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Systematic Review

Efficacy of whole-body vibration training in the management of patients with COPD: a systematic review and meta-analysis

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) often presents with skeletal muscle dysfunction, which worsens prognosis. Whole-body vibration training (WBVT) has been proposed as an adjunct to pulmonary rehabilitation, but evidence of its clinical efficacy remains inconsistent. Objective: To evaluate the effects of WBVT on functional capacity, muscle strength, pulmonary function, and quality of life in individuals with COPD. Methods: A systematic review and meta-analysis were conducted following PRISMA guidelines and registered in PROSPERO. Only randomized controlled trials were included. Outcomes assessed included 6-minute walk distance (6MWD), five-repetition sit-to-stand test (5STS), pulmonary function, and quality of life. Results: Fifteen RCTs met the inclusion criteria. WBVT significantly improved functional capacity measured by the 6MWD (MD = 34.35 m; 95% CI: 13.67,55.04; GRADE: very low). Subgroup analysis revealed a clinically meaningful improvement compared with usual care (MD = 75.97 m; 95% CI: 58.65,93.30), but not when compared with active exercise interventions. For the 5STS, a clinically relevant gain was observed versus usual care (MD = -5.95 seconds; 95% CI: -10.76, -1.14), with no significant difference compared to conventional exercise. No statistically significant effects were found for FEV_1 or quality of life. Most trials presented high risk of bias, and evidence certainty ranged from low to very low. Conclusion: WBVT may offer benefits in walking distance and sit-to-stand performance only when compared with no rehabilitation exposure, a scenario that is unrealistic in contemporary clinical practice given the strong evidence supporting structured exercise-based pulmonary rehabilitation for COPD management.

Introduction

Chronic Obstructive Pulmonary Disease (COPD) imposes a substantial burden on global health, not only impairing pulmonary function but also leading to systemic manifestations such as skeletal muscle dysfunction, which significantly contributes to exercise intolerance and is considered a key predictor of mortality in this population. [1–5] Within this context, exercise training remains a core component of pulmonary rehabilitation and is strongly recommended to improve functional outcomes and reduce symptom burden in individuals with chronic obstructive pulmonary disease.[1,6] Among emerging approaches, Whole-Body Vibration Training (WBVT) has been proposed as a non-pharmacological therapeutic strategy aimed at enhancing neuromuscular performance in this population.[7]

Although interest in WBVT has grown, current evidence on its efficacy in chronic obstructive pulmonary disease remains fragmented and inconclusive. To date, ten systematic reviews have explored this topic.[7–16] However, only five included meta-analyses, and all synthesized a smaller number of randomized controlled trials than the present review. Notably, one review combined observational studies with randomized controlled trials, thereby limiting the strength of inference regarding efficacy, due to the inherent risk of bias and reduced methodological rigor in non-randomized designs. Moreover, various methodological weaknesses are evident across the literature, including restrictive eligibility criteria based on language and publication year, as well as a predominant focus on mechanistic outcomes over clinically meaningful

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endpoints.[7–16] Furthermore, the frequent inclusion of samples with narrow age ranges and limited disease severity hampers the generalizability of previous findings.

In light of these limitations, the present systematic review adopts broader eligibility criteria and a more rigorous methodological approach to more accurately evaluate the effectiveness of WBVT in individuals with chronic obstructive pulmonary disease. Accordingly, the objective of this review is to investigate, in adults diagnosed with COPD, whether WBVT, when compared with conventional exercise programs or no intervention, leads to improvements in functional capacity, muscle strength, pulmonary function, and quality of life.

Methods

This systematic review and meta-analysis were conducted in accordance with the methodological guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement,[17] and its protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the registration number CRD42024604020.

Eligibility criteria

Eligible studies were selected based on a predefined PICO framework (Table S1 -supplementary material), focusing on the efficacy of WBVT in individuals diagnosed with chronic obstructive pulmonary disease. No restrictions were applied regarding language or year of publication. Studies were excluded if they were literature reviews, conference abstracts, protocols, posters, or lacked sufficient data for analysis. Duplicate records across databases were also removed.

Information sources

A comprehensive search was conducted between October and August 2024 across the following databases: MEDLINE/PubMed, Cochrane Central Register of Controlled Trials (CENTRAL, Cochrane Library), Virtual Health Library (BVS), Physiotherapy Evidence Database (PEDro), and EMBASE. To ensure the review reflected the most up-to-date evidence, we performed an additional updated search in August 2025.

Search strategy

Search terms were designed using a combination of controlled vocabulary (e.g., Medical Subject Headings – MeSH) and free-text keywords. Boolean operators were employed to structure the queries, as detailed in Table S2 (supplementary material). Additionally, the reference lists of included studies and relevant systematic reviews were manually screened to identify potentially eligible articles not captured by the initial search.

Study selection

Two reviewers (IGNA and CJO) independently performed the screening and selection of studies. The process involved a first phase of title and abstract screening, followed by full-text analysis to confirm inclusion eligibility. Any disagreements were resolved through discussion and consensus. In cases of missing or unclear data, the corresponding study authors were contacted for clarification.

Data extraction

Data extraction was carried out independently by two reviewers (IGNA and CJO) using a standardized and pre-piloted form. The extracted information included: Study identification (first author, year, country); Population characteristics (sample size, age, sex, chronic obstructive pulmonary disease severity, inclusion/exclusion criteria); Outcomes assessed (measurement tools, timing of assessments, blinding, and primary/secondary outcomes); Intervention characteristics (detailed description of WBVT and control interventions); Main findings and authors' conclusions. Discrepancies between reviewers were resolved through consensus to ensure data consistency.

Assessment of methodological quality and certainty of evidence

The methodological quality and risk of bias of the included controlled were evaluated using the Cochrane Risk of Bias 2.0 (RoB 2.0) tool, which assesses five domains: randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of the reported results.[18] Studies were classified as having low, high, or unclear risk of bias.

The overall certainty of the evidence was appraised using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach,[19] which considers risk of bias, inconsistency, imprecision, indirectness, and publication bias. The quality of evidence was categorized as high, moderate, low, or very low. Ratings were assigned independently by two reviewers, with any inconsistencies resolved by discussion.

Effect measures

The primary outcome was functional exercise capacity, measured by the six-minute walk test (6MWT) or six-minute step test (6MST), reported as mean difference (MD). Secondary outcomes included: Peripheral muscle strength: five-repetition sit-to-stand test (5STS), modified Medical Research Council (mMRC) scale, dynamometry, maximal voluntary contraction (MVC) - MD; Respiratory muscle strength: maximal inspiratory pressure (MIP) - MD; Pulmonary function: spirometric indices – MD; Symptom severity: chronic obstructive pulmonary disease Assessment Test (CAT) and modified Borg scale (mBORG) - MD; Oxygenation: MD; Physical functionality: reported as standardized mean difference (SMD); Health-related quality of life: MD.

Synthesis methods and effect measures

In the meta-analysis, the effect estimates for mortality were demonstrated as relative risk. For the other variables, the combined effect estimates were expressed as the mean difference between the groups. Statistical heterogeneity was assessed via the Cochran Q test and the I^2 test, in which values above 40% were considered moderate to high heterogeneity. Effect measure calculations were performed via a fixed or random effect model, considering the heterogeneity of the pooled data. Two sensitivity analyses were conducted to investigate the potential effects of certain studies on heterogeneity and the overall effect. The analysis was conducted via Review Manager version 5.3 (Cochrane Collaboration). For continuous outcomes assessed using different measurement scales across studies, we calculated the standardized mean difference (SMD) with 95% confidence intervals. This approach allows for the pooling of results by standardizing the effects, facilitating comparison across heterogeneous instruments. When means and standard deviations were not reported, they were estimated from medians and interquartile ranges using the method proposed by Wan et al. (2014),[20] Follmann et al 1992,[21] Luo et al 2018[22] and Cochrane Handbook for Systematic Reviews of Interventions[23] which provides validated equations for approximating parametric statistics from non-parametric summary data.

Results

Study selection

The initial search yielded 104 records, of which 53 were identified as

duplicates and subsequently removed. Following the screening of titles and abstracts, 51 studies were deemed potentially relevant and retrieved for full-text evaluation. After detailed assessment, 36 studies were excluded, with reasons documented in the PRISMA flow diagram (Fig. 1). Additionally, one eligible study was identified through manual reference searching. In total, 15 randomized controlled trials met the inclusion criteria and were included in the final synthesis. In two of these studies,[24,25] only the abstracts were available, and the authors were contacted to request access to the full texts, which remained pending at the time of submission.

Characteristics of included trials

The included randomized controlled trials were published between 2012 and 2021, with sample sizes ranging from 10 to 74 participants and a median sample size of 33.8 participants (IQR: 20 - 53.8). The mean age of participants ranged from 58 to 69 years. Most trials enrolled both male and female participants, although a predominance of males was observed overall. Baseline characteristics such as age, sex distribution, and clinical parameters were generally balanced across intervention and control groups. Complete references for the included studies are presented in Table S3.

Functional exercise capacity was primarily assessed using the six-minute walk test (6MWT), reported in all but one of the 15 included trials.[26] The sit-to-stand test (STS) was evaluated using two variations: the five-repetition STS (5STS) in seven studies,[24,27–32] and the one-minute STS (1minSTS) in five studies.[24,29,30,32,33]

Health-related quality of life (HRQoL) was assessed using the Chronic Respiratory Disease Questionnaire (CRQ) in four trials [27,30,31,34] and the St. George's Respiratory Questionnaire (SGRQ) in six trials.[25,28,33,35–37] Peripheral muscle strength was mostly measured by isometric knee extension, employed in four studies. [26,29,32,34]

Across studies, the WBVT intervention protocols frequently included static and dynamic squatting exercises, either as the sole training modality or in conjunction with vibration. Approximately half of the included trials implemented a 12-week intervention period. The vibration parameters varied considerably across studies; however, the most frequently reported settings included frequencies between 24-26 Hz, peak-to-peak amplitudes of 1.5-3 mm, and the use of side-alternating vibration platforms. Exercise intensity was the least consistently reported parameter, explicitly described in only one study[38] [38] which also documented a single mild adverse event that did not interrupt the intervention.

Regarding control interventions, five trials compared WBVT with usual care (no exercise), while ten trials used active control groups involving various exercise modalities. Further details concerning both WBVT and control group interventions can be found in Tables S4 and S5.

Meta-analysis

6-minute walk test

The meta-analysis was conducted using Review Manager 5.4 software, considering the mean difference in distance covered during the 6-Minute Walk Test (6MWT), the primary tool used in the included studies and a key marker of functional capacity. Of the fifteen studies analyzed in this review, eleven were included in the meta-analysis. Two clinical trials[26,33] were excluded due to reporting data as medians, and two other studies[24,25] were not included due to lack of full access to their datasets.

In the overall analysis comparing WBVT alone (only in Neves et al study [36], the control group performed WBVT alone) or combined to exercise vs control groups (no exercise and exercise-based interventions), a mean difference of 34.35 meters (95%CI: 13.67, 55.04) was observed in favor of WBVT ($p = 0.001$; $I^2 = 78\%$; random-effects model; GRADE: very low).

Given the high heterogeneity, a subgroup analysis was performed. WBVT was compared with usual care (without exercise) in four studies,

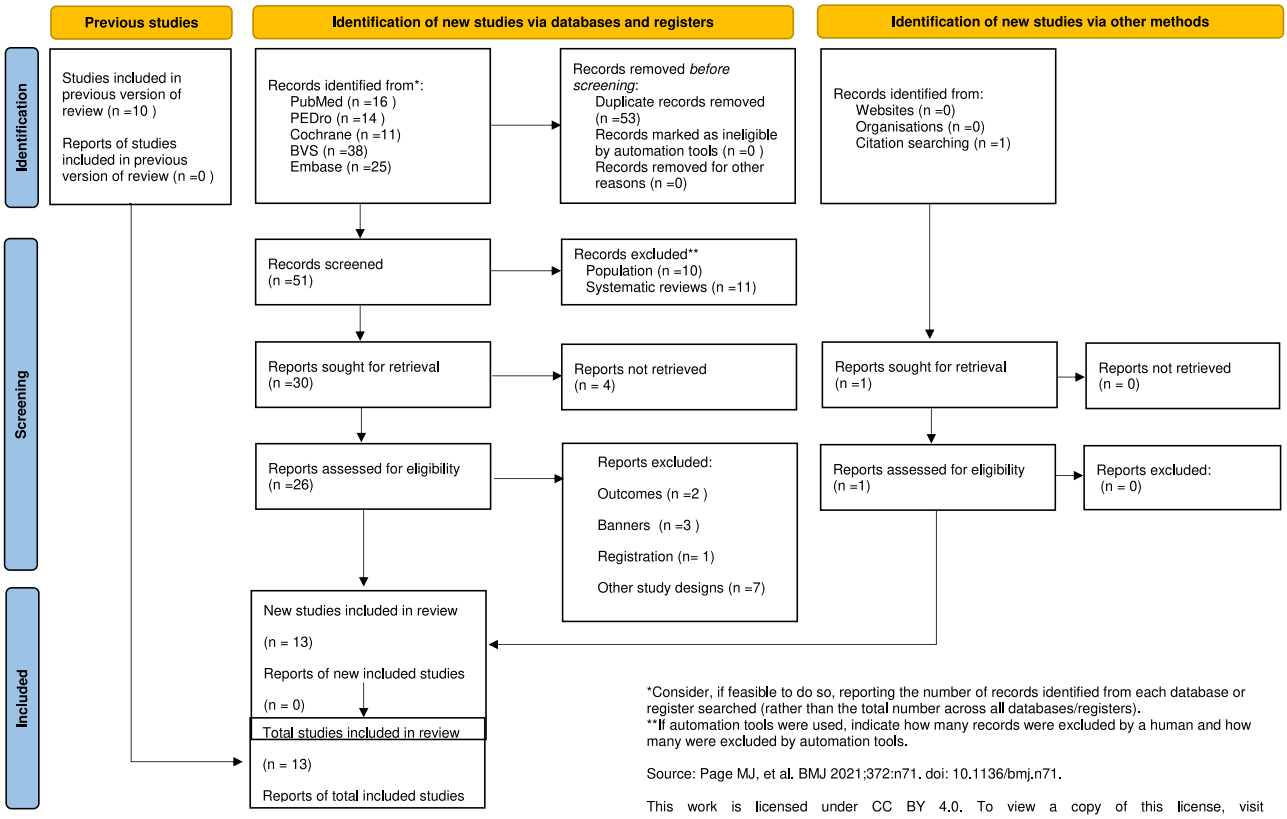

Fig. 1. Flowchart of the search strategy.

and the effect favored whole-body vibration training, with a mean difference of 75.97 meters (95% CI: 58.65, 93.30; $p < 0.00001$; $I^2 = 0\%$; GRADE: low). In contrast, seven studies compared WBVT to other forms of exercise and showed a mean difference of 13.06 meters (95%CI: -1.17, 27.30; $p = 0.07$; $I^2 = 32\%$; GRADE: moderate), indicating no clinically significant superiority of WBVT in this context (Fig. 2).

Considering that two non-randomized studies (Cardoso et al. and Neves et al.)[36,37] were included and were consequently penalized in the RoB 2.0 assessment, and given that the overall heterogeneity (I^2) was low, all studies were retained in the meta-analysis. It is also important to note that only the study by Cardoso et al. [37] implemented a formal exercise protocol consistent with pulmonary rehabilitation guidelines, incorporating both aerobic and resistance training.

Five times sit-to-stand test

Five included studies assessed the effect of WBVT compared to control groups (usual care - two studies - and physical exercise). The analysis revealed no statistically significant differences in the five times sit-to-stand test performance between the WBVT and control group (mean difference: -1.94; 95% CI: -4.11, 0.24; $I^2 = 81\%$; random-effects model; GRADE: very low).

Considering the high heterogeneity, a subgroup analysis was performed. WBVT was compared with usual care (without exercise) in two studies, and the effect was favorable to WBVT, with a mean difference of -5.95 (95% CI: -10.76, -1.14; $p < 0.00001$; $I^2 = 0\%$; GRADE: very low). However, when WBVT was compared with exercise-based interventions, no statistically significant difference was observed (mean difference: -1.24; 95% CI: -3.68, 1.21) (Fig. 3)

For the sit-to-stand (STS) outcome, only one non-randomized study (36) was included (penalized in the RoB 2.0 assessment), and in this case, heterogeneity was high. Accordingly, we conducted a sensitivity analysis excluding this study. Its removal did not modify the pooled effect estimate nor did it meaningfully reduce heterogeneity, thereby supporting the robustness of the findings.

Saint George's Respiratory Questionnaire (SGRQ)

No significant difference was observed when comparing WBVT to control groups (mean difference: 5.99; 95% CI: -1.14, 13.12; GRADE: very low) (Fig. 4). Considering that one non-randomized studies were included in the meta-analysis and were penalized in the RoB 2.0 assessment, and although the observed heterogeneity (I^2) was low, we conducted a sensitivity analysis to determine the true impact of these studies on both heterogeneity and the final pooled estimates. No differences were detected in the sensitivity analysis, and therefore, the studies were retained in the meta-analysis.

As one non-randomized study (Cardoso et al.)[37] was included, it was accordingly downgraded in the RoB 2.0 assessment. Nonetheless, heterogeneity (I^2=0%) for this outcome remained low, which supported the decision to retain the study in the meta-analysis. It is also important to highlight that Cardoso et al. was the only trial to implement a structured exercise protocol aligned with pulmonary rehabilitation standards, incorporating both aerobic and resistance training.

Forced expiratory volume in 1 second (FEV_1)

No significant difference was observed between WBVT and control groups (mean difference: -2.92; 95% CI: -16.29, 10.44; GRADE: very low) (Fig. 5).

Risk of bias assessment

The risk of bias among the included trials was assessed using the Cochrane Risk of Bias 2.0 (RoB 2.0) tool, which revealed a predominance of high risk of bias across the studies. One trial (36) did not implement random allocation of participants, while another[37] failed to report details regarding the randomization process. Regarding participant blinding, it is noteworthy that only one study in this review successfully incorporated a sham-controlled design to blind participants. [25] Given the nature of the intervention (WBVT), blinding of intervention providers was not feasible in any of the included trials.

In terms of blinding of outcome assessors, four studies [27,30,33,35] did not report whether assessors were blinded, introducing further risk of detection bias. Domain 3 of the RoB 2.0 tool, which evaluates missing outcome data and adherence to the intention-to-treat principle, had the greatest negative impact on the overall risk of bias assessment. Notably, only one trial[26] conducted an analysis including all randomized participants, in accordance with intention-to-treat principles. A summary of the risk of bias assessments is presented in Fig. S1.

GRADE: certainty of evidence

The certainty of the evidence, assessed using the GRADE approach, ranged from moderate to very low for the 6MWD outcome. For the other

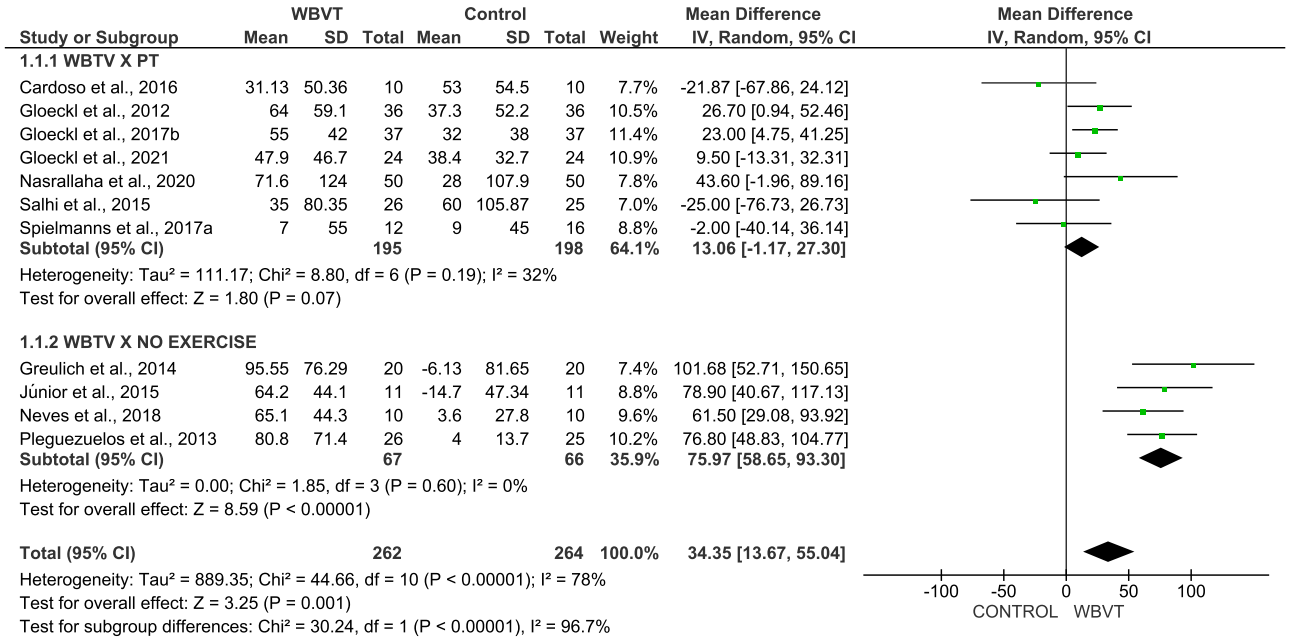

Fig. 2. MD and 95% CI for 6MWD for whole-body vibration training alone or combined vs usual care or exercise.

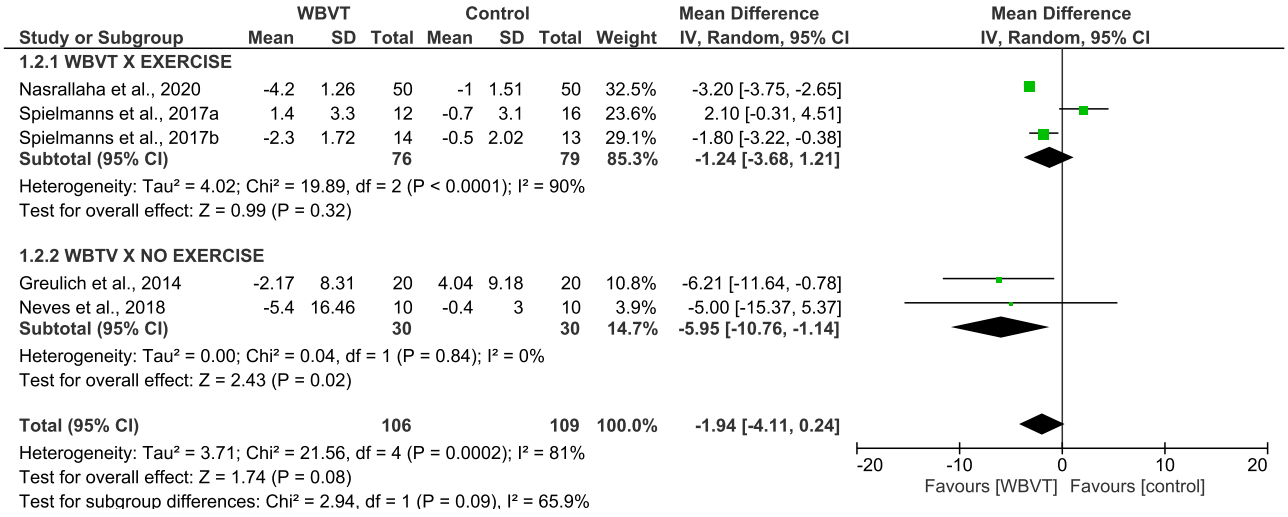

Fig. 3. MD and 95% CI for 5xSTS for whole-body vibration training alone or combined vs usual care or exercise.

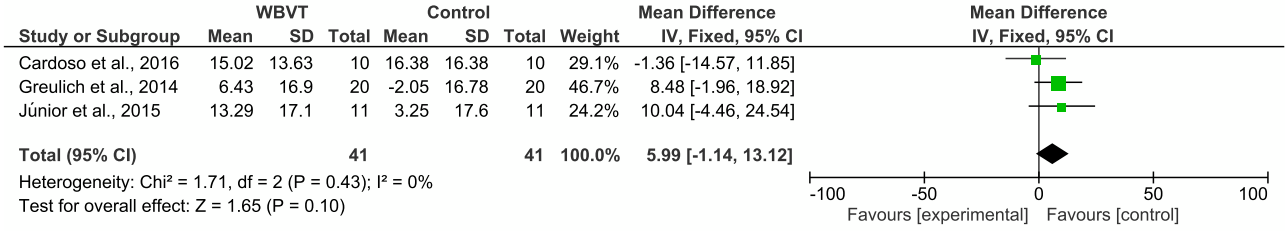

Fig. 4. MD and 95% CI for SGRQ for whole-body vibration training alone or combined vs usual care or exercise.

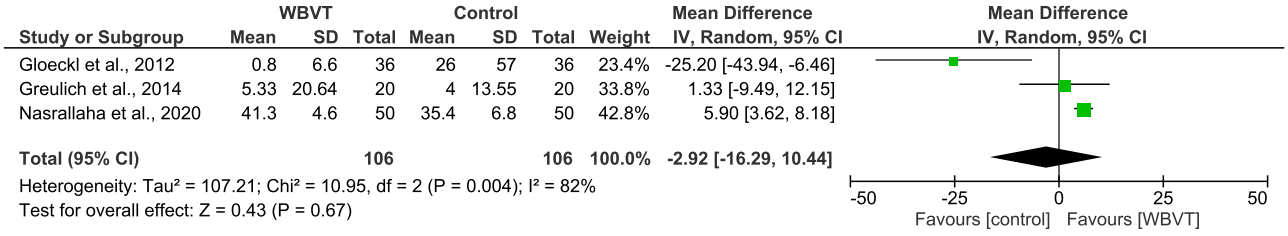

Fig. 5. MD and 95% CI for FEV1s for whole-body vibration training alone or combined vs usual care or exercise.

outcomes - SGRQ, 5STS, and FEV_1 -the certainty of evidence was rated as very low, primarily due to serious concerns regarding risk of bias, imprecision, and inconsistency across the included studies. (Table S6).

Discussion

This systematic review and meta-analysis examined the effectiveness of WBVT in individuals with COPD, with a particular focus on functional capacity, muscle strength, pulmonary function, and health-related quality of life. Our overarching aim was to elucidate whether WBVT offers a meaningful therapeutic advantage within the context of exercise training, physical therapy, or pulmonary rehabilitation programs. Overall, significant improvements were observed only for the six-minute walk test (6MWT) and the five-repetition sit-to-stand test (5STS) when WBVT was compared with usual care (i.e., absence of structured exercise). However, this apparent benefit for 6MWD disappeared entirely when WBVT was evaluated against active, exercise-based comparators. No statistically significant effects - whether for WBVT alone or in combination with exercise - were identified over conventional exercise training for FEV_1, SGRQ, 6MWT, or 5STS. Taken together, the current evidence does not indicate that WBVT is superior to active exercise training for any of the outcomes assessed.

The 6MWT is an established measure of functional capacity in COPD,[39] reflecting the integrated influence of pulmonary, cardiovascular, and muscular systems.[40] Reduced 6MWT performance has been consistently associated with increased mortality and higher risk of hospitalization due to exacerbations, underscoring its prognostic importance.[41] Although the pooled analysis revealed a statistically significant improvement in 6MWT distance with WBVT compared with usual care, the magnitude of this effect was substantially below the minimal clinically important difference (MCID) reported for COPD. Consequently, the clinical relevance of this finding is uncertain.

The MCID for the 6MWT in COPD has been reported to range from 25 to 80 meters. [42,43] Wise et al. (2005) (42) proposed a threshold of 54–80 meters, whereas Holland et al. (2010) [43] reported that a relative improvement of approximately 14% may represent a clinically meaningful change. However, relative change was found to be less sensitive than absolute change. Holland et al. also identified an absolute threshold of 25 meters, although patients in their cohort who perceived a “small change” improved by approximately 60 meters, and those reporting a

"substantial change" improved by nearly 78 meters. Adding to this complexity, the certainty of the evidence in our review was rated as *very low* according to both RoB 2.0 and GRADE, limiting confidence in these estimates.

Regarding the 5STS, the improvement observed for WBVT compared with usual care exceeded the MCID previously established in a large COPD cohort. Jones et al. (2013) [44] estimated the MCID for the 5STS at 1.7 seconds using an anchor-based approach, suggesting that the improvement seen in our pooled analysis may be clinically meaningful in this specific comparison. Nevertheless, given the *very low* certainty of the evidence, these findings should be interpreted with caution.

It is also noteworthy that the benefits associated with WBVT were observed only when compared with a non-exercising control group. In contrast, when WBVT was compared with structured exercise training - whether aerobic, resistance-based, or multimodal - no additional benefit was detected across any of the outcomes examined. This pattern underscores the influence of comparator type on effect estimates and highlights the importance of appropriately designed control groups in future trials.

An important consideration when interpreting these comparisons is that only the study by Cardoso et al. directly evaluated WBVT against a conventional pulmonary rehabilitation program. Although this study had a non-randomized design and was therefore judged to have important methodological limitations, it was the only included study that implemented a rehabilitation protocol consistent with contemporary pulmonary rehabilitation recommendations, incorporating both aerobic and resistance exercise training. Current evidence supports the combination of endurance and resistance training as a cornerstone of pulmonary rehabilitation in COPD, with well-established benefits for exercise capacity, muscle function, symptom burden, and health-related quality of life. Most of the remaining studies compared WBVT with less comprehensive exercise interventions or usual care, which may not reflect the benefits achievable through contemporary pulmonary rehabilitation practice.

Moreover, the current body of evidence is characterized by substantial heterogeneity in WBVT protocols, including differences in frequency, amplitude, duration, and exercise components performed during vibration exposure. Such methodological variability may partially account for inconsistent findings and limits the ability to draw firm conclusions regarding optimal parameters or expected responses.

Overall, the limitations identified - including small sample sizes, inconsistent reporting of intervention parameters, variability in outcome measures, and high risk of bias – contribute to the very low certainty of the evidence and restrict the generalizability of the findings. High-quality, adequately powered randomized controlled trials using standardized WBVT protocols are needed to determine whether this modality offers any consistent clinical advantage for individuals with COPD.

Conclusion

The findings of this review indicate that, although WBVT may offer some benefits as a standalone strategy compared to usual care (without exercise), it did not demonstrate superior effects on 6MWD, 5STS performance, lung function (FEV1s), quality of life, or muscle strength when compared to traditional active exercise modalities in patients with chronic obstructive pulmonary disease. A clinically and statistically meaningful improvement was observed only for the 5STS when WBVT was compared to usual care. The poor methodological quality of the included studies represents a critical limitation, as it reduces the overall confidence in these findings. Additionally, the variability in training protocols and vibration parameters across studies underscores the need for greater methodological standardization in future research to establish more consistent clinical recommendations.

Authors' contributions

All authors contributed to the design of the study, data collection, and interpretation. IGNA and CJO conducted the literature search and conceived the study. IGNA and CJO were involved in protocol development. IGNA and CJO participated in the study selection and data analysis. IGNA and CJO drafted the initial manuscript. All the authors reviewed and edited the manuscript and approved the final version.

Declaration of competing interest

The authors declare that they have no competing interests.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjpt.2026.101674.

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