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Effects of Different Neuromuscular Training Modalities on Balance Performance in Patients with Parkinson's Disease: A Systematic Review and Network Meta-Analysis of Randomized Controlled Trials

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ADMINISTRATIVE INFORMATION**Support -** No.**Review Stage at time of this submission -** Completed but not published.**Conflicts of interest -** None declared.**INPLASY registration number:** INPLASY202620010**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 3 February 2026 and was last updated on 3 February 2026.**INTRODUCTION**

Review question / Objective To systematically evaluate and compare the efficacy of different neuromuscular training (NMT) modalities—specifically Sensorimotor Training (ST), Proprioceptive Training (PT), Neurofunctional Training (NT), Whole-Body Vibration Training (WBVT), and Balance Training (BT)—on balance performance (assessed via TUGT and BBS) in patients with Parkinson's disease compared to control conditions or other exercise interventions.

Condition being studied The study population consisted exclusively of individuals with a confirmed clinical diagnosis of Parkinson's disease. The participants exhibited a broad spectrum of disease severity, with the majority of included trials involving patients classified between Hoehn and Yahr stages I and IV.

METHODS

Search strategy A comprehensive search will be conducted in five electronic databases: PubMed, Cochrane Library, Embase, Web of Science, and EBSCOhost. The search window extends from the inception of each database to January 7, 2026. The search strategy utilizes a combination of MeSH terms/Emtree terms and free-text keywords related to "Parkinson Disease," "Neuromuscular training," "Balance," and "Randomized Controlled Trial." No language restrictions will be applied. Reference lists of included studies and relevant reviews will be manually screened.

Participant or population Individuals with a clinical diagnosis of Parkinson's disease, regardless of disease stage (Hoehn and Yahr stages I-IV).

Intervention Intervention (I): Eligible studies investigated specific NMT modalities, including

sensorimotor training (ST), proprioceptive training (PT), neurofunctional training (NT), whole-body vibration training (WBVT), or balance training (BT).

Comparator Comparison (C): Comparisons were established either between exercise and control groups or among different exercise modalities. Control conditions included participants maintaining routine physical activity, receiving health education, performing stretching exercises, or continuing daily life habits. The experimental groups engaged in structured exercise training programs, potentially superimposed on the baseline activities of the control group.

Study designs to be included This review will exclusively include randomized controlled trials (RCTs) to ensure the highest level of evidence reliability. Eligible designs encompass parallel-group RCTs, cluster-randomized trials, and crossover trials (utilizing data from the first period only to avoid carry-over effects). Non-randomized interventional studies, quasi-randomized trials, and observational studies (e.g., cohort, case-control, or cross-sectional studies) will be strictly excluded from the synthesis.

Eligibility criteria 1. Inclusion criteria

The inclusion criteria were formulated based on the PICOS framework, encompassing five key dimensions: population, intervention, comparison, outcomes, and study design.

Population (P): Studies were eligible if they included participants clinically diagnosed with Parkinson's disease.

Intervention (I): Eligible studies investigated specific NMT modalities, including sensorimotor training (ST), proprioceptive training (PT), neurofunctional training (NT), whole-body vibration training (WBVT), or balance training (BT).

Comparison (C): Comparisons were established either between exercise and control groups or among different exercise modalities. Control conditions included participants maintaining routine physical activity, receiving health education, performing stretching exercises, or continuing daily life habits. The experimental groups engaged in structured exercise training programs, potentially superimposed on the baseline activities of the control group.

Outcomes (O): Studies were required to report objectively measured outcomes related to balance performance in patients with Parkinson's disease. Key outcome measures included dynamic balance assessments, such as the Timed Up and Go Test (TUGT), as well as static balance measures, such as the Berg Balance Scale (BBS).

Study Design (S): Only randomized controlled trials (RCTs), including cluster-randomized and crossover designs, were considered eligible for inclusion.

2. Exclusion criteria

Studies were excluded if they met any of the following conditions: (1) Non-original or grey literature such as reviews, dissertations, conference abstracts, or technical reports, which typically lack peer-review and standardized reporting, thereby increasing the risk of bias; (2) Lack of relevant outcome indicators related to balance performance; (3) Duplicate publications or repeated analyses, in which case the most recent or highest-quality version was selected; (4) Full text was unavailable, preventing quality appraisal and data extraction; (5) Studies that did not report both mean and standard deviation for balance outcomes, and for which the necessary data could not be extracted or obtained from the authors; (6) Non-randomized study designs; or (7) Unpublished studies were excluded, as they often lack sufficient methodological transparency and data accessibility for reliable meta-analytic synthesis.

Information sources PubMed, Cochrane Library, Embase, Web of Science, and EBSCOhost.

Main outcome(s) The primary outcomes of this review focus on the objective assessment of balance performance in patients with Parkinson's disease.

Dynamic Balance: Assessed using the Timed Up and Go Test (TUGT). Given the potential variability in measurement units or reporting scales across studies, the Standardized Mean Difference (SMD) with 95% confidence intervals (CIs) will be used as the effect measure.

Static Balance: Assessed using the Berg Balance Scale (BBS). As this outcome utilizes a standardized scoring system (0-56 points), the Weighted Mean Difference (WMD) with 95% CIs will be employed as the effect measure.

Timing: Outcome data will be extracted at the endpoint of the intervention (post-intervention). If studies report multiple follow-up time points, data from the time point immediately following the conclusion of the training program will be prioritized for analysis.

Quality assessment / Risk of bias analysis The methodological quality and risk of bias of the included randomized controlled trials will be independently assessed by two reviewers (W.G. and P.C.) using the Revised Cochrane Risk-of-Bias

Tool for Randomized Trials (RoB 2.0). Each study will be evaluated across five critical domains: (1) bias arising from the randomization process; (2) bias due to deviations from intended interventions; (3) bias due to missing outcome data; (4) bias in measurement of the outcome; and (5) bias in selection of the reported result. Based on the signaling questions within each domain, the overall risk of bias for each study will be categorized as "low risk," "some concerns," or "high risk." Any discrepancies in judgments will be resolved through rigorous discussion or, if necessary, by consulting a third reviewer (Y.Z.) to reach a consensus.

Strategy of data synthesis All statistical analyses and graphical presentations were executed using Stata software (Version 16.0, StataCorp, College Station, TX, USA). Given the potential variability in measurement units or reporting scales across the included trials for the Timed Up and Go Test (TUGT), the Standardized Mean Difference (SMD) along with 95% Confidence Intervals (CIs) was selected as the appropriate effect size to ensure comparability. Conversely, as the Berg Balance Scale (BBS) utilizes a standardized and uniform scoring system, the Weighted Mean Difference (WMD) with 95% CIs was employed to quantify the intervention effects.

The geometric structure of the evidence base was initially mapped through network plots, which visualized the direct comparisons among different intervention modalities, supplemented by contribution plots to delineate the weight of specific direct evidence to the entire network. To validate the fundamental assumptions of the network meta-analysis, statistical coherence was rigorously evaluated using a multi-dimensional framework comprising the loop-specific inconsistency test, the global inconsistency model fit, and the node-splitting method. Specifically, the consistency between direct and indirect evidence was deemed satisfactory if the 95% CIs derived from the node-splitting analysis encompassed zero, thereby confirming the suitability of the dataset for network synthesis.

The comparative efficacy of the interventions was synthesized and presented through pairwise forest plots and network league tables (inverted triangle format). To establish a hierarchy of treatment efficacy, the Surface Under the Cumulative Ranking Curve (SUCRA) was calculated, providing a probabilistic estimation to identify the optimal training modality. Furthermore, the potential for small-study effects or publication bias was inspected by examining the symmetry of comparison-adjusted funnel plots.

Subgroup analysis No subgroup analysis is currently planned. However, exploratory post-hoc subgroup analyses may be conducted if sufficient data become available or if significant heterogeneity is observed during the review process.

Sensitivity analysis No sensitivity analysis is currently pre-specified. However, post-hoc sensitivity analyses may be conducted to assess the robustness of the results (e.g., by excluding studies with high risk of bias) if deemed necessary during the data synthesis process.

Country(ies) involved China.

Keywords Neuromuscular Training, Balance, Parkinson, fall prevention, Network Meta-Analysis.

Contributions of each author

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