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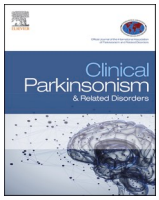

Non-Pharmacological interventions for managing fatigue in parkinson's disease: A systematic review and meta-analysis

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ABSTRACT

Background: Fatigue is a prevalent and disabling non-motor symptom in Parkinson's disease (PD), yet evidence for effective management strategies, particularly non-pharmacological approaches, remains limited.
Objective: To systematically review and *meta*-analyse the efficacy of non-pharmacological interventions aimed at reducing fatigue in people with PD (PwP).
Methods: MEDLINE, CINAHL and AMED were searched from inception to January 2026 for randomised controlled trials (RCTs) in which fatigue was a primary outcome. Risk of bias was assessed using the Cochrane RoB2 tool. Standardised mean differences (SMDs) were pooled using random-effects models, and certainty of evidence was assessed using GRADE. The protocol was registered with PROSPERO (CRD42023394180).
Results: Five RCTs (n = 270 participants) met the inclusion criteria, evaluating exercise-based interventions (3 trials, n = 142) and acupuncture (2 trials, n = 128). Exercise interventions were associated with a statistically significant reduction in fatigue compared with controls (SMD = − 1.34, 95% CI − 2.24 to − 0.44, p = 0.003), although heterogeneity was substantial (I2 = 89%). Acupuncture showed no significant effect compared with sham (SMD = 0.17, 95% CI − 0.13 to 0.51, p = 0.26), with low heterogeneity (I2 = 0%). Risk of bias was low in the acupuncture trials but rated as 'some concerns' for all exercise trials. GRADE assessment indicated low certainty evidence for exercise and moderate certainty evidence for acupuncture. Secondary outcomes such as quality of life and sleep were inconsistently reported and showed minimal change.
Conclusions: Exercise-based interventions show preliminary promise for reducing fatigue severity in PwP, but the evidence is limited by heterogeneity and methodological concerns. Acupuncture appears ineffective compared to sham. High-quality, adequately powered RCTs evaluating diverse non-pharmacological approaches, including psychological and self-management strategies, are urgently needed, using standardised PD-specific fatigue measures.

1. Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterised by motor symptoms such as bradykinesia, tremor, rigidity, and postural instability, primarily attributed to dopaminergic neuron degeneration [1,2]. However, the disease burden extends significantly beyond motor dysfunction. Non-motor symptoms (NMS), including fatigue, depression, cognitive impairment, sleep disturbances, and autonomic dysfunction, reflect widespread non-dopaminergic system involvement and profoundly impact quality of life [3,4]. NMS often precede motor onset, progress independently, and remain undertreated [5].

Among NMS, fatigue is particularly disabling, defined as a persistent, overwhelming sense of exhaustion disproportionate to activity [6]. Prevalence estimates in PD vary widely (one-third to almost 90%) depending on criteria and measurement tools [6–9]. PwP consistently rate fatigue as highly distressing, often more disabling than motor deficits, yet it remains under-recognised and inadequately addressed

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[10,11].

The aetiology of PD fatigue is multifactorial, potentially involving basal ganglia-cortical dysfunction, neurotransmitter imbalance (dopamine, serotonin), HPA axis dysregulation, neuroinflammation, and cardiac sympathetic denervation [12]. Clinical factors like motor demands, medication side effects, and psychiatric comorbidities (anxiety, apathy, depression) contribute [10,13–16], alongside environmental triggers like disrupted sleep [8]. This complexity suggests an interaction between central neurobiological mechanisms and behavioural/lifestyle influences [8].

Fatigue mechanisms may be shared across neurodegenerative disorders. In multiple sclerosis (MS), fatigue is linked to inflammation, cortical-subcortical disconnection, and coping styles [17,18]. In motor neurone disease (MND), it correlates with respiratory impairment and sleep disturbance [19]. In Huntington's disease (HD), fatigue overlaps with apathy and cognitive slowing [20]. This transdiagnostic nature suggests shared neurobiological and behavioural pathways [21–23], often implicating disrupted frontal and limbic circuit connectivity and altered neurotransmission [21,24,25]. This convergence supports a biopsychosocial model [18,26] that has informed fatigue interventions in MS and offers a framework for PD [17].

Despite the burden, consensus on effective PD fatigue management is lacking [11]. Fatigue tends to worsen over time, highlighting the need for early intervention [27]. Pharmacological trials have been largely disappointing; a Cochrane review found insufficient evidence to recommend agents like doxepin, rasagiline, modafinil, or methylphenidate [28]. Conversely, non-pharmacological strategies show potential. In MS, structured programmes (e.g., FACETS), exercise, energy conservation, and cognitive behavioural therapy (CBT) demonstrate efficacy [17,18,29]. In PD, these remain under-investigated [28]. Given the parallels, adapting and testing such approaches in PD is needed.

Despite strong evidence for cognitive behavioural therapy (CBT) in managing fatigue in multiple sclerosis and for mood symptoms in Parkinson's disease, it remains unclear whether CBT has been evaluated specifically for fatigue as a primary outcome in Parkinson's disease.

Measuring fatigue in PD is challenging due to its multidimensional, fluctuating, and subjective nature [6,30]. Tools often originate from other conditions. The Modified Fatigue Impact Scale (MFIS) [31], common in MS, has shown acceptable internal consistency in PD [32] but lacks comprehensive PD-specific validation. The Parkinson's Fatigue Scale (PFS-16) [33] is PD-specific, with good psychometric properties [34,35], but may underrepresent cognitive fatigue. The Fatigue Severity Scale (FSS) [36] is generic, with acceptable consistency in PD but less specific validity [35]. The Chalder Fatigue Scale (CFS) [37] has limited sensitivity to change in PD [38,39]. The lack of a validated, PD-specific gold standard hinders comparability and intervention research [6,30].

This systematic review and *meta*-analysis evaluates the efficacy of non-pharmacological interventions for reducing fatigue in PD. It aims to estimate effect sizes, assess study quality, identify gaps, and inform future research and clinical practice.

2. Methods

2.1. Review Registration and framework

The protocol was prospectively registered on PROSPERO (CRD42023394180) [40]. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [41] (Supplementary File 1).

2.2. Search strategy

MEDLINE (Ovid), CINAHL (EBSCOhost), and AMED (EBSCOhost) were searched from inception to 1 October 2024 (initial search 13 February 2023; updated 1 October 2024). Citation tracking and reference checking were performed. The search strategy combined controlled vocabulary (e.g. MeSH terms) and free-text keywords for "Parkinson's disease" and "fatigue", using randomised controlled trial filters (Supplementary File 2). Reference lists of included studies and relevant reviews were manually screened. Non-English language papers were excluded.

The PubMed database search was updated on 12 January 2026 to include studies published after the original search period; no additional randomised controlled trials meeting the inclusion criteria, specifically targeting fatigue as a primary outcome in Parkinson's disease, were identified.

2.3. Eligibility criteria

Studies included were: full-text, peer-reviewed RCTs published up to October 1, 2024; explicitly targeting fatigue as a primary therapeutic goal in adults with idiopathic PD; reporting fatigue outcomes using validated fatigue-specific measures (e.g., MFIS, FSS, MFI), reflecting the absence of a Parkinson's disease–specific fatigue measure at the time of trial design. This restriction was applied to maximise internal validity and ensure fatigue-targeted relevance, recognising it may reduce breadth.

Trials where fatigue was only a secondary or incidental outcome were excluded to maintain conceptual focus and reduce heterogeneity [6].

2.4. Risk of bias assessment

Two reviewers (SA, KD) independently assessed risk of bias using the Cochrane Risk of Bias 2 (RoB2) tool [42], selected for its domain-based evaluation specific to RCTs. Domains assessed were: (1) randomisation process; (2) deviations from intended interventions; (3) missing outcome data; (4) measurement of the outcome; (5) selection of the reported result. Studies were rated as low risk, some concerns, or high risk. Discrepancies were resolved by discussion. (Summary: Table 1; Details: Supplementary File 3). Blinding challenges in behavioural interventions were noted [43].

2.5. Statistical analysis

Meta-analyses used random-effects models. The primary outcome was fatigue severity. Standardised mean differences (SMDs) were calculated for pooling across different fatigue scales; mean differences (MDs) were reported if identical measures were used. Effect sizes followed Cohen's thresholds (small $\geq$ 0.20, moderate $\geq$ 0.50, large $\geq$ 0.80). Heterogeneity was assessed using Q statistic ($p < 0.05$) and I2 values (<25% low, >75% high). Publication bias was not formally assessed due to the small number of studies (<10). Certainty of evidence was assessed using GRADE [44–46], presented in a Summary of Findings (SoF) table (Table 4) and detailed evidence profiles (Supplementary File 4). Given the diversity of exercise modalities, this *meta*-analysis was undertaken on an exploratory basis to examine the direction and potential magnitude of effect rather than to provide a definitive pooled estimate.

2.6. Secondary outcomes

Available secondary outcomes (quality of life, sleep, depression, anxiety) were extracted and summarised narratively due to inconsistent reporting and measure heterogeneity. Use of PD-specific tools (e.g., PDQ-39 [47], PAS [48], GDS-15 [49]) was noted.

3. Results

3.1. Literature search

The search yielded 286 records. After removing duplicates, 13 full-

Table 1
Risk of Bias Summary Table (RoB2 Tool).

Study	Randomisation (D1)	Deviations (D2)	Missing Data (D3)	Measurement (D4)	Reporting (D5)	Overall Risk
Kluger et al. (2016) [50]	Low	Low	Low	Low	Low	Low
Kong et al. (2018) [51]	Low	Low	Low	Low	Low	Low
Abasi et al. (2020) [52]	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns
Ribas et al. (2017) [53]	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns
Wu et al. (2021) [54]	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns

Legend: Domains (D1–D5) correspond to the RoB2 tool [42].

text articles were screened. Eight were excluded (fatigue not a primary outcome). Five RCTs met the eligibility criteria (Fig. 1) [50–54]. This small yield highlights the scarcity of fatigue-targeted intervention research in PD.

3.2. Risk of bias assessment

Two studies (acupuncture trials) were rated low risk of bias [50,51]. Three studies (exercise trials) were rated as having some concerns, mainly due to the infeasibility of blinding participants/assessors and reliance on self-reported outcomes [52–54] (Table 1; Supplementary File 3).

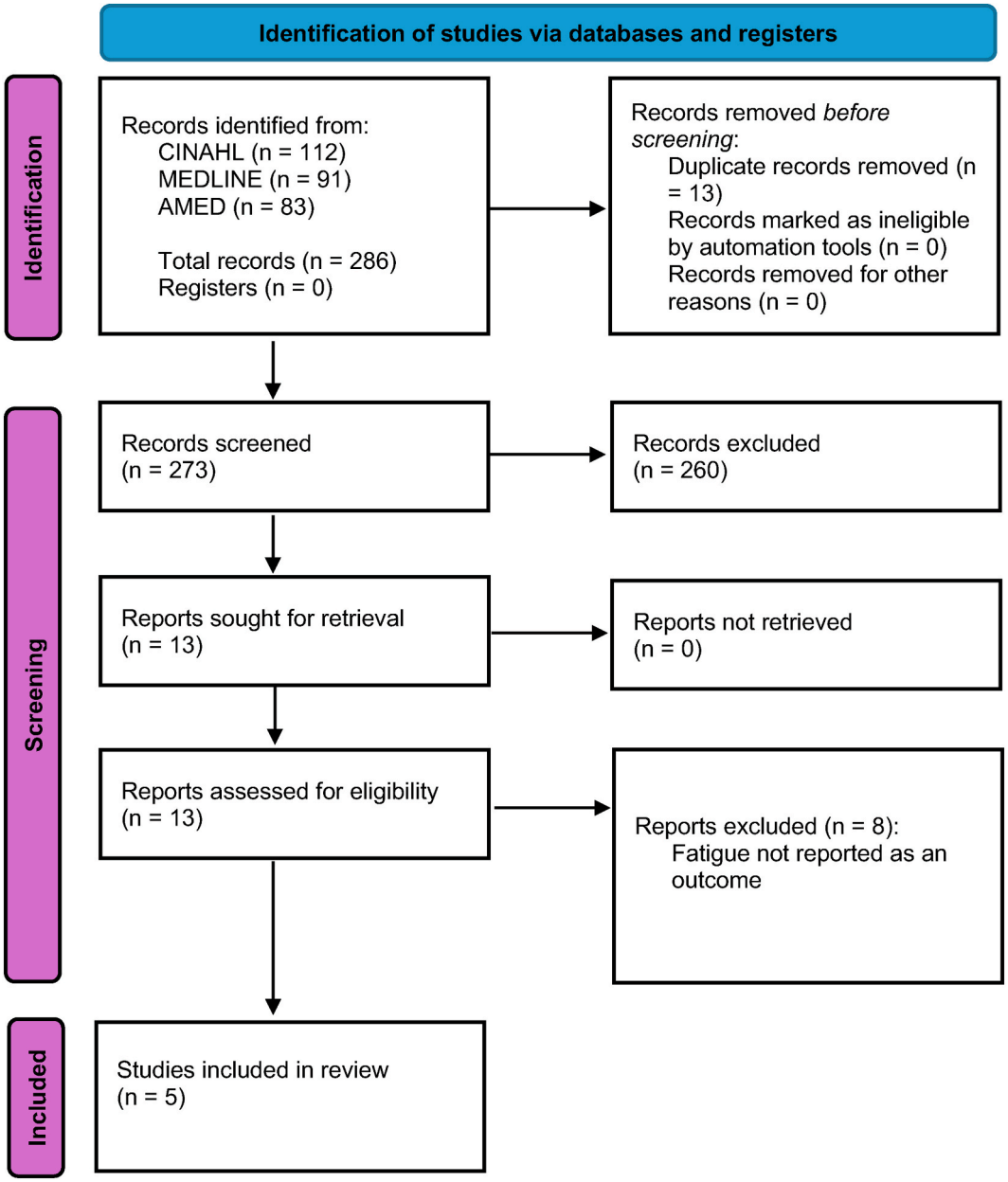

Fig. 1. PRISMA flow diagram illustrating the study selection process, including identification, screening, eligibility assessment, and final inclusion of studies in the systematic review and *meta*-analysis.

3.3. Study Characteristics

The five RCTs (N = 270 participants) were conducted in Taiwan, Iran, Singapore, Brazil, and the USA. Mean age was 64.7 years; 48.6% were male. Sample sizes ranged from 20 [53] to 98 [54]. Fatigue was assessed using MFIS [31], FSS [36] (including a Brazilian version), and the Multidimensional Fatigue Inventory (MFI). Diagnostic criteria varied: UK Brain Bank criteria [55] were used in two studies [50,53], NIH/NINDS criteria [56] in one [51], while two reported only Hoehn and Yahr staging [57] without formal criteria [52,54] (Table 2).

Notably, none of the included trials employed a Parkinson's disease-specific fatigue measure such as the Parkinson's Fatigue Scale (PFS-16).

3.4. Intervention Characteristics

Interventions included exercise (3 trials: vestibular rehabilitation [52], exergaming [53], home-based aerobic/resistance training [54]) and acupuncture (2 trials [50,51]). Exercise sessions were 30–60 min, 2–3 times/week for 8–12 weeks. Comparators were usual care or conventional physiotherapy. Acupuncture interventions (Traditional Chinese Medicine points) were delivered twice weekly for 5–6 weeks, using rigorous sham controls (toothpick stimulation or non-penetrating devices) (Table 3).

3.5. Meta-analysis

All five trials were included. Exercise interventions [52–54] showed a significant reduction in fatigue (SMD = -1.34, 95% CI −2.24 to −0.44, p = 0.003), but with substantial heterogeneity (I^2 = 89%). Acupuncture interventions [50,51] showed no significant effect versus sham (SMD = 0.17, 95% CI −0.13 to 0.51, p = 0.26), with no heterogeneity (I^2 = 0%) (Fig. 2).

3.6. Secondary outcomes

Secondary outcomes were inconsistently reported (Table 4). Quality of life (QoL), measured with PDQ-8 [58] or PDQ-39 [47], did not show significant between-group improvement overall [53,54], although Ribas et al. reported improvements in functional balance which may indirectly influence fatigue-related functioning [53]. Psychological outcomes (anxiety, depression) were rarely assessed with PD-specific tools (e.g., PAS [48], GDS-15 [49]); where measured with generic tools, changes were minimal. Sleep (PSQI [59]) was assessed in one trial [54] with no meaningful improvement observed.

3.7. Summary of Findings (SoF) and certainty of evidence (GRADE)

GRADE assessment indicated low certainty evidence for exercise reducing fatigue (downgraded for risk of bias and inconsistency) and moderate certainty evidence for acupuncture having little to no effect versus sham (downgraded for imprecision) (Table 5; Supplementary File 4). Evidence for effects on QoL, sleep, and adverse events was very low certainty

4. Discussion

This systematic review synthesized RCT evidence specifically targeting fatigue in PwP with non-pharmacological interventions, addressing a gap left by reviews focused on pharmacological treatments [28] or broader neurological populations [60].

The primary finding is the preliminary signal for exercise-based interventions may reduce fatigue severity, consistent with evidence in MS where exercise is a first-line strategy [17]. However, the substantial heterogeneity (I2 = 89%) across exercise modalities (vestibular, exergaming, aerobic/resistance), intensities, and comparators, coupled with methodological concerns ('some concerns' RoB rating for all exercise trials), limits certainty (GRADE: Low). The decision to pool exercise interventions was pragmatic and exploratory, intended to assess whether a signal of benefit existed across heterogeneous physical rehabilitation approaches rather than to imply equivalence between specific modalities. From a conceptual perspective, these interventions share common therapeutic targets related to deconditioning, motor efficiency, and activity tolerance, which provides a partial rationale for exploratory pooling. Nevertheless, the observed heterogeneity indicates that intervention-specific effects are likely, and pooled estimates should be interpreted with caution.

Greater standardisation in exercise trial design is needed [43]. Acupuncture, despite being tested in well-conducted, low-risk-of-bias trials with credible shams, showed no significant benefit over placebo for fatigue (GRADE: Moderate certainty, downgraded only for imprecision).

Outcome heterogeneity represents a major challenge in synthesising fatigue intervention trials in Parkinson's disease. While instruments such as the MFIS capture multidimensional aspects of fatigue, others focus primarily on severity, limiting direct comparability across studies. The absence of consistent use of Parkinson's disease–specific fatigue measures likely contributes to between-study variability and constrains clinical interpretation. Future trials should prioritise validated PD-specific tools, such as the Parkinson Fatigue Scale (PFS-16), to support standardisation, comparability, and cumulative evidence building.

Secondary outcomes like quality of life (QoL), sleep, and mood showed little improvement and were inconsistently measured. Notably, validated PD-specific tools like the PAS [48] or GDS-15 [49] were not used in the included trials assessing psychological outcomes [61–63]. This limits understanding of the broader impact of fatigue interventions and highlights the need to include patient-centred outcomes like fatigue self-efficacy [14].

The findings support a biopsychosocial and potentially transdiagnostic view of fatigue [18,26]. Shared mechanisms across neurodegenerative diseases, including basal ganglia-cortical dysfunction,

Table 2
Summary of Included Study Characteristics.

Study	Design	Country/ Region	Sample Characteristics	Fatigue Measure	PD Diagnostic Criteria
Wu et al. (2021) [54]	Parallel RCT	Taiwan	N = 98 (49 intervention; 49 comparator); mean age 65.1 years; 57.1% male; mean 5.3 years with PD	FSS	H&Y I-II [57]; no formal criteria cited
Abasi et al. (2020) [52]	Parallel RCT	Iran	N = 24 (12 intervention; 12 comparator); mean age 63.1 years; 41.5% male; mean 3.5 years with PD	MFIS	H&Y 1–4 [57]; no formal criteria cited
Kong et al. (2018) [51]	Parallel RCT	Singapore	N = 34 (18 intervention; 16 comparator); mean age 64.6 years; 32.5% male; mean 5.7 years with PD	MFI	Gelb et al. (1999) [56]
Ribas et al. (2017) [53]	Parallel RCT	Brazil	N = 20 (10 intervention; 10 comparator); mean age 61 years; 40% male; mean 6.8 years with PD	FSS-BR	UK Brain Bank criteria [55]
Kluger et al. (2016) [50]	Parallel RCT	USA	N = 94 (47 intervention; 47 comparator); mean age 63.7 years; 59% male; PD duration not reported	MFIS	UK Brain Bank criteria [55]

Abbreviations: FSS = Fatigue Severity Scale; FSS-BR = Brazilian FSS; H&Y=Hoehn & Yahr; MFI = Multidimensional Fatigue Inventory; MFIS = Modified Fatigue Impact Scale; N = sample size; PD=Parkinson's disease; RCT = randomised controlled trial; y = years.

Table 3
Characteristics of Interventions in Included Studies.

Intervention Type	Study	Intervention Details	Comparator	Comparator Details
Home-based exercise	Wu et al. (2021) [54]	30–50 min/session, 3×/week or 10–15 min/day; 150 min/week for 8 weeks. Supervised home-based aerobic and resistance training.	Usual care	Routine daily activities with no added exercise for 8 weeks.
Vestibular rehabilitation	Abasi et al. (2020) [52]	24 sessions (60 min), 3×/week for 8 weeks. Vestibular rehab including gaze stabilisation, eye–head coordination, and balance tasks.	Conventional exercise	24 sessions (35 min), 3×/week. Warm-up, stretching, and axial rotation.
Exergaming (digital exercise)	Ribas et al. (2017) [53]	Wii Fit (7 games), 30 min/session, 2×/week for 12 weeks (24 sessions). Supervised sessions using motion sensors.	Conventional physiotherapy	Stretching, resistance, and functional exercises. Same frequency/duration.
Real acupuncture	Kong et al. (2018) [51]	30 min/session, 2×/week for 5 weeks (10 sessions). 11 acupoints per session. Sessions spaced ≥ 3 days apart.	Sham acupuncture	Non-invasive acupuncture mimicking, same schedule.
Real acupuncture	Kluger et al. (2016) [50]	30 min/session, 2×/week for 6 weeks (12 sessions). Needling at 11 acupoints per participant protocol.	Sham acupuncture	Toothpick stimulation in guide tubes. Same frequency/duration.

Abbreviations: min = minutes; wk = weeks; wkly = weekly.

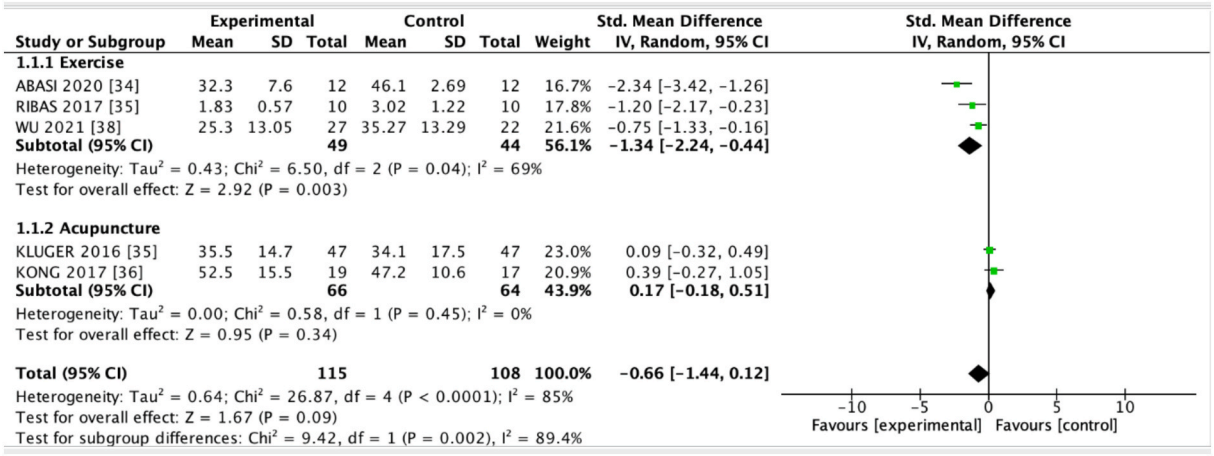

Fig. 2. Forest plot presenting pooled standardised mean differences (SMD) for fatigue outcomes comparing non-pharmacological interventions with control conditions in people with Parkinson's disease using a random-effects model.

Table 4
Secondary Outcomes Reported in Included Studies.

Study	Secondary Outcomes Assessed	Measurement Tools	Findings
Wu et al. (2021) [54]	Quality of life, sleep	PDQ-8 [58]; PSQI [59]	Minimal changes in QoL; negligible improvement in PSQI sleep scores.
Abasi et al. (2020) [52]	Activities of daily living	ADL scales	Small improvements in ADL, not specific to fatigue-related function.
Ribas et al. (2017) [53]	Quality of life, balance	PDQ-39 [47]; balance tests	No significant changes in PDQ-39; some improvements in functional balance.
Kong et al. (2018) [51]	None reported beyond fatigue	—	No secondary outcomes assessed.
Kluger et al. (2016) [50]	None reported beyond fatigue	—	No secondary outcomes assessed.

Abbreviations: ADL = Activities of Daily Living; PDQ=Parkinson's Disease Questionnaire; PSQI=Pittsburgh Sleep Quality Index; QoL = Quality of Life.

neurotransmitter imbalance, HPA axis dysregulation, neuroinflammation, and autonomic issues, are implicated in PD, MS, MND, and HD [21–23]. Neuroimaging suggests altered connectivity in frontal, limbic, and striatal networks is common [24,25,64–66]. These commonalities provide a rationale for adapting interventions effective in other conditions, such as CBT and energy conservation, for PD.

One of the most salient findings of this review is the complete absence of CBT trials specifically targeting fatigue in Parkinson's disease. CBT improves depression and anxiety in PwP [67] and is well-established for MS fatigue, targeting unhelpful beliefs, sleep hygiene, and behavioural activation [18]. Given fatigue's multidimensional nature in PD, CBT warrants investigation, potentially combined with exercise.

The evidence base is limited by the small number of eligible trials (n = 5), modest sample sizes (20–98), inconsistent use of PD-specific fatigue measures, and variable diagnostic criteria [55–57]. Notably, an updated literature search identified several recent RCTs in Parkinson's disease where fatigue was measured as a secondary outcome, highlighting ongoing interest in the symptom but reinforcing the scarcity of trials explicitly designed to target fatigue as a primary therapeutic outcome.

Methodological limitations in primary studies include difficulties with blinding in behavioural trials [43] and often inadequate reporting according to CONSORT extensions for non-pharmacological treatments [68] or TIDieR guidelines [69]. Blinding of participants and intervention providers was not feasible due to the behavioural nature of the included interventions, a recognised limitation of non-pharmacological trials, and all studies were limited to short-term follow-up, precluding assessment of long-term durability.

From a clinical perspective, the current evidence does not support definitive recommendations but offers cautious guidance. Supervised, multimodal exercise programmes may be considered for motivated people with Parkinson's disease experiencing fatigue, provided safety and individual capability are carefully assessed. Given the low certainty of evidence, such interventions should be framed as adjunctive and experimental, with realistic expectations discussed. The absence of

Table 5
Summary of Findings (SoF) — Non-pharmacological Interventions for PD-related Fatigue.

Population	Intervention	Comparator	Outcome (time point)	Effect (95% CI)	Certainty (GRADE)/Key reasons
Adults with idiopathic PD in RCTs	Exercise-based programmes (vestibular rehab; exergaming; home-based aerobic/ resistance)	Usual care/ conventional physiotherapy/minimal intervention	Fatigue severity (post-intervention)	SMD −1.34 (−2.24 to −0.44) — pooled from 3 trials ([52–54]), total N = 142	LOW — Downgraded for risk of bias (all 3 trials "some concerns") and inconsistency (I^2≈89%); imprecision noted.
Adults with PD in sham-controlled RCTs	Acupuncture (10–12 sessions over 5–6 weeks)	Credible sham acupuncture (non-penetrating/toothpick)	Fatigue severity (post-intervention)	SMD 0.17 (−0.13 to 0.51) — pooled from 2 trials ([50,51]), total N = 134	MODERATE — Downgraded for imprecision (CI spans small benefit to small harm); low RoB due to credible shams.
Adults with PD in RCTs	Exercise-based programmes	Usual care/active control	Quality of life (PDQ) — post-intervention	No pooled estimate; narrative: no clear between-group effect	VERY LOW — Imprecision, inconsistency of instruments/ reporting, and indirectness (QoL distal to fatigue target).
Adults with PD in RCTs	Exercise-based programmes	Usual care/active control	Sleep quality (PSQI) — post-intervention	No pooled estimate; narrative: negligible change	VERY LOW — Single small study reporting PSQI [54]; indirectness and imprecision.
Adults with PD in RCTs	Exercise or acupuncture	Usual care/sham	Adverse events (AEs)	Infrequently and inconsistently reported; no serious AEs attributed	VERY LOW — Sparse/unsystematic AE capture; imprecision.

Abbreviations: CI=Confidence Interval; PD=Parkinson's Disease; PDQ=Parkinson's Disease Questionnaire; PSQI=Pittsburgh Sleep Quality Index; RCT = Randomised Controlled Trial; RoB = Risk of Bias; SMD=Standardised Mean Difference.

evidence for psychological interventions targeting fatigue highlights an unmet need within multidisciplinary Parkinson's care.

Future trials should be adequately powered for fatigue as a primary outcome, adhere to reporting guidelines [68,70], and use standardised, ideally PD-specific, fatigue measures or core outcome sets. Qualitative data exploring patient experiences would enrich understanding. Following the MRC framework for complex interventions [71,72], next steps involve articulating programme theory, specifying interventions for replication (e.g., using TIDieR [69]), and conducting feasibility testing before definitive trials. Multimodal interventions integrating physical training, psychological therapies (like CBT), education, and self-management strategies, co-designed with PwP, are likely needed to address fatigue's complexity [14]. Future trials should incorporate longer follow-up periods (≥6 months) and adopt methodological strategies recommended for behavioural interventions to strengthen confidence in sustained fatigue outcomes.

5. Conclusion

Exercise-based interventions show preliminary promise for alleviating fatigue in PwP, but evidence certainty is low due to heterogeneity and methodological limitations. Acupuncture appears ineffective compared to sham. Evidence for other non-pharmacological approaches like CBT, occupational therapy, or mindfulness remains sparse in PD fatigue RCTs. The multidimensional nature of PD fatigue, likely involving shared mechanisms with other neurodegenerative conditions, suggests multimodal, theory-informed interventions integrating physical, psychological, and behavioural components are needed. Future research requires larger, methodologically rigorous RCTs with standardised PD-specific outcomes, prioritising patient-centred measures like self-efficacy alongside fatigue severity and adhering to reporting standards.

CRediT authorship contribution statement

Sarah Alageel: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Jane Hibberd:** Writing – review & editing, Validation, Supervision, Methodology. **Katherine H.O. Deane:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization.

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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.

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