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Effects of nature-based mindfulness on pain and wellbeing for adults with persistent pain: a systematic literature review

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ABSTRACT

Background: Persistent pain (PP) is a complex mechanism affecting 35% to 51.3% of adults in the United Kingdom and is associated with significant reductions in quality of life. Understanding of PP and how best to treat it has developed over the past 50 years, but there is still a vacuum of research to inform novel applications for self-management. Mindfulness techniques and nature exposure have separately been found to have beneficial effects on general well-being and health. The integration of the two could produce much needed self-management strategies, improving quality of life in this patient group.
Objectives: To determine if nature-based mindfulness (NBM) interventions improve pain and quality of life in adults with PP.
Methods: Systematic literature review. Seven electronic databases were searched to identify quantitative papers investigating nature-based mindfulness and persistent pain. Included articles were appraised using the PEDro tool.
Results: A total of 362 studies were identified. Of these, three were included in the final review. All studies reported statistically significant improvements in self-reported scores for pain ($p \leq 0.001$–0.006) and depression ($p \leq 0.001$–0.000). Other outcomes, such as stress and fatigue produced mixed results.
Conclusion: Despite showing statistical significance in multiple outcomes, the minimal clinically important difference was not reached across all measures. Heterogeneity of interventions and outcomes, as well as methodological issues of internal and external validity, preclude definitive conclusions. Further research is required, employing explicit mindfulness interventions and outcome measures with greater relevance and specificity, as well as further investigation of theoretical mechanisms.

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Persistent pain; chronic pain; mindfulness; nature-based mindfulness; green space

Introduction

Persistent pain (PP) defines a continual pain experience lasting for more than three months [1]. The specific mechanisms behind PP are complex; however, there are commonly changes in central sensitization, involving increased sensitivity and pain response to sensory input [2]. Risk factors for developing PP are also complex, with socio-demographic, psychological, clinical, and biological factors as potential contributors [3]. PP represents the leading cause of disability and disease burden globally, and its prevalence is escalating [3]. PP can be highly debilitating to the individual and treatment is often multi-faceted and challenging [4]. The condition can have a negative effect on the individual's quality of life (QOL) [5] with a subsequent impact on family members, friends, and carers [6]. In the United Kingdom (UK) population it is estimated at 35% to 51.3%, with 10.4% to 14.3% of people having PP which is moderately or severely disabling [7]. The COVID-19 pandemic has increased the social threats associated with PP, including isolation, increased stress, and lack of access to treatment [8,9]. Globally, it is reported that for some nations, the burden of pain also consequently increased for those already diagnosed with PP during the pandemic [9].

Historically, management of PP has focused on pharmaceutical treatment, initially relying on opioid-based medications, progressing to the use of other medications, such as non-steroidal anti-inflammatory drugs and antidepressants [10,11]. Recent advances in evidence have, however, precipitated a decrease in opioid-based medications which are no longer advised in primary care, due to a lack of evidence for PP alongside the risk of adverse effects and addiction [1,12].

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Although medication continues to be an option within specialist pain management settings, in which opioids can be employed in some limited cases [13], there exists a need for holistic treatment modalities that go beyond shorter-term analgesic prescriptions. PP treatment modalities have evolved alongside developments in pain theory [14], which views pain mechanisms as a protector rather than a marker of tissue damage [15]. This divergence from a purely biomedical model of pain management, of which physiotherapy has played a leading role [16], has led to a range of initiatives such as mindfulness practices [17].

Mindfulness

A commonly held definition of mindfulness is cited as 'paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally' [18]. Mindfulness-based interventions (MBIs) are an umbrella term for a range of programs based on these principles of awareness, openness, acceptance, and the processing of attention [19,20]. These concepts have stemmed from mindfulness roots in Eastern Buddhist and Hindu traditions [21]. Mindfulness was introduced into the healthcare context with concepts such as Kabat-Zinn's 1982 [22] mindfulness stress-based reduction for chronic pain and MBIs are now widespread in Western medicine [23]. However, Western medicine can be defined as being evidence-based and historically examining different mechanisms compared with an Eastern medicine approach [24]. It is important to note therefore that in a healthcare context MBIs often use varied and isolated elements that are not representative of the full context of the original cultural settings [25].

MBIs have been utilized to influence a person's relationship with their pain rather than eliminating the experience, with the goals of improving their independence and QOL [26]. They have been implicated in the direct reduction of pain intensity, particularly with central sensitization mechanisms [17], possibly by affecting the processing of pain and by reducing anxiety about the future and the past [27,28].

Mindfulness can be present in untrained individuals as an innate characteristic disposition and also as a transient state, with sustained practice linked to increased dispositional mindfulness [29]. Lower levels of dispositional mindfulness are linked with increased susceptibility to rumination and catastrophizing, whereas higher levels are linked with increased self-regulation, engagement in acceptance-based pain strategies, and lower pain in multiple PP populations [30,31]. One mechanism behind this change in pain outcomes is explored in predictive processing theory. Expectations play a large part in perception, to the extent that negative expectations can lead to negative experiences despite positive inputs [32]. These prediction errors should be corrected with new information [33]; however, the process can become maladaptive. In PP, it is these maladaptive predictions that may be responsible for the persistence of pain, and phenomena such as pain sensation without painful stimuli [33]. Mindfulness facets such as attentional control or self-regulation may help people with PP to untie and change these ways of thinking [28,34]. The construct of mindfulness has a multitude of facets discussed in the literature with no current gold standard measure [35]. Five common facets of mindfulness have however been identified across multiple mindfulness measurement tools: observing, describing, acting with awareness, non-judgement of internal experiences, and non-reactivity to internal experiences [36].

There is mixed-quality evidence to support MBIs effectiveness in the treatment of PP [37–39]. They do however have an evidence-based treatment approach in other long-term conditions, such as chronic obstructive pulmonary disease [40], depression [41], substance misuse [42] and fatigue [43], and are recommended to promote self-management strategies in PP [1,44].

Nature-based mindfulness

Within MBIs, nature-based mindfulness (NBM) has emerged as a broad category of interventions stemming from practices such as Shinrin-Yoku, or forest bathing, which utilize the potential benefits of exposure to a forest environment [45]. Proposed mechanisms include a gentle attentive response, encouraging reflection and introspective thinking [46], stress reduction [47], or an evolutionary need for nature for well-being [48]. Nature exposure reduces the effort required to engage in MBIs, particularly for those new to mindfulness [49] and is also associated with the development of dispositional mindfulness [29].

There is cogent evidence linking NBM with positive health outcomes, with statistically significant improvements found in psychological, physiological and interpersonal measures in a recent systematic literature review and meta-analysis [20]. Given the importance of positive top-down protective factors [50], and the mechanisms by which natural environments could improve health outcomes linked to PP conditions such as reducing inflammation and levels of cortisol and lessening anxiety, the effectiveness of NBM as a treatment adjunct for PP is a pertinent question [51,52]. Furthermore, this accessible intervention may help to reduce health inequalities by providing an alternative to green exercise or group based green activities that may be limited by both mobility and fatigue levels for some PP populations.

Systematic literature reviews (SLR) exist examining NBM [20] and MBI for PP [26,38,39], as well as a non-systematic review exploring nature exposure and possible mechanisms for effects in PP [53]; however, there is no SLR combining NBM with PP. The aim of this review therefore is to determine if NBM interventions improve pain and QOL in adults with PP.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used when conducting this SLR [54].

Search strategy

The search strategy and terms (Table 1) were developed in consultation with a subject librarian and were drawn from background research of the literature concerning PP and NBM. The electronic databases used for the systematic search were AMED, CINAHL, SportDiscus and PsycINFO, Medline (*via* the EBSCO search engine), Cochrane Library, and Embase. These databases provide resources appropriate to allied health, physical and psychological therapies [55]. Snowballing was used to highlight further missed articles adding rigor to the search strategy [56]. Preliminary reading into NBM identified appropriate terminology, leading to a predicted heterogeneity of outcome measures (OMs) and comparators; therefore, these parameters were left open for the purpose of the search strategy.

Inclusion/exclusion criteria

Inclusion and exclusion criteria (Table 2) were agreed upon a priori. There was no historical limit placed upon the findings, due to mindfulness being a relatively new concept in Western medicine [57,58] To increase the number of possible papers, the terms included conditions such as fibromyalgia which are characterized by PP. Outcome measures were not specified as outlined in the search strategy but were judged by group discussion during screening. Papers were screened at title and abstract as well as at full text by all individuals working initially in two pairs and then discussed and agreed upon collectively.

Ethics

Ethically approved as low risk by scrutiny committee [59]

Data extraction

A data extraction table was designed following a recent SLR on MBIs for PP [38] and used for the included papers. Each included paper was assigned to a separate reviewer for extraction of data and the results were then discussed and verified collectively.

Quality appraisal

The Physiotherapy Evidence Database (PEDro) scale was used to appraise the quality of each paper. Despite potential issues highlighted with validity when used as an overall score [60], it has been shown to have 'fair' to 'good' reliability [61]. After discussion, the tool was also chosen in comparison to more complex tools due to its simplicity of use and increased chance of inter-rater reliability within the review team.

Results

Identification of studies

The initial database search yielded 368 articles, with one additional article found through snowballing, after removal of duplications ($n = 7$). Of these, 330 studies were excluded based on title, 27 on abstract, and two upon reading the full text, leaving three papers that met the inclusion criteria (Figure 1).

Table 1. PICO And search terms.

PICO component	Theme	Terms
Population	People with PP	'Chronic* pain' OR fibromyalgia OR 'persistent pain' OR 'pain syndrome' OR 'myofascial pain' OR migraine OR headache OR endometriosis OR 'chronic fatigue syndrome' OR 'visceral pain' OR neuralgia OR 'irritable bowel syndrome' OR 'inflammatory bowel disease' OR 'functional bowel disease*'
Intervention component 1	Mindfulness or nature-based mindfulness	Mindfulness OR meditation OR relax* OR 'Acceptance-Based Stress Therapy' OR 'Acceptance And Commitment Therapy' OR 'forest therapy' OR 'forest bathing' OR 'attention restoration' OR 'shinrin-yoku' OR ecotherapy OR 'eco*therapy' OR 'Nature-based therapy' OR 'Nature therapy' OR 'Nature-based Therapy' OR 'Wilderness therapy' OR 'Horticultural therapy' OR 'Restorative nature' OR 'nature contact' OR 'nature exposure' OR 'nature-based activities' OR 'nature-based intervention*' OR 'Nature involvement' OR 'Restorative garden' OR 'Healing nature' OR 'Healing garden*' OR 'Therapeutic nature' OR 'Therapeutic Garden*' OR 'Therapy garden*' OR 'Care garden*'
Intervention component 2	Natural environment	Forest* OR 'green space' OR 'nature-based' OR 'natural environment*' OR 'restorative environment*' OR 'restorative nature' OR 'nature exposure' OR garden OR outdoor* OR greenspace OR wilderness OR Woods OR Outdoor* OR 'Open space*' OR Park OR 'Green space' OR 'Green Gym' OR greenspace* OR 'Natural environment' OR 'Marine environment' OR 'Ocean wealth' OR 'Blue gym'

Table 2. Inclusion/exclusion criteria with justification.

Inclusion and exclusion criteria	Reason
Includes nature-based mindfulness therapy.	Relevance to research question.
Includes pain and/or quality of life outcome measures.	Relevance to research question.
Participants with PP.	Relevance to research question.
Papers yielding quantitative results.	Ability to compare outcomes and synthesize data [56]
Human adults over 18 years old.	Children are physiologically different from adults.
English language papers.	Avoidance of misinterpretation.
Full text available.	Prerequisite for appraisal.

Quality appraisal

Summaries of the critical appraisal process are shown in Table 3 as a PEDro score. All three studies were of at least ‘fair’ methodological quality. Two studies scored 6/10 indicating ‘good’ quality, and one study scored 5/10. Specific methodological challenges are highlighted within the discussion.

Participant characteristics

The three studies were published between 2016 and 2021 with a total of 266 participants. Sample sizes ranged from 33 to 169 participants. The studies were carried out in South Korea [62,63] and Catalonia [64]. The study types were a pragmatic randomized control trial [64], a randomized control trial [62], and a non-randomized control trial [63].

Two of the studies considered people with chronic widespread pain (CWP) [62,63] and one with fibromyalgia [64]. The average age ranged from 37.5 to 54.1 years. The participants in two of the studies [62,63] were recruited from the workforce of a public organization in Seoul, with the former excluding people requiring pain medication daily and participants over 65 years of age, whilst the latter excludes those not in full-time employment and women who have begun menopausal transition. The third study [64] recruited participants from a specialized unit within a hospital with demographic characteristics showing high levels of comorbidity, an older age group, predominantly female and with multiple years lived with illness, with the exclusion of people with severe mental disorders and neurogenerative conditions.

Interventions

The studies used different interventions, and none of them used an active control, although all three studies used a forest as their nature setting. One study [63] had participants spent two days in a forest setting combining guided mindfulness-based meditation with exercise, music therapy, forest activities, and social activities. Half an hour of the second day was spent engaged in mindfulness-based meditation and a total of eleven hours were spent in the forest. The control group was under instructions to carry out normal weekend activities, with a caveat of avoiding nature-based activities. One study [64] used a 12-week intervention of treatment as usual plus weekly 2-h sessions made up of nature-based mindfulness training and other interventions such as pain neuroscience education, exercise therapy, cognitive behavioral therapy, mindfulness training, and nature activity. The control group received a 12-week control of treatment as usual (education and pharmacological treatment). The third [62] used a single 4-h mindfulness-based mandala-coloring session in nature as an intervention, described as supervised coloring-in of a pre-drawn mandala while encouraging participants’ awareness of their emotions and surroundings. The control arm completed a 4-h urban bus tour.

Outcome measures

All three studies assessed outcome measures at the start and end of the intervention, and the 12-week study [64] also assessed mid-way. None of the studies carried out follow-up assessments. Two studies [62,64] included power calculations. Between-group baseline differences were calculated in each paper. Effect sizes and p-values were given for the outcome measures in the selected studies but confidence intervals were only provided by one study [64]. All the studies gained informed consent from participants and reported no conflict of interest.

Findings

All studies measured pain, fatigue, and psychological factors employing a range of instruments. Based on a statistical significance threshold of $p. < 0.05$ [65] all studies reported statistically significant reductions in pain experience and depression in the intervention group in contrast to the control group. All papers included at least one measure for physical or psychological outcomes and all but one [64] included a physiological marker.

Pain

All three papers found a statistically significant decrease in pain following treatment with large effect sizes. Two studies found a significant improvement in Visual Analog Scale (VAS) pain scores, ($p \leq 0.001$,

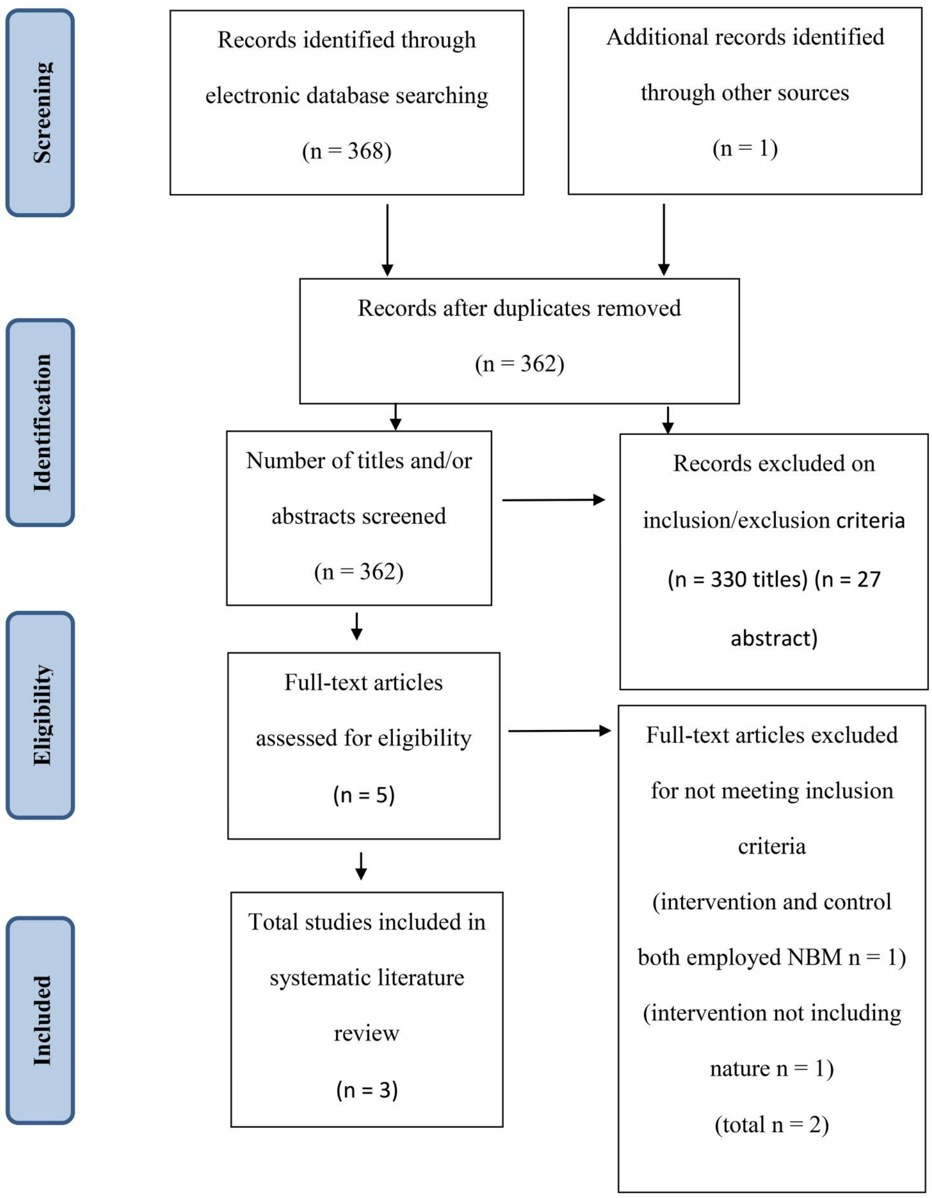

Figure 1. PRISMA flow diagram.

$d = 5.62$) [64] and ($p = 0.001$, $np^2 = 0.19$) [63]. The third study found a significant decrease in the number of tender points ($p = 0.006$, $np^2 = 0.205$) [62].

Fatigue

Two studies measured fatigue. One study found statistically significant improvements ($p \leq 0.001$) with a large effect size ($d = 0.93$) in fatigue using a VAS measure [64] while the other did not find improvement, using the Fatigue Severity Scale ($p = 0.133$) [62]

Depression

All three studies found statistically significant reductions in depression with large effect sizes, although the outcome measures varied. Outcome measures used were the Beck Depression Inventory (BDI) ($p = 0.001$, $np^2 = 0.16$) [63], the depressive symptom on the Stress Response Inventory-Modified Form (SRI-MF) ($p = 0.001$, np2 = 0.309) [62] and the Hospital Anxiety and Depression Scale (HADS) for anxiety ($p \leq 0.001$, $d = 1.59$) and depression ($p \leq 0.001$, $d = 1.45$) [64].

Stress

Two studies measured stress. Statistically significant improvements were seen in with total stress levels as measured by the Stress Response Inventory Modified Form (SRI-MF) (*p*. 0.001, $np^2 = 0.300$); however, improvements did not reach significance in anger (*p*. 0.011) and somatization symptoms (*p*. 0.016) [62]. No significant changes were seen using the perceived stress scale [64].

Quality of life

Two studies employed quality of life measures and found some outcomes to be statistically significant

Table 3. PEDro Scores.

PEDro item	Choi et al. (2021)	Han et al. (2016)	Serrat et al. (2020)
1) Eligibility criteria were specified	√	√	√
2) Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	√	X	√
3) Allocation was concealed	X	X	X
4) The groups were similar at baseline regarding the most important prognostic indicators	√	√	√
5) There was blinding of all subjects	X	X	X
6) There was blinding of all therapists who administered the therapy	X	X	X
7) There was blinding of all assessors who measured at least one key outcome	√	X	X
8) Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	√	√	√
9) All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by 'intention to treat'	X	√	√
10) The results of between-group statistical comparisons are reported for at least one key outcome	√	√	√
11) The study provides both point measures and measures of variability for at least one key outcome	√	√	√
Total score	6/10	5/10	6/10

with large effect sizes. One study found a significant change in the Euro Quality-of-Life Visual Analogue Scale ($p = 0.000$, $np^2 = 0.21$) [63]. Significant reductions ($p < 0.001$, $d = 1.83$) were found in the revised fibromyalgia impact questionnaire (FIQR), as well as the Short Form 36 Heath Survey Questionnaire physical functioning component ($p \leq 0.001$, $d = 1.59$) [64].

This study also separated the results of the Cognitive Emotional Regulation Questionnaire (CERQ), finding significant (all $p \leq 0.001$) improvements in three out of nine sub-sections with a large effect size; refocusing ($d = 0.99$), planning ($d = 0.83$), positive reappraisal ($d = 1.42$) and one showing medium effect size, perspective ($d = 0.71$) [64]

Two studies identified physiological biomarkers. A significant reduction in salivary cortisol was found with a large effect size ($p = 0.001$, $np^2 = 0.238$) [62]. Statistically significant positive differences with large effect sizes were found in measures of heart rate variability; electrocardiogram standard deviation of normal to normal ($p \leq 0.001$, $np^2 = 0.34$) and total power ($p \leq 0.001$, $np^2 = 0.23$), although heart rate did not decrease. They also found an increase in natural killer (NK) cell activity ($p \leq 0.002$, $np^2 = 0.15$) [63].

Discussion

This review aimed to ascertain if NBM interventions could improve QOL and pain in adults with PP. The selected studies found that NBM reduces pain by a large effect size compared to an inactive control, and this is a superior benefit to that found in previous reviews of both NBIs and MBIs. All studies showed a significant improvement in depression and QOL indicators in the intervention group in contrast to control. Two studies demonstrated clinically significant improvements in the measurement of biomarkers [62,63]. The methodological quality of the included studies was ranked as high for two studies and moderate for one although there are limitations to the included studies in regard to the risk of bias, heterogeneity in outcomes and lack of follow-up, the length and type of interventions and populations studied.

Randomization and blinding

Two studies randomized participants [62,64]. One study [63] did not randomly allocate participants, although this was in part mitigated by similar demographic characteristics of the two groups, with effort made to achieve parity of age and gender, indicating that systematic bias was minimized [65]. The study's source of funding raises the risk of unintended or unconscious bias, which randomization helps protect against [66].

The risk of bias could be inferred in all papers due to lack of allocation concealment, blinding of the therapists administering the interventions and of the assessors [63,64]. This should be qualified, however, given that the blinding of participants and therapists in behavioral interventions may not be plausible [67,68], and sham therapy was unrealistic given the nature of interventions [69]. Although it is not possible to disguise a nature setting, sham mindfulness has been used in other studies enabling participant blinding [28]. There were no significant differences in baseline measurements of participant demographics, apart from one study, with differences in sleep and age across groups [63].

Outcomes and measurement

A shortcoming of all three studies is the lack of follow-up outcomes, limiting the transferability to clinical practice. Final measurements were taken directly post-intervention in all cases. Hilton [38] recommends 6-to-12-month follow-up measurements for studies of PP which could help to ensure validity in measuring interventions in complex long-term conditions in which beneficial effects may be transient [65]. Although all studies reported significant reductions in self-reported parameters, the heterogeneity of OMs limits the results' synthesizability [70]. The disparity in OMs is a finding shared by previous SLRs of PP and MBIs, in which recommendations were made for a standardized criteria for assessing treatment effect [17,38].

Further limitations exist within the application of significant findings to practice as only one study [64] study considered clinical implications of their outcome measure, with analysis of the number needed to treat (NNT), which shows the number of patients to be treated to have a clinical impact on one patient [71]. Although of clinical significance, this differs from the patient-focused minimally clinically important difference (MCID). An MCID is a measure of the smallest difference that could be meaningful to a patient within a particular outcome measure [72]. MCID values are studied for some of the primary outcomes such as VAS pain although far from being standardised, there is considerable heterogeneity when applying them to PP [73]. Consideration of findings within the context of MCID would aid clinical interpretation although this would require clear reflection to apply clinically [73]

Pain

The findings are promising for the application of NBM in PP management. However, they could be facilitated by reduced stress levels from confounding variables such as participants having time away from their usual lives or feeling that their pain has been acknowledged; a powerful tool in the management of PP and associated conditions [74]. This is a difficulty of using multifactorial interventions, affecting the reliability and validity of the findings [75]. Pain and well-being are subjective experiences, with many OMs available to measure these [76]. MTPS and VAS-Pain were used to measure pain; concurrent validity has not been identified between these two OMs therefore establishing consistency between them is difficult. Although MTPS has been found to be sensitive and specific in the diagnosis of fibromyalgia [77], research indicating its effectiveness as an OM for the PP population is lacking. VAS-pain has been shown to be reliable, responsive, and sensitive to the PP population [78]. Breivik [79] recommends the utilization of multi-modal OMs for PP, arguing the validity of VAS is reduced by a failure to capture the condition's complexity, something employed to the credit of all three studies.

Quality of life and wellbeing

FIQR and CERQ are valid and reliable outcome measures for fibromyalgia populations, although these may be difficult to generalize to other populations [80,81]. The Stress Response Inventory was found to be valid and reliable; however, it was not assessed in the PP population [82]. One study did use a modified version; however, the development paper is not available in English so cannot be assessed [62,83]. The use of subjective outcome measures also presents challenges with floor and ceiling effects. This is especially pertinent as mobility issues are common in fibromyalgia and other PP conditions [84].

The other outcome measured in all three studies was depression, using varied OMs. There is conflicting research into the validity of HADS in persistent pain especially outside of an inpatient environment [85,86]. The BDI and SRI-MF have been validated for their use in identifying depression, although the BDI has been found to be unsuitable for PP populations [87,88].

Lastly, the use of biomarkers can be effective measures if they reflect diagnostic accuracy in a target condition [89]. Reductions in cortisol levels add to the validity of findings [62] given the link between PP and stress levels and findings of heightened cortisol levels in the PP population [51,90,91]. The increase of NKC activity found by [63] is less significant, given findings that indicate NKC activity is not significantly altered in PP conditions [92].

Mindfulness measures

No study assessed dispositional or state mindfulness. The concept of measuring behaviors associated with improved outcomes in PP is established in research. For example, self-compassion levels are associated with improved functioning [93]. One study [64] did measure and find changes in emotional regulation within the CERQ subsections of refocusing, planning, positive affect, and perspective which could be considered within the construct of self-regulation. There could be multiple benefits to measuring state or dispositional mindfulness as well as specific facets in NBM studies, both at baseline and after treatment. First, it would help improve understanding of the mechanisms behind NBM in treating PP, by providing evidence of whether changes in mindfulness traits are reflected in the patient's well-being and pain experience. Second, taking baseline measures would help ensure experiment groups are similar. Third, it could contribute to the understanding of what makes people more or less likely to respond to NBM, utilizing similar statistical analysis as in [64]. Finally, measuring changes in mindfulness can help resolve some of the difficulties of heterogenous NBM interventions, by providing evidence of changes in the level of mindfulness traits in response to treatment.

There is however no gold standard outcome measure for mindfulness and there are many instruments available. The Mindful Attention Awareness Scale (MAAS) [94] measures dispositional mindfulness and is cited as one of the most commonly used in research [95], which may ease implementation into studies and decrease heterogeneity. It has also been shown to have internal reliability in the PP population [96]. The Five Facet Mindfulness Questionnaire (FFMMQ) [36] is also much used due to its development from analysis of multiple tools and is suggested to provide superior analysis at a facet level, as opposed to the general measure of the MAAS [35]. This measure has also been validated in PP although this should be interpreted with caution as a modified form was used [97]. The use of both has been advocated for a more comprehensive measurement [31]. More recently, the Philadelphia Mindfulness Scale (PMS) [98] has been validated in a PP population and has been advocated for in MBI research [99]. In terms of state mindfulness measures, research is emergent and therefore less validated clinically although the Toronto Mindfulness Scale (TMS) [100] and the State Mindfulness Scale (SMS) [101] are the leading tools [102].

Data analyses

A withdrawal rate of 11.7% in the intervention group in one study [64] could cast doubt on the findings' significance, due to the risk of attrition bias whereby a systematic difference in an unknown variable in participants may be influencing the outcome rather than the hypothesized variable [103]. The authors did however compare baseline characteristics of dropouts versus non-dropouts, no significant differences were found, which decreases the suspicion of systematic attrition. However, reasons for dropouts were not explored, although this is recommended in order to fully understand any bias [104]. The withdrawal rate from the intervention group only may indicate that the intervention was not tolerated by or acceptable for the intended population [105] with implications for its utilization in clinical practice. However, the dropout rate was not large enough to affect the calculated sample size so there is a decreased risk of a type 2 error in which a false negative finding is concluded due to inadequate sample size and therefore power [106]. The authors did also perform an intention-to-treat analysis (ITT), whereby all participants are analyzed in the group they were allocated to, helping to produce a less biased estimate of the intervention's efficacy by preserving the randomization effect against confounding variables within groups [107]. They also used the last observation carried forward method to input missing data, where the last known value is used [108]. This is a commonly advocated approach although bias may be introduced due to missing data not being random in nature [108].

One study [63] had three dropouts from the control arm. The study recruited patients with the promise of receiving NBM treatment and therefore this could be a potential result of selection bias where participants' knowledge of and belief in the study's aims may result in bias. The study was however already underpowered and this along with a lack of management for missing outcome data the risk of a type 2 error.

Types of intervention

All studies used different forms of NBM and whilst there is no unequivocal definition of mindfulness [109], all studies used 'attention' and 'awareness' when describing their intervention, words that have been corroborated by Nilsson and Kazemi [110] in their work to thematize mindfulness. All three studies acknowledge that combining NBM with other treatments prevents isolation of the effects of NBM. Of the NBIs in two studies [63,64], only Shinrin-Yoku and nature photography in the former, and mindfulness-based meditation in the latter, could constitute NBM [111,112]. The inclusion of physical activity, which has well-evidenced benefits for PP [113,114], prescribed to intervention groups only, furthers this limitation. One study [64] provided some insight using intra-session assessment of individual activities and found Shinrin-Yoku resulted in significant improvements in a range of factors including pain, stress, and fatigue. However, these results were taken from measuring the short-term impact of activities, with potential cross-over effects of previous activities, and based on only 37 participants, without information on their characteristics.

External validity

Within the PP population in Western healthcare, there exists a disproportionately high number of older adults, those racialized as black and minority ethnic communities, and in areas of higher economic deprivation [115,116]. There is a marked overlap with these populations regarding reduced access to quality green space, especially in the light of widening inequalities due to COVID-19 [117]. This may prevent generalization of interventions to these populations and further exacerbate these inequalities. The results of the studies carried out in Korea [62,63] may not generalize to Western culture as concepts of nature depend upon contextual social and cultural constructs, for example, differences between European and Asian countries [118]. Practices such as Shinrin-Yoku have been reported as well accepted by participants of a Western culture [119]. However, further research is needed into diverse populations [120], including the at-risk PP populations identified above.

Only CWP/fibromyalgia was studied so there are questions about generalizability to other PP conditions. However, although each PP condition, as well as each person, has varied contributing factors, there are many key features of PP which are likely to be common to all PP conditions, increasing generalisability [121]. However, the CWP studies [62,63] only included people in employment, and one [62] excluded people using daily pain medication. These restrictions mean that the findings may not apply to people with higher levels of pain or disability.

Other individual characteristics of the studies may also impact the generalisability of this research; 40% ($n = 97$) of the participants were from South Korea [62,63], were 99% female [64], and recruitment was from a particularly distinct group of workers [62,63]. Age ranged from 37 to 54 years, which may make it difficult to generalize to the older or younger adult population. This is perhaps an oversight when figures show up to 86% of OAs experience PP [122,123]. Finally, In terms of clinical application, there is little agreement about MCID figures for chronic pain [73]. Their lack of use in the studies makes the stated results hard to interpret for clinical use.

Limitations of this study

Grey literature was not searched and hand searching was not undertaken. In addition, only English-language studies were included. A more thorough risk of bias tool could have been utilized when appraising the studies such as the Cochrane risk of bias tool; however, this tool was considered and the PEDro tool was chosen to promote higher levels of inter-rater reliability. Individual completion of the PEDro appraisal tool prior to group appraisal would have reduced bias; however, any disparities were discussed and agreed upon.

Conclusion

This review finds promising improvements in pain and QOL outcomes in adults with PP across three studies of moderate to high quality with a large effect size, delivered without significant adverse effects. This supports previous evidence showing that nature-based interventions and MBI can improve outcomes for PP patients. Two studies [62,63] provide interesting information regarding the use of short-term NBM in less severe PP populations, and the range of outcome measures in the final study provides potential insight into the mechanisms of NBM. [64]

Although the significance and effect sizes of benefits were encouraging, considerable methodological issues undermine the validity of results, as well as a small number of eligible studies. Heterogeneous OMs and difficulties capturing PP outcomes due to the complexity of pain processing lessen certainty in results. The clinical usefulness of results is also undermined by a lack of information on long-term outcomes, MCID interpretation, and limited generalisability of specialized participant characteristics, which may exacerbate existing inequalities. The inability to isolate NBM interventions reduces the impact of the results as a causal relationship between NBM and the outcomes cannot be explicitly implied. A definitive conclusion is therefore not possible and future research is recommended.

Future research

Future research recommendations include adequately powered studies with participants from clinically relevant and diverse populations, such as those with higher levels of pain and disability and from diverse ethnic and socio-economic backgrounds. The development of standardized categories for the mindfulness and the nature aspects of NBM would aid future analyses. Studies should be designed to allow isolation of the NBM variable for causal analysis and active controls used, ideally of a currently recommended non-pharmacological treatment or comparison of MBI with NBM.

Measurement of dispositional and state mindfulness should be considered, with measures of both general mindfulness and facet-level mindfulness. Measurement tools to consider that have some level of validation for PP include the MAAS, FFMMQ, or PMS for dispositional mindfulness and SMS or TMS for state mindfulness. This may aid the current understanding of theoretical mechanisms of action for NBM. Follow-up measures should be taken at six to twelve months and MCID for PP further developed and used to help clinical interpretation. Future research should attempt to estimate the cost of delivering NBM and ensuring that it occurs in a suitable natural environment that is accessible and equitable.

To further improve internal validity, future studies should ensure random allocation and assessor blinding, as well as accounting for loss to follow-up. Placebo effects should be minimized by avoiding the use of a single therapist for a long intervention, and selection bias reduced by avoidance of convenience sampling.

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Appendix A. Characteristics and results summary table

Study: Author, Year, Country	Total N	Age: Mean (Standard Deviation)	Gender: Male: Female	Drop out details	Pain-related diagnosis	Pain Duration I:C	Intervention	Comparator	PEDro Quality Rating (out of 10)
Choi et al. 2021, South Korea	36	I1: 41.7 (4.6) C1: 39.2 (6.4) I2: 47.4 (5.5) C2: 43.6 (4.9)	I1: 56%: 44% C1: 67%: 33% I2: 75%: 25% C2: 56%: 44%	I: 0% C: 7.69%	Chronic widespread pain	Not recorded	4 h of mandala colouring in natural recreation forest.	4-h urban bus tour.	6/10
Han et al. 2016, South Korea	61	I: 41.6 (6.5) C: 37.5 (8.4)	I: 48%: 53% C: 36%: 64%	I: 0% C: 0%	Chronic widespread pain	Months I: C: <3 3 7 3–6 4 3 6–12 9 5 12–24 4 3 24> 13 11	2-day weekend forest camp including 30 mins mindfulness meditation, forest walk, music therapy, education, and exercise.	Usual 2-day weekend excluding urban greenspace.	5/10
Serrat et al. 2020a, Spain	169	I: 54.1 (8.6) C: 53.1 (9.0)	I: 2%: 98% C: 0%: 100%	I: 11.7% C: 0%	Fibromyalgia	I: 16.75 years (9.74) C: 19.51 years (11.99)	Treatment as usual, plus 12 weekly 2-h sessions in a natural setting of pain neuroscience education, exercise therapy, cognitive behavioural therapy and mindfulness training.	Treatment as usual (education on fibromyalgia, advice on aerobic exercise, and pharmacological treatment).	6/10

Notes: I – Intervention (Only, 1, or 2). C – Comparator (Only, 1, or 2).

Study	Outcome measures:	Group	Pre-test M. (SD)	Mid-test M. (SD)	Post-test M. (SD)	Effect size	p
Choi et al. (2021)	Tender Point Pain	Intervention	7.52 (3.20)	n/a	3.81 (2.42)	PES = 0.205	0.006
		Control	6.73 (2.34)	n/a	5.67 (2.23)		
	Fatigue Severity Scale (FSS)	Intervention	41.19 (9.13)	n/a	37.90 (11.73)	PES = 0.065	0.133
		Control	42.93 (11.36)	n/a	44.73 (13.82)		
	SRI-MF Somatization Symptom	Intervention	11.71 (8.31)	n/a	7.29 (8.93)	PES = 0.158	0.016
		Control	13.53 (10.51) 1	n/a	12.87 (11.07)		
	SRI-MF Depressive Symptom	Intervention	9.48 (8.73)	n/a	6.05 (8.82)	PES = 0.309	0.000
		Control	9.27 (10.14)	n/a	9.73 (10.38)		
	SRI-MF Anger Symptom	Intervention	5.57 (4.63)	n/a	3.67 (5.16)	PES = 0.176	0.011
		Control	7.80 (6.20)	n/a	7.47 (6.45)		
	SRI-MF Total Stress Level	Intervention	28.10 (21.80)	n/a	18.05 (23.47)	PES = 0.300	0.001
		Control	32.13 (26.63)	n/a	31.53 (27.74)		
	Salivary Cortisol	Intervention	0.24 (0.15)	n/a	0.18 (0.13)	PES = 0.238	0.003
		Control	0.27 (0.20)	n/a	0.30 (0.21)		
Serrat et al. (2020a)	FIQR (0–100)	Intervention	73.07 (13.79)	58.78 (18.70)	50.69 (18.05)	*d* = 1.83	<0.001
		Control	73.21 (14.72)	69.68 (13.36)	69.18 (17.88)		
	VAS Pain (0–10)	Intervention	7.74 (1.52)	6.78 (1.99)	5.60 (1.98)	*d* = 5.62	<0.001
		Control	7.80 (1.61)	7.52 (1.59)	7.47 (1.79)		
	VAS Fatigue (0–10)	Intervention	7.61 (1.89)	5.98 (2.10)	5.58 (2.00)	*d* = 0.93	<0.001
		Control	7.76 (1.91)	7.32 (2.09)	7.08 (2.34)		
	HADS-A (0–21)	Intervention	13.95 (3.80)	11.03 (4.25)	10.16 (4.19)	*d* = 1.59	<0.001
		Control	13.13 (4.22)	12.35 (4.07)	12.68 (4.63)		
	HADS-D=(0–21)	Intervention	11.27 (3.71)	9.66 (4.47)	8.18 (4.42	*d* = 1.45	<0.001
		Control	11.49 (4.64)	11.22 (5.02)	11.67 (5.18)		
	SF-36 (0–100)	Intervention	27.03 (18.85)	35.09 (20.47)	43.42 (20.92)	*d* = 1.59	<0.001
		Control	26.04 (18.11)	28.24 (17.38)	25.07 (15.86)		
	PANAS-PA (0–50)	Intervention	11.95 (5.79)	12.81 (5.39)	14.11 (4.28)	*d* = 0.40	0.039
		Control	12.26 (4.38)	12.20 (4.30)	13.01 (4.03)		
	PANAS-NA (0–50)	Intervention	13.84 (6.08)	13.22 (4.83)	13.12 (4.24)	*d* = 0.28	0.167
		Control	14.34 (5.81)	13.94 (5.13	14.95 (4.50)		
	RSES (10–40)	Intervention	16.03 (3.36)	16.60 (2.70)	16.53 (2.25)	*d* = 0.03	0.809
		Control	15.41 (3.57)	15.48 (2.57)	16.25 (3.45)		
	PSS (0–16)	Intervention	8.93 (2.31)	7.91 (1.87)	8 (1.87)	*d* = 0.37	0.098
		Control	8.88 (2.15)	8.81 (1.90)	8.88 (2.20)		
	TSK (11–44)	Intervention	29.23 (7.40)	21.36 (6.83)	17.95 (4.97)	*d* = 2.2	<0.001
		Control	29.92 (7.58)	25.59 (6.46)	28 (7.44)		
	PCS (0–52)	Intervention	27.04 (11.33)	17.83 (9.56)	13.53 (8.87)	*d* = 2.03	<0.001
		Control	27.72 (12.65)	26.72 (13.25)	27.49 (13.35)		
	PPCS	Intervention	23.77 (7.98)	27.50 (8.08)	28.67 (8.62)	*d* = 1.2	<0.001
		Control	25.05 (7.84)	25.35 (8.22)	24.57 (8.50)		
	CERQ (0–20) Acceptance	Intervention	6.19 (2.27)	7.02 (2.12)	7.47 (2.15)	*d* = 0.53	0.012
		Control	6.46 (2.33)	6.28 (2.37)	6.77 (2.28)		
	CERQ (0–20) Self-blame	Intervention	4.47 (2.26)	4.24 (2.09)	3.74 (1.96)	*d* = 0.14	0.980
		Control	5.14 (2.39)	4.63 (2.01)	4.43 (2.13)		
	CERQ (0–20) Rumination	Intervention	5.89 (2.11)	5.36 (2.06)	4.70 (2.10)	*d* = 0.47	0.110
		Control	6.45 (2.33)	5.80 (2.21)	5.84 (2.48)		
	CERQ (0–20) Refocusing	Intervention	4.26 (1.92)	5.19 (2.11)	5.82 (2.20)	*d* = 0.99	<0.001
		Control	4.48 (1.94)	4.70 (1.99)	4.77 (2.13)		
	CERQ (0–20) Positive Reappraisal	Intervention	4.96 (2.42)	6.07 (2.26)	6.42 (2.28)	*d* = 1.42	<0.001
		Control	5.12 (2.11)	4.80 (1.77)	4.67 (2.23)		
	CERQ (0–20) Perspective	Intervention	5.45 (2.23)	6.03 (2.14)	6.46 (2.51)	*d* = 0.71	0.0002
		Control	5.45 (2.25)	5.52 (2.08)	5.23 (1.95)		
	CERQ (0–20) Catastrophizing	Intervention	5.27 (2.17	4.09 (1.83)	3.70 (1.72)	*d* = 0.85	<0.001
		Control	5.34 (2.37)	4.87 (2.07)	5.04 (2.21)		
	CERQ (0–20) Blame Others	Intervention	3.42 (2.20)	2.97 (1.62)	3.02 (1.72)	*d* = 0.11	0.620
		Control	3.45 (2.16)	3.20 (1.65)	3.20 (1.70)		
Han et al. (2016)	ECG SDNN	Intervention (*n* = 32)	51.86 (19.55)	n/a	73.50 (29.17)	MET PES = 0.11 ITG PES = 0.34	<0.001
		Control (*n* = 26)	60.60 (21.37)	n/a	53.43 (19.90)		0.014
	ECG TP	Intervention (*n* = 32)	2645.43 (1898.77)	n/a	5244.58 (4185.12)	MET PES = 0.10 ITG PES = 0.23	<0.001
		Control (*n* = 26)	3670.36 (2318.96)	n/a	3018.80 (2592.86)		0.097
	ECG HR	Intervention (*n* = 32)	77.09 (6.30)	n/a	76.21 (6.23)	MET PES = 0.12 MEG PES = 0.04	0.279
		Control (*n* = 26)	80.98 (8.06)	n/a	77.59 (7.55)	ITG PES = 0.05	0.021
	NK Cell Activity	Intervention (*n* = 33)	604.20 (754.92)	n/a	1131.56 (990.29)	MET PES = 0.31 ITG PES = 0.15	<0.001
		Control (*n* = 28)	1067.16 (908.15)	n/a	1194.80 (996.99)		0.098
	VAS Pain	Intervention (*n* = 33)	4.94 (1.62)	n/a	3.26 (1.69)	MET PES = 0.33 IG PES = 0.19	<0.001
		Control (*n* = 28)	4.63 (1.92)	n/a	4.30 (2.10)		0.246

(*continued*)

Continued.

Study	Outcome measures:	Group	Pre-test M. (SD)	Mid-test M. (SD)	Post-test M. (SD)	Effect size	p
	BDI	Intervention ($n = 33$)	15.06 (9.43)	n/a	8.12 (7.05)	MET PES = 0.44 IG PES = 0.16	<0.001
		Control ($n = 28$)	14.64 (9.67)	n/a	12.32 (9.99)		0.015
	EQ-VAS	Intervention ($n = 33$)	62.88 (16.78)	n/a	76.09 (16.34)	MET PES = 0.19 MEG PES = 0.1	<0.001
		Control ($n = 28$)	57.21 (23.14)	n/a	56.75 (24.35)	ITG PES = 0.21	0.884

Note on effect sizes: Serrat et al. (2020a) used Cohen's d, and Choi et al. (2021) and Han et al. (2016) used repeated measures ANOVA partial eta squared (PES). For Han et al. (2016), MEG: Main effects of Group, MET: Main effects of Time, IETG: Interaction Effect between Time and Group, IG: Interaction with Group.

Key: M: Mean, SD: Standard Deviation. BDI: Beck Depression Inventory, CERQ: Cognitive Emotion Regulation Questionnaire, EMA: Ecological Outcome Measures, EQ-VAS: EuroQol Visual Analog Scale, FIQR: Fibromyalgia Impact Questionnaire Revised, FSS: Fatigue Severity Scale, HADS: Hospital Anxiety and Depression Scale, ECG HR: Electrocardiogram heart rate, ECG TP: Electrocardiogram Total Power, ECG SDNN: Electrocardiogram standard deviation of normal to normal intervals, MTPS: Manual Tender Point Survey, NK: Natural Killer, PANAS: Positive and Negative Affect Schedule, PCS: Pain Catastrophising Scale, PPCS: Personal Perceived Competence Scale, PSS-4: Perceived Stress Scale, RSES: Rosenbern Self-Esteem Scale, SF 36: Short Form Survey physical functioning component, SRI-MF: Stress Response Inventory - Modified Form, TSK: Tampa Scale for Kinesiophobia, VAS: Visual Analogue Scale.