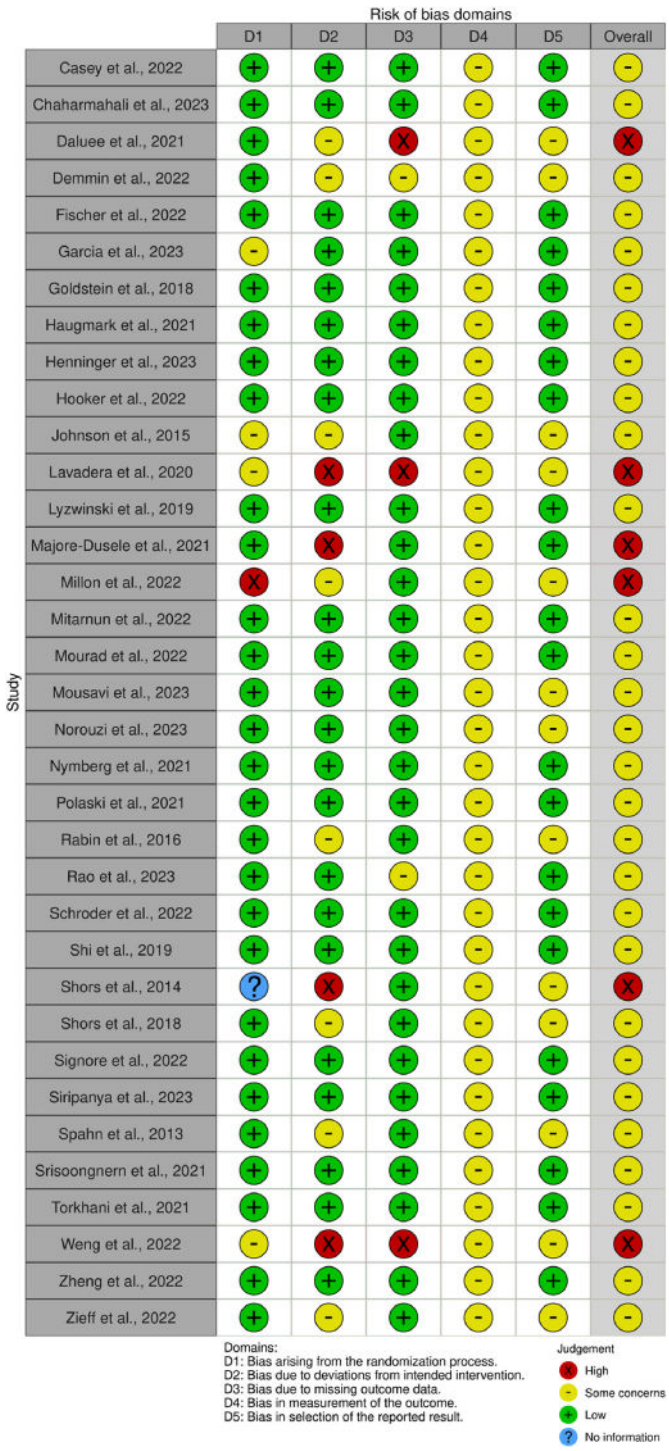

Fig. 2. Risk assessment of included studies by domain according to the Cochrane Risk of Bias 2 tool. Created with Robvis tool (McGuinness & Higgins, 2020).

3.9. Quality of life

Quality of life (QoL) was assessed in 11 trials with eight measures, whereas five trials focused on disease-specific QoL using five different measures. General QoL improved in most intervention arms pre-post (n = 5/7 [71%]; including all three effectiveness trial reporting this). Interventions improved QoL more than waitlist controls (Demmin et al., 2022; Goldstein et al., 2018; Lavadera et al., 2020; all pilots), but not relative to TAU in Haugmark and colleagues' (2021) effectiveness trial. Combined interventions provided equivalent increases in QoL as active comparators both in pilot (n = 3/3 [100%] vs. PA-only; Schröder et al., 2022; Shi et al., 2019; Torkhani et al., 2021) and effectiveness studies (n = 3/4 [75%]; only in Chaharmahali et al. [2023]'s comparisons intervention outperformed both PA-only and PA with attention-matched component). Disease-specific QoL largely improved in pre-post analyses of combined interventions, with increases reported for cancer (Siripanya et al., 2023; Spahn et al., 2013), diabetes (Weng et al., 2022), but not for multiple sclerosis (Torkhani et al., 2021) or heart failure-related QoL (Srisoongnern et al., 2021). Compared to control conditions, effectiveness trials found combined interventions superior to TAU (Siripanya et al., 2023) but not PA only (Spahn et al., 2013; Srisoongnern et al., 2021).

3.10. Wellbeing

Two pilot trials reported wellbeing measures: Demmin et al. (2022) determined improvement on their own composite questionnaire relative to waitlist control, whereas Garcia et al. (2023) used the Mental Health Continuum Questionnaire and found no improvement pre-post, nor relative to a PA-only control.

3.11. PTSD

PTSD symptoms were assessed in four trials with three measures. All studies assessing pre-post changes found a reduction in PTSD symptoms in intervention arms (including Fischer et al. (2022) effectiveness trial), whereas comparisons to passive controls favoured combined interventions over waitlist in 2/3 studies (67%; Goldstein et al., 2018; Shors et al., 2018; but not Millon et al., 2022). PTSD symptoms did not improve relative to active comparators in Fischer and colleagues' (2022) trial.

3.12. Self-rated health

Four trials explored changes in perceived health using three measures. Two effectiveness trials (Casey et al., 2022; Haugmark et al., 2021) measured perceived improvement with the Patient Global Impression of Change Scale (PGICS; Kamper, 2009) – Casey and colleagues' (2022) trial determined pre-post improvement in the intervention arm, as well as improvement over and above a PA-only control. PGICS scores also improved relative to a TAU control (Haugmark et al., 2021). Feasibility work by Nymberg et al. (2021) reported improvement on a single-item self-rated health measure within the intervention arm, but this was no greater than effects in mindfulness-only or PA-only groups. Finally, spiritual health was monitored in Daluee's et al., (2021) trial: they found increased spiritual health over time for the intervention arm, which outperformed the passive TAU condition but not active mindfulness-only control arm.

3.13. Mechanistic variables

Several potential mechanisms were also explored. Rumination, defined as maladaptive repetitive thought (Nolen-Hoeksema & Morrow, 1991), was monitored in six trials (five pilots), mostly using the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991). Levels of rumination were reduced in pre-post analyses (n = 5/6 [83%]; including in Hooker et al. [2022] effectiveness trial), as well as relative to waitlist controls (n = 3/4 [75%]). Comparisons with active control conditions favoured combined interventions in 1/3 trials (33%).

Mood and affect were measured in four studies. Both effectiveness trials detected improvement in the intervention groups, as well as over and above active controls (Hooker et al., 2022; Norouzi et al., 2023). In contrast, Rabin and colleagues' (2016) pilot found no changes in mood disturbance in their per-protocol analyses (with ITT analyses not reported). Signore's et al., (2022) trial reported no formal analyses of their

Table 3
Visual summary of intervention effects.

Authors	Outcomes	Within-group effects						Between-group effects
		INT	PA	M	TAU	WL	AM	
Casey et al. (2022)	Dep (PHQ-9)	++	/					Group × time interaction *SMD* = −1.35, *p* = .13
	Anx (GAD-7)	++	/					Group × time interaction *SMD* = −0.97, *p* = .22
	Health (PGIC)	+	/					NR
Chaharmahali et al. (2023)	QoL (SF-36)	++	++				++	Omnibus ANCOVA *F* (2, 49) = 7.40, *p* = .002, INT vs PA 95% *CI*(1.33 to 2.55), *p* < .001
Daluee et al. (2021)	Health (SHQ)	+		++	–			Group × time interaction *F* = 22.89, *p* < .001
Demmin et al. (2022)*	Dep (PHQ-9)	+[a]				/[a]		Group × time interaction *F* (1,43) = 6.34, *p* = .02
	Anx (GAD-7)	+[a]				+[a]		Group × time interaction *F* (1,43) = 13.15, *p* <. 01
	Stress (PSS)	/[a]				/[a]		Group × time interaction *F* (1,43) = 7.97, *p* = .01
	Wellbeing (MAP-Q)	+[a]				-[a]		Group × time interaction *F* (1,43) = 5.40, *p* = .02
	QoL (ProQOL)	/[a]				-[a]		Group × time interaction *F* (1,43) = 7.74, *p* = .01
	Distress tolerance (DTS)	-[a]				-[a]		Group × time interaction n.s.
	Rumination (RSS)	/[a]				/[a]		Group × time interaction n.s.
Fischer et al. (2022)	Dep (HADS)	++	+	+				Group × time interaction n.s.
	Anx (HADS)	++	++	++				Group × time interaction n.s.
	Stress (PSS)	+	+	+				Omnibus ANOVA *F* = 2.62, *p* = .078
	QoL (SF-36)	++	++	+				Group × time interaction n.s.
	PTSD (PCL-5)	++	+	+				Group × time interaction n.s.
	Burnout (MBI)	+	+	+				Group × time interaction <.05, INT vs PA *p* = .017; M vs PA *p* = .036, INT vs M *p* > .05
Garcia et al. (2023)*	Dep (HADS)	/	/					INT vs PA *p* = .536
	Anx (HADS)	+	/					INT vs PA *p* = .046
	Wellbeing (MHC-SF)	/	/					INT vs PA *p* = .825
	Rumination (PSWQ)	/	/					INT vs PA *p* = .538
Goldstein et al. (2018)*	QoL (WHOQOL-BREF)	/				–		Group × time interaction 'psychological domain' *d* = .53, *p* = .005: 'physical domain' *d* = .33, *p* = .183
	PTSD (CAPS)	+				/		Group × time interaction *d* = −.90, *p* = .038
Haugmark et al. (2021)	Distress (GHQ-12)	NR			NR			INT vs TAU *SMD* = 1.57, *p* = .11
	QoL (EQ-5D-5L)	NR			NR			INT vs TAU *SMD* = 0.02, *p* = .86
	Health (PGIC)	/			–			INT vs TAU *p* = .01
Henninger et al. (2023)	QoL (WHOQOL-100)	NR		NR			NR	Group × time interaction 'psychological domain' *MD (CIs)* = 1.2 (−1.9, 4.3), *p* = .46; 'physical domain' *MD (CIs)* = 1.0 (−1.6, 3.6), *p* = .46
Hooker et al. (2022)	Dep (PHQ-9)	+	+					INT vs PA + AM *MD* = −0.83, *p* = .14, *d* = −0.22
	Anx (STAI)	+	+					INT vs PA + AM *MD* = −0.15, *p* = .88, *d* = −0.02
	Stress (PSS)	+	/					INT vs PA + AM *MD* = −0.87, *p* = .28, *d* = −0.15
	Affect (DES)	+	/					INT vs PA + AM *MD* = 2.35, *p* = .01, *d* = 0.36
	Rumination (RRQ)	+	+					INT vs PA + AM *MD* = −0.06, *p* = .51, *d* = −0.08
Johnson et al. (2015)*	Dep (PHQ-9)	++				/		Group × time interaction *MD* = −6.46, *p* = .001
	Dep (CESD-10)	++				/		Group × time interaction *MD* = −6.67, *p* = .002
	Anx (STAI)	++				/		Group × time interaction 'state' *MD* = −7.97, *p* = .068; 'trait' *MD* = −9.11, *p* = .008
	Stress (PSS-4)	++				/		Group × time interaction *MD* = −3.19, *p* = .002
Lavadera et al. (2020)*	Dep (PHQ-8)	/				/		INT vs WL *t* (1,16) = 1.21, *p* > .05
	Stress (PSS)	+				–		INT vs WL *t* (1,16) = 2.22, *p* < .05
	QoL (QOLS)	+				–		INT vs WL *F* (1,45) = 5.64, *p* < .05
	Rumination (RRS)	+				/		INT vs WL *F* (1,45) = 5.36, *p* < .05
Lyzwinski et al. (2019)*	Stress (PSS)	/					/	INT vs AM ITT *p* > .05; per protocol *p* = .02;
Majore-Dusele et al. (2021)*	Dep (PHQ-9)	/			/			Group × time interaction *MD* = −3.17, *p* = .02
	Dep (HADS)	/			/			Group × time interaction *MD* = −1.94, *p* = .07
	Anx (HADS)	/			/			Group × time interaction *MD* = −2.08, *p* = .06
Millon et al. (2022)*	Dep (BDI-II)	++				–		Group × time interaction *F* (1, 24) = 4.83, *p* = .04
	Anx (BAI)	+				–		Group × time interaction *p* = .15
	Stress (PSS)	++				/		Group × time interaction *p* = .41
	PTSD (PTCI)	++				/		Group × time interaction *p* = .54
	Rumination (RRS)	++				–		Group × time interaction *F* (1, 24) = 17.37, p < .001
Mitarnun et al. (2022)	Anx (HADS)	+				–		NR
Mourad et al. (2022)	Dep (PHQ-9)	+					/	INT vs AM *p* > .05
	QoL (EQ-VAS)	+					–	INT vs AM *p* = .03
Mousavi et al. (2023)	Dep (BDI)	+	+	+			/	Group × time interaction *F* (6, 84) = 3.84, *p* < .01, INT > AM but not PA or M
	Anx (BAI)	+	+	+			/	Group × time interaction *F* (6, 84) = 4.57, *p* < .05, INT > PA, M, AM
Norouzi et al. (2023)	Dep (BDI)	+	+	+				Group × time interaction *F* (4, 84) = 0.33, *p* = .85
	Affect (DERS)	+	+	+				Group × time interaction *F* (2) = 4.38, *p* = .01, INT > PA, M
Nymberg et al. (2021)*	Health (single-item)	/	/	/				Group × time interaction *p* = .86
Polaski et al. (2021)*	Anxiety (STAI)	/					/	INT vs AM 'state' *p* = .258, 'trait' *p* = .805
Rabin et al. (2016)*	Mood (POMS)	NR				NR		INT vs WL *p* > .05
Rao et al. (2023)*	Dep (DASS-21)	NR	NR					INT vs PA *p* > .05

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Table 3 (*continued*)

Authors	Outcomes	Within-group effects						Between-group effects
		INT	PA	M	TAU	WL	AM	
	Dep (HADS)	NR	NR					INT vs PA $p > .05$
	Anx (DASS-21)	NR	NR					INT vs PA $p > .05$
	Anx (HADS)	NR	NR					INT vs PA $p > .05$
	Stress (DASS-21)	NR	NR					INT vs PA $p > .05$
Schröder et al. (2022)*	QoL (WHOQOL-BREF)	+	+					INT vs PA 'psychological domain' at 8 wks $p = .796$, at 16 wks $p = .312$; 'physical domain' at 8 wks $p = .958$, at 16 wks $p = .721$
	Stress (PSQ)	+	+					INT vs PA at 8 wks $p = .972$, at 16 wks $p = .796$
Shi et al. (2019)*	Dep (BEDS)	+	+					INT vs PA at 4 wks $p = .92$, at 8 wks $p = .80$
	Stress (PSS)	+	–					INT vs PA at 4 wks $p = .02$, at 8 wks $p = .77$
	QoL (MHI-5)	/	/					INT vs PA $p > .05$
Shors et al. (2014)*	Dep (BDI-II)	+			/			INT vs TAU $F(1,12) = 7.61$, $p < .05$
	Anx (BAI)	+			/			INT vs TAU $p > .05$
Shors et al. (2018)*	PTSD (PTCI)	+	–	++		/		NR
	Rumination (RRS)	++	/	/		–		NR
	Self-worth (BSS)	+	/	/		–		NR
Signore et al. (2022)*	Affect (NAF)	NR					NR	NR
Siripanya et al. (2023)	DSQoL (QLQ-C30)	+			/			INT vs TAU $p < .05$, $d = .136$
Spahn et al. (2013)	Dep (HADS)	/	/					INT vs PA $p > .05$
	Anx (HADS)	+	+					INT vs PA at 10 wks $p = .043$, at 22 wks $p = .422$
	DSQoL (QLQ-C30)	+	+					INT vs PA $p > .05$
Srisoongnern et al. (2021)	DSQoL (MLHFQ)	/	–					INT vs PA $p = .577$
Torkhani et al. (2021)*	QoL (EQ-5D-5L)	NR	NR				NR	NR
	DSQoL (MFIS)	+	/				+	NR
	DSQoL (MSIS)	++	+				+	NR
Weng et al. (2022)	DSQoL (DMQLS)	+	/				/	NR
Zheng et al. (2022)*	Dep (PHQ-9)	/	/					INT vs PA at 4 wks $p = .471$
	Anx (GAD-7)	+	–					INT vs PA at 4 wks $p = .030$
Zieff et al. (2022)*	Dep (DASS-21)	+	+			/		Group × time interaction $p = .07$
	Anx (DASS-21)	+	+			/		Group × time interaction $p = .07$
	Stress (DASS-21)	+	+			/		Group × time interaction $p = .09$

Note. / positive effect (non-significant); + ($p < .05$); ++ ($p < .01$); - negative effect (from Thomson & Thomas, 2013). * denotes feasibility and pilot trials, which are less likely to detect effects due to insufficient statistical power. [a] within-group analyses reported for compliant participants only (i.e., per-protocol). AM – attention-matched group; ANCOVA – analysis of covariance; ANOVA – analysis of variance; Anx – anxiety outcomes; BAI – Beck's Anxiety Inventory; BDI – Beck's Depression Inventory; BEDS – Brief Edinburgh Depression Scale; BSS – Best Self Scale; CAPS – Clinician-Administered PTSD Scale; CESD-10 – Center for Epidemologic Studies Depression 10; CI – confidence intervals; DASS-21 – Depression, Anxiety & Stress Scales 21; Dep – depression outcomes; DERS – Difficulties in Emotion Regulation Scale; DES – Differential Emotions Scale; DMQOLS – Diabetes Mellitus Quality of Life Scale; DTS – Distress Tolerance Scale; EQ-5D-5L – EuroQoL 5-Level Quality of Life; EQ-VAS – EuroQoL Visual Analog Scale; GAD-7 – Generalised Anxiety Disorder 7; GHQ-12 – General Health Questionnaire 12; HADS – Hospital Anxiety & Depression Scale; INT – intervention group (combined physical activity and mindfulness); ITT – intention-to-treat analysis; M – mindfulness-only group; MAP-Q – Mental and Physical Training Questionnaire; MBCT – mindfulness-based cognitive therapy; MBSR – mindfulness-based stress reduction; MD – mean difference; MFIS – Modified Fatigue Impact Scale; MHCSF – Mental Health Continuum Short Form; MHI-5 – Mental Health Inventory 5; MLHFQ – Minnesota Living with Heart Failure Questionnaire; MSIS – Multiple Sclerosis Impact Scale; n.s. – not significant; NAF – Negative Affect Scale; NR – not reported; PA – physical activity-only group; PGIC – Patient Global Impression of Change scale; PHQ-9 – Patient Health Questionnaire 9; POMS – Profile of Mood States; ProQOL – Professional Quality of Life scale; PSQ – Perceived Stress Questionnaire; PSS-10 – Perceived Stress Scales 10; PSWQ – Penn State Worry Questionnaire; PTCI – Post-Traumatic Cognitions Inventory; PTSD – post-traumatic stress disorder; QLQ-C30 – EORTC Core Quality of Life Questionnaire 30; QoL – quality of life; QOLS – Quality of Life Scale; RRQ – Rumination-Reflection Questionnaire; RRS – Ruminative Response Scale; SF-36 – Short Form 36 scale; SHQ – Spiritual Health Questionnaire; SMD – standard mean difference; STAI – State-Trait Anxiety Inventory; TAU – treatment as usual group; Vs – versus; WHOQOL-BREF – World Health Organisation Quality of Life scale; WL – waitlist group.

negative affect scores, citing insufficient statistical power to detect effects.

Burnout was an outcome in Fischer and colleagues' (2022) effectiveness trial. Their combined intervention group reduced symptoms in pre-post comparisons, as well as relative to PA-only control, but not relative to mindfulness only. A single pilot trial (Demmin et al., 2022) assessed distress tolerance, detecting no change in the intervention group, nor relative to waitlist control. Finally, one pilot trial (Shors et al., 2018) studied participants' sense of self-worth, concluding that their combined intervention led to higher self-worth over time, as well as relative to passive (waitlist) and active (PA-only and mindfulness-only) comparators.

3.14. Effects on PA

PA was an outcome of 13 included studies, out of which four measured it objectively (Casey et al., 2022; Garcia et al., 2023; Nymberg et al., 2021; Torkhani et al., 2021), six through self-report (Goldstein et al., 2018; Haugmark et al., 2021; Henninger et al., 2023; Johnson et al., 2015; Lyzwinski et al., 2019; Siripanya et al., 2023), and three studies used both types of measure (Rabin et al., 2016; Shi et al., 2019; Signore et al., 2022). Accelerometer-measured PA did not improve over the course of the intervention in the two pilot trials reporting this (Rabin et al., 2016; Shi et al., 2019), nor relative to passive (Rabin et al., 2016) or active control conditions (Nymberg et al., 2021; Shi et al., 2019; Casey et al., 2022, the latter being the only effectiveness trial using accelerometers). An exception to this was Garcia and colleagues' (2023) pilot, where intervention group increased the number of daily steps over PA-only control, even though the same effect was not found for active minutes.

Self-reported PA results were mixed: combined interventions led to increased PA in pre-post analyses (n = 4/4 [100%]; Johnson et al., 2015; Rabin et al., 2016; Shi et al., 2019; Siripanya et al., 2023; all but the latter pilots), and some of the time relative to passive comparators (n = 3/5 [60%]; in Goldstein et al., 2018; Rabin et al., 2016; Siripanya et al., 2023, but not in Johnson et al., 2015; Haugmark et al., 2021). Active

comparators yielded equivalent effects on PA based on the sparse data available (Lyzwinski et al., 2019; Shi et al., 2019). Two trials with objective measures and two using self-report did not perform inferential analyses on PA data (Signore et al., 2022; Torkhani et al., 2021 & Henninger et al., 2023; Signore et al., 2022, respectively).

4. Discussion

This systematic review aimed to synthesise and evaluate trials reporting on the effects of interventions combining PA with mindfulness-based approaches on mental health and wellbeing outcomes, and, where reported, PA engagement. The work provides a necessary assessment of this emerging field, highlighting the current lack of consensus, and research questions to be answered in future empirical work.

The review's principal takeaway is that combined interventions show promise, although the evidence base is presently insufficient to draw firm conclusions. We found considerable heterogeneity between study interventions, populations, methodologies, and quality, as well as a relative overabundance of pilot studies. Available data indicate that combined interventions are generally feasible to deliver and acceptable to a range of populations, if care is taken with recruitment and support provided for continued engagement with self-delivered components. Further full-scale effectiveness trials will be able to research the specific elements of combined interventions that make them effective, for whom, and under what circumstances (Michie et al., 2013; Yardley, Morrison, Bradbury, & Muller, 2015).

4.1. Combined interventions and psychological health

Evidence from 35 trials with 2243 total participants suggests that interventions combining PA and mindfulness training can improve psychological health outcomes across populations, despite variations in intervention protocols, durations, and delivery methods. Their broad effectiveness hints at the potential utility of combined interventions in a range of contexts and may suggest that similar mechanisms drive their effects—although further research into these drivers is needed to confirm this. Combined interventions are also safe, with few reported adverse events (generally not related to the intervention) and no studies reporting a deterioration in the intervention arm. Relative to passive controls, including waitlist and TAU, combined interventions effectively reduce symptoms of depression (6/6 trials [100%]), anxiety (4/7 [57%]), and stress (3/4 [75%]). There is currently mixed evidence comparing to active controls, with most trials reporting equivalent effects in PA-only arms (intervention favoured for depression in 1/10 trials [10%], 4/8 for anxiety [50%], 1/4 for stress [25%], and 1/5 for QoL [20%]). Data are presently sparse against mindfulness-only controls, although combination shows promise for improving rumination, emotion regulation, and self-worth over and above mindfulness training itself.

Population characteristics, particularly its clinical status, did not play a decisive role in intervention effectiveness. Across the 12 trials with non-clinical populations, 23/29 (79%) mental health outcomes improved in the intervention groups. Clinical samples with mainly physical conditions (17 trials) reported improvement in 19/25 (76%) comparisons, whereas clinical samples with psychiatric concerns (5 trials) saw their mental health outcomes improve in all 11 comparisons (100%). This could indicate particular value of combined interventions for populations with existing mental health concerns, for whom mindfulness training could be a valuable catalyst for participation in otherwise inaccessible PA (Roychowdhury, 2021). Yet, the current data is not yet robust enough to substantiate this: All but one trials were pilots and only one was rated methodologically strong. One pilot trial recruiting participants with both physical and mental symptoms (Rao et al., 2023) did not report a pre-post comparison.

Interventions delivered in all-female groups seemed particularly reliable at improving mental health in the intervention arm (6/6 trials reporting pre-post comparisons), although four were pilot studies and all had small sample sizes. While there is currently insufficient data to conclude that sex had an influence on the effectiveness of combined interventions, these findings may reflect the value of shared group identity (e.g., gender) for the effectiveness of health interventions. Previous work suggests that interventions with more varied member characteristics (e.g., mixed gender groups) may still be able to harness these effects by actively fostering social cohesion, in turn promoting higher attendance and enhancing the effects (Izumi et al., 2015). Alternatively, they may highlight the importance of carefully considering the target group's needs and tailoring the intervention to them, as advocated for by person-centred and co-creation approaches to intervention development (e.g., Yardley et al., 2015).

Other examples of good practice from reviewed effective interventions include adapting intervention content to the population's key concerns (e.g., ACT focusing on pain management in Casey et al., 2022), or providing personalised advice and demonstrations (Johnson et al., 2015). In contrast, some research has found that interventions relying solely (or largely) on self-delivery may be less effective than regular supervised sessions (e.g., Polaski et al., 2021; Rabin et al., 2016; Srisoongnern et al., 2021; Torkhani et al., 2021), highlighting the importance of cultivating a supportive intervention setting with regular check-ins to enhance adherence and fidelity. Providing separate (versus integrated) sessions of PA and mindfulness yielded comparable results—separate components led to improvements in 43/53 (81%) comparisons, integrated components in 12/14 (86%) comparisons—suggesting that the exact format of delivering combined interventions may be tailored to population preferences or optimised for scalability when targeting mental health. These pragmatic concerns can be balanced alongside insights from neuroscience literature, which stipulates that the greatest benefits to cognitive and executive control may be gained from tasks requiring simultaneous mental and physical effort (Herold, Hamacher, Schega, & Müller, 2018).

4.2. Combined interventions and PA levels

Although only a subset of the included studies measured participants' PA levels, the evidence suggests that combined interventions have equivalent effects on PA levels compared to control groups (except in Goldstein et al. [2018] and Siripanya et al. [2023], both self-reported relative to passive controls). The latter was the only effectiveness trial that observed a PA level increase (versus TAU), whereas Haugmark and colleagues' (2021) trial with a similar design did not, nor did Casey and colleagues' (2022) work comparing objectively measured activity to PA-only control.

In line with existing evidence (Dyrstad, Hansen, Holme, & Anderssen, 2014; Slootmaker, Schuit, Chinapaw, Seidell, & Van Mechelen, 2009), self-reported PA data suggests greater increases in PA levels than accelerometer-based data, at times giving conflicting results in the same studies (Rabin et al., 2016; Shi et al., 2019 – although both trials were primarily focused on exploring feasibility rather than effectiveness). Therefore, it is crucial to include objective measures of PA where possible, to ensure accurate assessment and interpretation of intervention effects on PA engagement.

4.3. Mechanisms of combined interventions

Few studies to date have explored mechanisms of change or attempted to determine 'active ingredients' of successful interventions (Michie et al., 2013). Several studies in this review provided psycho-educational support for engagement with PA, finding benefits to mental health. Examples include content on "goal-setting, understanding pain, managing setbacks" (Casey et al., 2022), personalised PA recommendations and techniques aiming to support adherence, like motivational interviewing (Haugmark et al., 2021). There was mixed

evidence for assisting with the transition from supervised to independent PA practice – this model of support was successful in a sample of adults with Parkinson's disease (Mitarnun et al., 2022) but not in a larger trial for non-cardiac chest pain (Mourad et al., 2022). Existing evidence from behavioural interventions therefore concurs with the notion that targeting psychological constructs (e.g., motivation, self-efficacy, goal-setting) is key to engagement and maintenance of PA behaviour, and that this is more effective than mere 'prescription' of PA—particularly in the long term (Samdal et al., 2017; Williams & French, 2011).

Previous research has captured effects of mindfulness training on psychological constructs related to behaviour change. Verhaeghen's (2021) review concluded that mindfulness training reliably improves one's attentional resources and executive control—cognition researchers affirm that partaking in PA can do the same (Leshem, De Fano, & Ben-Soussan, 2020; Pesce & Ben-Soussan, 2016). Increased attentional control, paired with the non-judgement that MBIs promote, enables better recognition and regulation of emotional states, as discussed in models of mindful or embodied emotion regulation (Chambers, Gullone, & Allen, 2009; Guendelman, Medeiros, & Rampes, 2017). Furthermore, mindfulness training facilitates the development of autonomous motivation, which is consistently associated with greater wellbeing and more sustained engagement in health behaviours (Donald et al., 2020; Ryan, Donald, & Bradshaw, 2021). Evidence also demonstrates increases in self-efficacy (Bowen et al., 2014; Moniz-Lewis et al., 2022), self-compassion (Ferrari et al., 2019; Quist Møller, L Shapiro, & Sami, 2019), and better coping with pain or discomfort (McClintock, McCarrick, Garland, Zeidan, & Zgierska, 2019; Zeidan, Grant, Brown, McHaffie, & Coghill, 2012) as a result of MBIs. These findings hint at the possible mechanisms involved in effects of combined interventions and should be explored in future work alongside intervention effectiveness.

However, the current evidence base is insufficient to be able to demonstrate that combined interventions of PA and mindfulness training indeed change above constructs or improve PA engagement. Notably, only two small-scale interventions to date tailored their mindfulness-based components to support PA engagement (Mousavi et al., 2023; Norouzi et al., 2023), which could help explain the relative lack of effects on participants' PA levels (Yardley et al., 2015). Future interventions aiming to change exercise participation should consider tailoring mindfulness training to support PA engagement and address relevant cognitive aspects to enhance intervention effectiveness. This could not only lead to increased PA engagement, but also make mindfulness training more tangible and immediately relevant to participants, in agreement with previous qualitative research (Remskar, Western, Maynard, & Ainsworth, 2022).

4.4. Strengths, limitations, and future research

We adhered to rigorous methodology and reporting guidelines (PRISMA) in providing an overview of this emerging field. Yet, the review is not without its limitations. Our scope and inclusion criteria were iterative throughout the screening process, as new dilemmas emerged (e.g., specifying that athlete's usual training does not qualify as PA component). This is characteristic of reviews of complex interventions (Kelly et al., 2017), where multiple intervention components and mechanistic pathways make defining a focus and eligibility more difficult than in simple reviews. Each change to the protocol was agreed by the research team and transparently communicated. The cut-off for PA and mindfulness being primary intervention components (> 50% intervention time) was set arbitrarily, meaning that we could have excluded valuable interventions that did not satisfy this criterion. We also excluded studies of yoga, tai chi, and other mind-body therapies where no purposeful teaching of mindfulness could be confirmed. While this allowed us to better delineate contributions of either component, it removed a substantial number of potentially relevant studies. Other work previously reviewed research in this area (e.g., Capon, O'Shea, & McIver, 2019; Pascoe et al., 2021; Yin, Yue, Song, Sun, & Wen, 2023).

The predominant inclusion of feasibility trials impeded our ability to draw firm conclusions regarding intervention effectiveness, yet signals the rapid growth of research on combined interventions. To strengthen the evidence base, pilot and feasibility trials should be followed up with full-scale randomised controlled trials, ideally including active (or multiple) control conditions. We know that several large trials are ongoing or forthcoming (e.g., Sylvia et al., 2023), indicating that the field may be shifting from feasibility to efficacy testing. Future research should also aim to measure process variables or adopt mixed-methods approaches to help elucidate the mechanisms of action in combined interventions, as well as who they work for; in what frequencies/durations; and how we can best deliver them to different target populations. We aim to update this review in the coming years to get a more complete picture of the effectiveness of interventions combining mindfulness training and PA for mental health outcomes, including a meta-analytic review and sub-group analyses (e.g., clinical vs. non-clinical samples, young vs. older adults), once sufficient data is available.

5. Conclusion

This review represents the first comprehensive synthesis and evaluation of existing literature on interventions combining physical activity and mindfulness training, with a focus on mental health and wellbeing outcomes. Although research into the combined impact of these behaviours is in its infancy, the evidence base offers promise that such interventions are feasible to administer and evaluate, are well adhered to, and point to favourable psychological health outcomes. Further research is needed to guide the development and establish robust evidence for the effectiveness of combined interventions, as well as delineate the mechanisms through which they work.

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Data statement

Supplementary materials are available through the University of Bath Research Data Archive and accessible at https://researchdata.bath.ac.uk/id/eprint/1331.

CRediT authorship contribution statement

Masha Remskar: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Max J. Western:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. **Emma L. Osborne:** Formal analysis, Validation, Writing – review & editing. **Olivia M. Maynard:** Conceptualization, Supervision, Writing – review & editing. **Ben Ainsworth:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data is available through the University of Bath Research Data Archive.

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Appendix A. Supplementary data

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