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Has the evidence for dance, music therapy and singing in Parkinson's disease changed since 2020? A systematic review and meta-analysis

Maxwell S. Barnish[1] and Rebecca V. Nelson-Horne[2]

[1] Peninsula Technology Assessment Group (PenTAG), School of Public Health and Sport Sciences, University of Exeter, Exeter, UK.

[2] Independent Scholar, Glasgow, UK.

Correspondence to: Dr Maxwell S. Barnish; m.s.barnish@exeter.ac.uk

3717 words.

ABSTRACT

Objectives: To examine how the evidence for dance, music therapy and singing for people with Parkinson's disease (PD) has developed over four years.

Setting: Scholarly literature from any country or countries globally.

Data sources: Five key bibliographic databases.

Primary and secondary outcome measures: Quality of life, functional communication, speech, motor function and cognitive status.

Results: Database searches returned a total of 1677 records, of which 1280 remained following deduplication. From these database searches, a total of 67 records proceeded to full-text screening. These were supplemented by five additional records from supplementary searches. From a total of 72 records assessed at the full-text screening stage, 35 records (32 unique studies) included in the systematic review. Published from 2020 to 2024, these studies involved a total of 825 people with PD from 12 countries. Dance was the most studied artistic modality (21 studies), followed by singing (8 studies) and music therapy (three studies). Included studies showed that additional evidence supporting the benefit of the performing arts in PD was available for dance, singing and music therapy. However, key uncertainties were only partially resolved.

Conclusions: This systematic review presents evidence from 2020-2024 showing how the evidence base for dance, music therapy and singing in PD has evolved over this time period. The evidence strengthens the case that the performing arts may be a useful therapeutic medium in PD. However, further research is required to address key uncertainties, including the need for studies comparing dance, music therapy and/or singing with each other. At present, it is not possible to conclude which performing arts modalities are most effective and whether different modalities may be more effective for people with PD with different clinical features.

STRENGTHS AND LIMITATIONS

- Systematic review methods minimised subjectivity and bias.
- This study assessed how the evidence for dance, music therapy and singing for Parkinson's disease has developed over four years.
- A standardised outcome set was used.
- Independent dual review was conducted on all screening, data extraction and risk of bias procedures, but only reviewer designed and ran the searches.
- For practical reasons, only English language publications could be considered.

INTRODUCTION

Parkinson's disease

Parkinson's disease (PD) is among the most common age-related neurodegenerative conditions and its societal burden is increasing internationally.[1] PD has a widespread and diverse range of motor and non-motor symptoms.[2] It typically exerts a significant impact upon the quality of life of people with PD[3] and their caregivers.[4] Quality of life, functional communication, speech, motor function and cognitive status have been identified as a set of five key outcomes in PD.[5]

Treatment options for PD

Levodopa-based pharmacotherapy has been the mainstay of treatment for PD for several decades and is generally effective for controlling motor symptoms.[6] However, a relative lack of evidence for a benefit on speech and non-motor symptoms has stimulated interest in other therapeutic mediums, including lifestyle interventions, that can be used alongside pharmacotherapy. Group-based performing arts have been identified as one potentially beneficial approach.[7,8]

Evidence for the performing arts in PD

One systematic review[5] has considered a range of performing arts modalities for people with PD. This broader scope is important to provide the comparative perspective. Other systematic reviews both prior to and after[9-13] this review[5] focused instead on specific performing arts modalities, especially dance. The Barnish et al review[5] included 56 studies, of which 38 were on dance and the artistic modalities with the next greatest volume of evidence were singing (12 studies) and music therapy (4 studies). Some evidence of each of these intervention modalities was observed on at least some of the eligible outcomes: quality of life, speech, functional communication, cognitive status and motor function. Key uncertainties in the evidence base included: i) no studies comparing different artistic modalities (e.g. dance vs singing), ii) lack of a control arm in 16 (42%)

dance studies and 10 (83%) singing studies, iii) a relative lack of evidence on functional communication (only two studies, both on singing), iv) underrepresentation of men in studies compared to the PD population and v) lack of standardisation of outcome measures.

Aims and rationale

The present work offers a systematic review of evidence published between 2020 and February 2024 that assessed the potential benefit of dance, music therapy or singing on quality of life, functional communication, speech, motor function or cognitive status in people with PD. The key rationale for this work is to enable an assessment of how the evidence base for the top three most promising performing arts modalities identified by Barnish et al[5] has progressed over a four-year period since this review. This focus makes it preferable to focus the systematic review on evidence published between 2020 and 2024 rather than producing a new systematic review of all evidence from database inception to 2024. Then, to assess the latest state of the evidence, we integrate available data from our present work with data from the Barnish et al[5] review in a meta-analysis.

METHODS

D*esign*

A systematic review and meta-analysis was conducted following PRISMA 2020 guidelines.[14] While the review was not pre-registered, it followed the methods of a previous published review[5] as closely as feasible. Any changes are detailed in Supplementary file 11. A pre-specified protocol was used (available from the corresponding author on request). All design decisions were made in advance of the review and there were no protocol changes during the course of the review.

Data sources

Searches were conducted in February 2024 using five pivotal bibliographic databases: AMED (Ebsco), APA PsycINFO (Ovid), CINAHL (Ebsco), EMBASE (Ovid) and MEDLINE (Ovid). Supplementary searches were conducted on Google Scholar and through forward and backward citation chasing on studies identified for full-text review. Searches were designed to retrieve articles on Parkinson's disease and the performing arts (strategies for all databases are shown in Supplementary file 1), were time limited to the start of 2020 onwards and designed and conducted by MSB.

Inclusion criteria

Screening was initially conducted based on title and abstract. Potentially relevant articles were screened at the full-text stage to determine inclusion (Supplementary file 2) or exclusion (Supplementary file 3) in the systematic review. Screening was conducted independently by MSB and RVNH and any disagreements resolved through discussion. Eligibility criteria are shown in Table 1.

Data extraction

Information extracted is shown in Table 2. All data extraction processes were conducted independently by two reviewers (MSB and RVNH) and any disagreements resolved through discussion. The appendix provides additional information on study characteristics (Supplementary file 4), interventions (Supplementary file 5), controls (Supplementary file 6) and narrative results (Supplementary file 7).

Narrative synthesis

Thematic narrative synthesis was used as the primary analysis method. This was pre-specified in advance due to the high levels of observed methodological and clinical heterogeneity in the Barnish et al[5] review. Synthesis was initially by outcome domain: quality of life, functional communication, speech, motor function and cognitive status. Within outcome domains, synthesis was by arts modality. There was a focus on the

extent to which the evidence has progressed over 2020-4 and addressed key uncertainties identified in the Barnish et al[5] review.

Meta-analysis

Random effects meta-analysis was also conducted using STATA/SE 18.0 (StataCorp) for combinations of key scale outcomes and interventions for which there were at least two studies using a common comparator. Evidence from this review was integrated in the meta-analysis with evidence from the Barnish et al[5] review. Singing and music therapy were assessed as unitary categories in the meta-analysis. The higher number of studies on dance facilitated the creation of three dance categories: i) Brazilian or tango-based dance, ii) PD-specific dance, and iii) Argentine or adapted tango-based dance. Further details on the meta-analysis method are shown in Supplementary file 11. Due to methodological and clinical heterogeneity, and the fact that due to differences in intervention-comparator-outcome combinations a relatively small proportion of available studies can contribute to the meta-analysis, it is important to see the meta-analysis as a secondary analysis to supplement the narrative synthesis.

Risk of bias assessment

The Specialist Unit for Review Evidence (SURE) Experimental Studies Critical Appraisal Checklist[15] was used for the assessment of all randomised and non-randomised trials. The SURE Cohort Studies Critical Appraisal Checklist[15] was used for the assessment of observational longitudinal designs. Risk of bias assessment was conducted independently by two reviewers (MSB and RVNH) and any disagreements resolved through discussion. Supplementary file 8 shows the results of the assessment for trials. Supplementary file 9 shows the results of the assessment for observational studies.

Patient and public involvement

Patient and public involvement could not be conducted for this systematic review assessing a broad range of performing arts interventions due to a lack of funding. The corresponding author will respond to any reputable media enquiries.

RESULTS

Search results

Database searches returned a total of 1677 records (AMED 97, APA PsycINFO 111, CINAHL 128, EMBASE 1077, MEDLINE 264), of which 1280 remained following automatic and manual deduplication. A total of 72 records were assessed at full text screening (including five from supplementary searches), 35 records (32 unique studies) were included in the systematic review and four studies were included in the meta-analysis, alongside studies from the Barnish et al[5] review (Supplementary file 10). A PRISMA flow chart is provided (Figure 1). Studies came from a total of 12 countries and used a variety of quantitative designs, including eight randomised trials (25% of included studies, Supplementary files 4 and 12). Studies were published from 2020 to 2024 and involved a total of 825 people with PD. The number of participants (across all arms) ranged from 6 to 83 per study (median sample size 21). Studies covered singing, music therapy and three predominant dance forms: Argentine tango-based dance, Brazilian samba-based dance and PD-specific dance forms (Supplementary file 5). In total, there were 21 dance studies, 8 singing studies and 3 music therapy studies. The countries studied were diverse in terms of cultural, political and health system. characteristics.

Narrative synthesis

Here we discuss the new studies that have become available between 2020 and 2024 to address each outcome domain.

Quality of life

While most (19 out of 32, 59%) studies assessed quality of life, this was more common among trials (randomised and non-randomised, 13 out of 16, 81%) than observational studies (6 out of 16, 38%). The most common tool to assess quality of life was PDQ-39[16] (15 studies). Out of the 21 studies on dance, 13 assessed quality of life. Evidence of a significant benefit was shown for five studies[35-40] and not shown for six studies,[41-46] while two studies showed partial evidence of a benefit.[47-48]

Out of the 8 studies on singing, four assessed quality of life. Stegemoller et al[26-28] found a significant benefit of a single singing session on quality of life, while Tamplin et al[33] found a significant benefit of weekly singing on voice-related quality of life, but the effect of monthly singing did not reach statistical significance. Butala et al[22] reported a benefit of singing on quality-of-life sub-scales related to emotional wellbeing and body discomfort, but not the overall quality of life score. No follow-up scores for this outcome were reported by Lee et al,[20] meaning that the impact of singing could not be assessed.

All three studies on music therapy assessed quality of life. Pohl et al[49] showed evidence of a statistically significant benefit associated with music therapy. Bastepe-Grey et al[50] also showed a numerical effect in favour of music therapy but did not reach statistical significance, while Shah-Zamora et al[51] did not find any evidence of a significant benefit of virtual music therapy. Overall, there was some evidence of a benefit of music therapy on quality of life, but it was not conclusive.

Functional communication

Functional communication outcomes were only assessed by one dance study. Using a single group repeated measures design (n=6), Park et al[17] did not find evidence of a statistically significant benefit of vocal dance on Voice Handicap Index (VHI)[18] scores. However, the study was likely too small and limited to assess this relationship. Despite a plausible rationale for an expressive art such as dance offering a benefit on communication, no other studies assessed this relationship. Furthermore, there were no

music therapy studies assessing functional communication. Two singing studies, one[19] a non-randomised trial compared to usual care and one[20] a randomised controlled trial compared to a speaking-only control group assessed VHI, while one[19] also assessed the Communicative Effectiveness Survey (CES).[21] One study[20] only reported baseline values for communication, while the other[19] did not identify a significant improvement in communication scores.

Speech

No dance or music therapy studies assessed speech outcomes. Meanwhile, speech was assessed by all studies using singing as the therapeutic modality. Acoustic voice and speech measures, such as vowel duration, intensity, minimum and maximum fundamental frequency (pitch), jitter, shimmer and harmonic-to-noise ratio were assessed by six studies,[19,22-28] of which all but Stegemoller et al (2020)[25] – a small (n=8) single-arm study – demonstrated some evidence of a statistically significant benefit of group singing on acoustic measures. However, studies often assessed a wide range of acoustic parameters and did not always find a robust effect on all measures. The only randomised controlled trial to assess acoustic parameters was Butala et al[22] against a duration- and frequency-matched discussion group control. The acoustic parameters for which this study found a significant benefit of singing were average loudness on the Cookie Theft picture description task and minimum loudness on the Rainbow passage task. However, the presentation of analysis in the paper focused on overall cohort effects and within-arm effects over time, rather than a between-arm comparison. In addition to the studies using traditional acoustic parameters, a randomised controlled trial by Lee et al[20] used the Acoustic Voice Quality Index (AVQI),[29] an innovative measure of acoustic voice quality based on a weighted combination of six acoustic measures. AVQI has been shown to be valid as a measure of voice quality, although there are contradictory findings about the effect of age on the validity of the tool.[30] While AVQI has been used in people with PD,[31-32] no disease-specific validation study could be identified. Lee et al[20] found

evidence of a statistically significant benefit of singing (both alone and in combination with straw phonation) on AVQI compared to a speaking-only control group. Three studies[19,20,33] assessed perceptual speech or voice ratings, all offering evidence for a benefit of singing on perceived speech or voice quality.

Motor function

Motor function was assessed by all but two studies[40,44] on dance (19/21,90%), all but one study[51] on music therapy (2/3, 67%), but only two studies[22,26-8] on singing (2/8, 25%). Motor function was the domain for which the greatest variety of outcome measures used. However, three core measures used frequently among included studies were MDS-UPDRS-III[52], Timed Up-and-Go (TUG)[53] and six-minute walk test (6MWT). There was generally consistent evidence that dance improved motor function. All dance studies demonstrated a statistically significant benefit in this domain except for Lihala et al,[37] Peter et al[45] and Pinto et al,[46] the latter designed only to assess feasibility not efficacy. It was noted that Moratelli et al[38,39] found that only binary dance rhythms significantly improved freezing of gait, while both binary and quaternary dance rhythms improved balance and overall motor function. While findings were generally consistent across studies, on occasion a statistically significant effect was not observed for all measures where studies used multiple measures of motor function. While Bastepe-Grey et al[50] showed a significant benefit of music therapy in PD, Pohl et al[49] found that the Ronnie Gardiner method improved short-term confidence about falling, but did not significantly improve balance, dual task motor performance or freezing of gait. Both studies[22,26-8] on singing that assessed motor function found a significant benefit, although in the case of Stegemoller et al[26-8] this was not observed for all measures of motor function.

Cognitive status

Cognitive status was assessed by nine dance studies (43%), of which six used the Montreal Cognitive Assessment (MoCA).[54] Among these nine studies, six (67%)[35,37 38,39,

[40,58,59] showed evidence of a benefit of dance on cognitive status, while the remaining three[41,42,57] did not. Two music therapy studies assessed cognitive function. Pohl et al[49] used MoCA[54] plus three parts of the Cognitive Assessment Battery.[55] Meanwhile, Shah-Zamora used a modified version of MoCA[56] suitable for telephone administration. Neither showed a significant benefit of music therapy on cognition. Only one singing study (13%)[22] assessed cognitive function, using MoCA, and did not show evidence of a significant benefit of singing on this outcome.

Meta-analysis

Here we present the results of meta-analyses integrating the results of the present work with those of Barnish et al.[5] This provides an indication of the overall state of the evidence, limitations that preclude meta-analysis being the primary analytical method notwithstanding. Three new analysis sets were presented. Additionally, there were five analysis sets that remained unchanged from Barnish et al.[5] UPDRS motor scores were significantly better for tango-based dance than usual care (mean difference -9.89 (95% confidence interval -16.65, -3.13). TUG scores were significantly better for tango-based dance than exercise (-1.99 (-2.34, -1.65)). PDQ-39 scores were significantly better for PD-specific dance than usual care (-7.81 (-11.87, -3.75)). PDQ-39 scores were significantly better for Brazilian/Samba-based dance than usual care (-0.61, -1.09, -0.12). Other reported comparisons did not reach statistical significance. Further details can be found in Supplementary file 10.

Risk of bias and main methodological concerns

The main methodological concerns that were applicable to the body of evidence were small sample sizes (median sample size 22), the absence of control groups in nearly half (47%) of included studies (52% of dance studies, 38% of singing studies and 33% of music therapy studies), variation in intervention duration, frequency and outcome measures, potential underrepresentation of male participants (mean 57% male)

compared to the PD population, and a focus on statistical rather than clinical assessment. Analysis of risk of bias assessment at the individual study level using SURE checklists can be found for experimental and observational studies in Supplementary files 8 and 9 respectively.

Assessment of progress on key uncertainties

An assessment of the progress made on each key uncertainty is shown in Table 3.

DISCUSSION

Summary

This paper presents a systematic review of evidence published between 2020 and 2024 on the benefit of dance, music therapy and singing on five standard outcomes. This demonstrates how the field has evolved since the last systematic review[5] (Table 4) addressing this research question. Additionally, meta-analyses incorporating data from the present review and the Barnish et al[5] review from 2020 offer quantitative insight into the current state of the evidence. The systematic review demonstrated additional evidence for a benefit of all three of dance, music therapy and singing in PD. The evidence was generally consistent in supporting a benefit across outcome domains, although methodological limitations should be considered. There was, however, no evidence of a significant benefit on functional communication. Although overall, the evidence for a benefit of the performing arts in PD has strengthened over the period assessed by the present review, key uncertainties identified by Barnish et al[5] have only been partially addressed. Issues remain with a lack of studies comparing different performing arts modalities, lack of control arms in a significant minority of studies, a lack of focus on functional communication, underrepresentation of men compared to the PD population, and inconsistency in outcome measures used.

Interpretation of findings

Across the Barnish et al[5] review and the present work, there are a total of 85 studies assessing the potential benefit of dance (59 studies), singing (19 studies) or music therapy (7 studies) for PD. One paper[33] from the present work adds an additional paper to a study included in the Barnish et al[5] review rather than being a new study. The present work provides the broader picture across these key artistic modalities, unlike other reviews[9-13] in the past few years that have focused on specific artistic modalities. The evidence gathered in the past four years, subsequent to the Barnish et al[5] review, is generally consistent with the earlier evidence. The impact of adding to the evidence base the additional 32 studies identified in the present update review is generally a continuation, strengthening and confirmation of the findings from the Barnish et al[5] review. Within the field of dance, within the present review Brazilian samba-based dance has emerged as an additional potentially beneficial dance form in PD, alongside Argentine tango-based and PD-specific dance forms. There is emerging evidence that singing-based interventions may not offer a benefit for functional communication, although this may be a result of small sample sizes and other methodological limitations. The 32 studies identified in the present review offer some progress towards resolving some of the key uncertainties in the evidence base – for example an increase in the availability of control arms, especially for singing studies; additional studies on functional communication (although limited in number and all on singing or vocal dance); and a move towards greater use of certain key outcome measures. Greater standardisation of intervention-comparator-outcome combinations has facilitated the development of additional meta-analysis sets. However, the proportion of studies from the systematic review that could be included in the meta-analysis remains insufficient for meta-analysis to be the primary analytical technique. Instead, as in Barnish et al[5], it remains a secondary analytical technique to supplement the narrative synthesis.

Strengths and limitations of the systematic review

The use of systematic review methods minimised subjectivity and bias and increased robustness. This update matched the methods of the first systematic review to assess the evidence for a range of performing arts interventions in Parkinson's disease as closely as possible to ensure comparability. The use of a standardised outcome set as well as searches on five pivotal bibliographic databases, supplemented by Google Scholar searches and citation chasing, are other key strengths of this work. Independent dual review was conducted. A meta-analysis integrated with the results from the Barnish et al[5] review provides quantitative estimates of the current state of the evidence. However, only one suitably experienced researcher was available to design and run searches. For practical reasons, only studies published in English could be considered.

Research implications

The evidence base is not yet sufficiently mature and robust to make specific recommendations for clinical practice, although there are no specific contraindications in the evidence base that would merit ceasing any services already provided. While a considerable number of additional studies were published between 2020 and 2024, future research needs to be better targeted to address remaining key uncertainties. There remain no studies comparing any two or more of dance, music therapy and singing. Future comparative studies are likely to be the best way to address the relative effectiveness of these artistic modalities. Alternatively, greater standardisation of control arms and outcome measures and reporting of change scores with a measure of variance will make meta-analyses more robust and may enable a network meta-analysis to be used. Future studies should include control arms, ideally either randomised controlled trials or high-quality comparative real-world evidence studies. The value of single-arm studies is very limited as it cannot be inferred that the observed benefit is due to the intervention. Future studies should include a greater focus on functional communication – this should not be limited to singing studies, as it is possible for example that expressive dance forms may offer a communicative benefit. Studies should attempt to

recruit a sample that is more reflective of the PD population in terms of gender – or if this is not possible, alternatively to offer analyses stratified by or adjusted for gender. This would increase confidence in the generalisability of findings to the male-dominant PD population. Furthermore, studies should consider clinical significance as well as statistical significance to ensure relevance to decision-making.

CONCLUSION

The present report presents a four-year update of the first systematic review to assess the benefit of dance, music therapy and singing on five key outcomes in PD - quality of life, functional communication, speech, motor function and cognitive status. This enables us to see how the evidence base has progressed over a four-year period and to what extent key uncertainties have been resolved. Thirty-two additional eligible studies were identified. These new studies form 38% of the total available evidence base (85 studies) for this combination of performing arts modalities and outcomes in PD. This shows that the performing arts for PD remains an area of active research interest. The evidence presented in this report shows that the new evidence since the Barnish et al[5] review has generally strengthened the case for a benefit of the performing arts in PD. However, methodological limitations remain and key uncertainties are only partially resolved.

DECLARATIONS

Contributors. The work was managed and directed by MSB, who had the initial idea for the work. Both authors contributed to the acquisition, reviewing and interpretation of data. MSB wrote the first draft of the manuscript and RVN-H revised the manuscript for important intellectual content. Both authors reviewed the final submission version of the manuscript and approved the submission. Both authors take appropriate responsibility for the work they undertook. Overall responsibility for the work rests with MSB, who is guarantor.

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Competing interests. MSB and RVN-H are experienced recreational musicians and have been involved in promoting the arts to the public. MSB declares having received expenses but not payment for arts promotion activities (this is not within the past 5 years).

Patient and public involvement. Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication. Not applicable.

Data availability statement. All data relevant to the study are included in the article or uploaded as online supplemental material. The presented work is a systematic review. All relevant information is provided in the manuscript and appendices. This includes the data extraction form completed with the data from all included studies and analytical code for the meta-analyses.

ORCID iD: Maxwell S Barnish http://orcid.org/0000-0003-0139-6548

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32. Convey RB, Laukkanen AM, Ylinen S, et al. Analysis of voice in Parkinson's disease utilizing the Acoustic Voice Quality Index. J Voice 2024; e-pub ahead of print, DOI: 10.1016/j.jvoice.2023.12.025.
33. Tamplin J, Morris ME, Marigliani C, et al. ParkinSong: Outcomes of a 12-Month Controlled Trial of Therapeutic Singing Groups in Parkinson's Disease. J Parkinsons Dis 2020; 10(3): 1217-30.
34. Cerri S, Mus L, Blandini F. Parkinson's Disease in women and men: what's the difference? J Parkinsons Dis 2019; 9(3): 501-15.
35. Duarte JDS, Alcantara WA, Brito JS, et al. Physical activity based on dance movements as complementary therapy for Parkinson's disease: Effects on movement, executive functions, depressive symptoms, and quality of life. PLoS ONE 2023; 18(2): e0281204.
36. Feenstra W, Nonnekes J, Rahimi T, et al. Dance classes improve self-esteem and quality of life in persons with Parkinson's disease. J Neurol 2022; 269(11): 5843-7.
37. Lihala S, Mitra S, Neogy S, et al. Dance movement therapy in rehabilitation of Parkinson's disease - A feasibility study. J Bodyw Mov Ther 2021; 26: 12-7.
38. Moratelli J, Alexandre KH, Boing L, et al. Binary dance rhythm or quaternary dance rhythm which has the greatest effect on non-motor symptoms of individuals with Parkinson's disease? Complement Ther Clin Pract 2021; 43: 101348.

39. Moratelli JA, Alexandre KH, Boing L, et al. Dance Rhythms Improve Motor Symptoms in Individuals with Parkinson's Disease: A Randomized Clinical Trial. J Dance Med Sci 2022; 26(1): 1-6.
40. Walton L, Domellof ME, Astrom AN, et al. Digital Dance for People With Parkinson's Disease During the COVID-19 Pandemic: A Feasibility Study. Front Neurol 2021; 12: 743432.
41. Frisaldi E, Bottino P, Fabbri M, et al. Effectiveness of a dance-physiotherapy combined intervention in Parkinson's disease: a randomized controlled pilot trial. Neurol Sci 2021; 42(12): 5045-53.
42. Haas AN, Delabary MDS, Passos-Monteiro E, et al. The effects of Brazilian dance, deep-water exercise and nordic walking, pre- and post-12 weeks, on functional-motor and non-motor symptoms in trained PwPD. Arch Gerontol Geriatr 2024; 118: 105285.
43. Harrison EC, Earhart GM, Leventhal D, et al. A walking dance to improve gait speed for people with Parkinson disease: a pilot study. Neurodegener Dis Manag 2020; 10(5): 301-8.
44. Park E, Boutsen F, Kollia B, et al. Effect of vocal-dance program on speech, voice quality, and quality of life in persons with Parkinson's disease [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 154.
45. Peter S, Crock ND, Billings BJ, et al. Argentine Tango Reduces Fall Risk in Parkinson's Patients. J Am Med Dir Assoc 2020; 21(2): 291-2.
46. Pinto C, Figueiredo C, Mabilia V, et al. A Safe and Feasible Online Dance Intervention for Older Adults With and Without Parkinson's Disease. J Dance Med Sci 2023; 27(4): 253-67.
47. Moratelli JA, Delabary MDS, Curi VS, et al. An Exploratory Study on the Effect of 2 Brazilian Dance Protocols on Motor Aspects and Quality of Life of Individuals with Parkinson's Disease. J Dance Med Sci 2023; 27(3): 153-9.

48. Tillmann AC, Swarowsky A, Correa CL, et al. Feasibility of a Brazilian samba protocol for patients with Parkinson's disease: a clinical non-randomized study. Arq Neuropsiquiatr 2020; 78(1): 13-20.

49. Pohl P, Wressle E, Lundin F, et al. Group-based music intervention in Parkinson's disease-findings from a mixed-methods study. Clin Rehabil 2020; 34(4): 533-44.

50. Bastepe-Gray S, Wainwright L, Lanham DC, et al. GuitarPD: A Randomized Pilot Study on the Impact of Nontraditional Guitar Instruction on Functional Movement and Well-Being in Parkinson's Disease. Parkinsons Dis 2023; 2022: 1061045.

51. Shah-Zamora D, Anderson S, Barton B, et al. Virtual Group Music Therapy for Apathy in Parkinson's Disease: A Pilot Study. J Geriatr Psychiatry Neurol 2024; 37(1): 49-60.

52. Goetz CG, Tilley BC, Shaftman SR, et al. Movement Disorder Society-sponsored revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): Scale presentation and clinimetric testing results. Mov Disord 2008; 23(15): 2129-70.

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54. Nasreddine Z, Phillips NA, Bedirian V, et al. The Montreal Cognitive Assessment, MoCA: a Brief Screening Tool for Mild Cognitive Impairment. J Am Geriatr Soc 2005; 53(4): 695-9.

55. Nordlund A, Pahlsson L, Holmberg C, et al. The Cognitive Assessment Battery (CAB): a rapid test of cognitive domains. Int J Psychogeriatr 2011; 23(7): 1144-51.

56. Katz MJ, Wang C, Nester CO, et al. T-MoCA: A valid phone screen for cognitive impairment in diverse community samples. Alzheimers Dement. 2021;13(1):e12144.

57. Bouquiaux O, Thibaut A, Beaudart C, et al. Dance training and performance in patients with Parkinson disease: Effects on motor functions and patients' well-being. Sci Sports 2022; 37(1): 45-50.

58. Fisher M, Kuhlmann N, Moulin H, et al. Effects of improvisational dance movement therapy on balance and cognition in Parkinson's disease. Phys Occup Ther Geriatr 2020; 38(4): 385-99.

59. Valverde-Guijarro E, Alguacil-Diego IM, Vela-Desojo L, et al. Effects of contemporary dance and physiotherapy intervention on balance and postural control in Parkinson's disease. Disabil Rehabil 2022; 44(12): 2632-9.

Tables

Table 1. Inclusion criteria

Eligible studies assessed:

- Participants: people with a diagnosis of Parkinson's disease.
- Intervention: active group-based singing, dance or music therapy interventions (active in this context excludes passive arts activities such as listening to music).
- Comparator: studies with and without control arms were eligible. There were no specific requirements for what control arms could involve.
- Outcomes: quality of life, functional communication, speech, motor function and cognitive status.
- Other: quantitative studies published in an English-language peer-reviewed journal since 2020 (and not included in the Barnish et al[5] review), or alternatively published as an English-language conference abstract in the two years before the search.

Studies were included in the meta-analysis if they provided sufficient quantitative information on outcomes and contributed to a comparison for which there were at least two studies for a given combination of intervention, comparator, and outcome.

Table 2. Data extracted

The following information was extracted for each included study:

- Bibliographic details (authors, year, citation)
- Country of study
- Study design

- Participants (sample size, gender profile, mean age,
- Inclusion criteria
- Outcomes
- Content of intervention
- Professional background of intervention leader
- Location of intervention (e.g. community centre, outpatient clinic)
- Frequency and duration of intervention
- Content of control arm
- Professional background of control arm leader
- Location of control arm
- Frequency and duration of control arm
- Study results for narrative synthesis for all eligible reported outcomes
- Study results for meta-analysis (for studies included in the meta-analysis)

Table 3. Assessment of progress since 2020 in resolving key uncertainties

- Key uncertainty 1: “no studies comparing different artistic modalities (e.g. dance vs singing)”. Review authors’ assessment: Not addressed. There remain no studies comparing any two of dance interventions, singing interventions and music therapy interventions. This is a significant limitation in assessing which performing arts modality may be most promising on PD and whether any specific demographic or clinical characteristics may influence this.
- Key uncertainty 2: “lack of a control arm in 16 (42%) dance studies and 10 (83%) singing studies”. Review authors’ assessment: Partially addressed. Of the newly available studies over the period 2020-2024, 52% of dance studies lack a control (minor deterioration), but this is only 38% for singing studies

(major improvement). More than half of the newly available studies across modalities have a control arm.

- Key uncertainty 3: "a relative lack of evidence on functional communication (only two studies, both on singing)". Review authors' assessment: Partially addressed. One new dance study and two new singing studies were available for functional communication. However, there remains no substantive evidence supporting a benefit of the performing arts on this outcome.
- Key uncertainty 4: "underrepresentation of men in studies compared to the PD population". Review authors' assessment: Unclear. The mean percentage of men in included studies in the present review was 57%. This is higher than in the 2020 review (53%), although it is unclear if this difference is meaningful. Furthermore, both values appear to underestimate the proportion of men in the PD population. According to a review by Cerri et al,[34] PD is twice as common in men than women, while women tend to have more rapidly progressing disease.
- Key uncertainty 5: "lack of standardisation of outcome measures". Review authors' assessment: Partially addressed. Progress noted on using key measures more frequently for assessed concepts, facilitating more meta-analysis sets. However, some inconsistency remains in measures used.

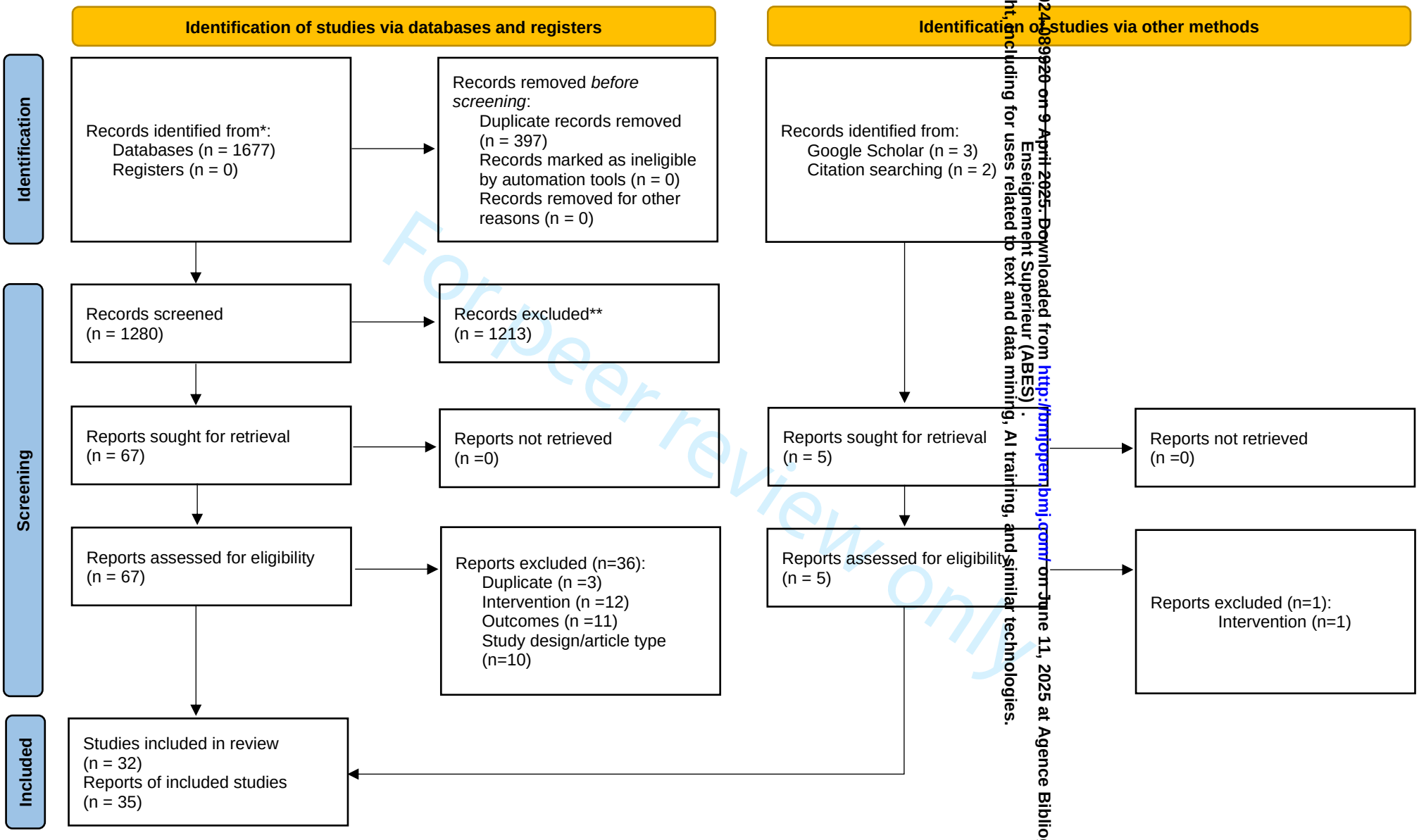
Table 4. Evidence landscape

This table indicates the number (%) of included studies that show evidence of benefit for each performing arts modality for each outcome domain.

	Barnish et al[5]	**Present review**	**Totality of evidence**
Quality of life			
Dance	15/22 (68%)	7/13 (54%)	22/35 (63%)

Music therapy	4/4 (100%)	2/3 (67%)	6/7 (86%)
Singing	4/5 (80%)	3/4 (75%)	7/9 (78%)
Functional communication			
Dance	0/0	0/1 (0%)	0/1 (0%)
Music therapy	0/0	0/0	0/0
Singing	1/2 (50%)	0/2 (0%)	1/4 (25%)
Speech			
Dance	0/0	0/0	0/0
Music therapy	0/0	0/0	0/0
Singing	10/11 (91%)	7/8 (88%)	17/19 (89%)
Motor function			
Dance	30/31 (97%)	16/19 (84%)	46/50 (92%)
Music therapy	2/4 (50%)	2/2 (100%)	4/6 (67%)
Singing	1/1 (100%)	2/2 (100%)	3/3 (100%)
Cognitive status			
Dance	9/10 (90%)	6/9 (67%)	15/19 (79%)
Music therapy	2/3 (67%)	0/2 (0%)	2/5 (40%)
Singing	0/0	0/1 (0%)	0/1 (0%)

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

SUPPLEMENTARY FILES

Supplementary file 1. Detailed search strategies

The same search strategy was used as in the 2020 review. All databases were searched on 15 February 2024, using the most up-to-date available version of each database.

A date filter of January 2020 onwards was applied. No other filters or limits were applied in the search. Instead, eligibility was handled in the screening process.

AMED (Ebsco)

Expanders: Apply equivalent subjects

Search modes: Boolean/Phrase

Limiters: Publication date: 20200101 – 20241231

(Parkinson's disease (2167 hits) OR Parkinson disease (2167 hits)) AND (singing (104 hits) OR sing* (15,029 hits) OR music* (1,768 hits) OR music ther* (1,191 hits) OR danc* (981 hits) OR dram* (1,278 hits) OR theat* (160 hits) OR performing art* (101 hits) OR art* (43,162 hits) OR art ther* (1,766 hits))

Combining disease terms using OR = 2,167 hits

Combining performing arts terms using OR = 58, 830 hits

Combining disease and performing arts terms using AND = 408 hits

Applying publication date filter = 97 hits

APA PsycINFO (Ovid)

Limit: publication date: yr "2020-2024"

(exp Parkinson's disease/ (29, 549 hits) AND (singing.mp (4,941 hits) OR exp Singing/ (1, 629 hits) OR music.mp (42, 884 hits) OR exp Music/ (21,285 hits) OR music therapy.mp (6, 981 hits) OR exp Music Therapy/ (5, 784 hits) OR dance.mp (8,211 hits) OR dancing.mp (2,659 hits) OR exp Dance/ (3,056 hits) OR drama.mp (6,833 hits) OR exp Drama/ (2,281 hits) OR theatre.mp (3,321 hits) OR theater.mp (2,784 hits) OR theatrical.mp (1,074 hits) OR performing art*.mp (893 hits) OR art.mp (58,898 hits) OR arts (27,329 hits) OR exp Art/ (15, 175 hits) OR art therapy.mp (6,878 hits) OR exp Art Therapy/ (5,733 hits))

Combining performing arts terms using OR = 138, 572 hits

Combining disease and performing arts terms using AND = 370 hits

Applying publication date filter = 111 hits

CINAHL (Ebsco)

Expanders: Apply equivalent subjects

Search modes: Boolean/Phrase

Limiters: Publication date: 20200101 – 20241231

(MM "Parkinson Disease" (22,125 hits) AND (singing (4,895 hits) OR MM "Singing" (2,667 hits) OR music (21,585 hits) OR MM "Music" (7,279 hits) OR music therapy (7,672 hits) OR MM "Music Therapy" (5,272

hits) OR dance (5, 609 hits) OR dancing (4,398 hits) OR MM "Dancing" (3,039 hits) OR drama (2,374 hits) OR MM "Drama" (941 hits) OR theatre (6,773 hits) OR theater (6,773 hits) OR theatrical (162 hits) OR performing art* (9,372 hits) OR art (63,611 hits) OR arts (52,051 hits) OR MM "Art+" (9,308 hits) OR art therapy (10,645 hits) OR MM "Art Therapy" (3,037 hits)

Combining performing arts terms using OR = 106,104 hits

Combining disease and performing arts terms using AND = 371 hits

Applying publication date filter = 128 hits

EMBASE (Ovid)

Limit: publication date: yr "2020-2024"

(exp Parkinson disease/ (197, 451 hits)) AND (singing.mp (6,246 hits) OR exp singing/ (4,384 hits) OR music.mp (36,829 hits) OR exp music/ (22,566 hits) OR music therapy.mp (9,843 hits) OR exp music therapy/ (9,337 hits) OR dance.mp (8,378 hits) OR dancing.mp (8,042 hits) OR exp dancing/ (6,729 hits) OR drama.mp (2,306 hits) OR exp literature/ (265,430 hits) OR theatre.mp (19,631 hits) OR theater.mp (5,593 hits) OR theatrical.mp (424 hits) OR performing art*.mp (1,540 hits) OR art.mp (254,375 hits) OR arts.mp (13,218 hits) OR exp art/ (74,728 hits) OR art therapy.mp (5,635) OR exp art therapy/ (5,035 hits)

Combining performing arts terms using OR = 613,993 hits

Combining disease and performing arts terms using AND = 3,594 hits

Applying publication date filter = 1,077 hits

MEDLINE (Ovid)

Limit: publication date: yr "2020-2024"

(exp Parkinson Disease/ (84,655 hits)) AND (singing.mp (4,710 hits) OR exp Singing/ (1,397 hits) OR music.mp (31,010 hits) OR Music/ (17,226 hits) OR music therapy.mp (5,794 hits) OR exp Music Therapy/ (4,440 hits) OR dance.mp (6,194 hits) OR dancing.mp (5,215 hits) OR exp Dancing/ (3,595 hits) OR drama.mp (3, 575 hits) OR exp Drama/ (2,100 hits) OR theatre.mp (9,950 hits) OR theater.mp (4,522 hits) OR theatrical.mp (342 hits) OR performing art*.mp (945 hits) OR art.mp (170, 808 hits) OR arts.mp (16,664) OR exp Art/ (38,483 hits) OR art therapy.mp (2,515 hits) OR exp Art Therapy/ (1,753 hits))

Combining performing arts terms using OR = 263,463 hits

Combining disease and performing arts terms using AND = 750 hits

Applying publication date filter = 264 hits

Supplementary searches

Google Scholar: combining 'Parkinson disease' and 'singing', 'music', 'dance', 'dancing', 'art', 'arts' in turn. Then repeating using 'Parkinson's disease'. 3 additional potentially relevant hits identified.

Citation chasing: backwards citation chasing using reference lists of articles from full-text screening. Forwards citation chasing using 'cited by' feature on Google Scholar for articles from full-text screening. 2 additional potentially relevant hits identified.

Supplementary file 2. Full list of included publications

Total = 35.

Dance (n=22)

1. Bouquiaux O, Thibaut A, Beaudart C, et al. Dance training and performance in patients with Parkinson disease: Effects on motor functions and patients' well-being. Sci Sports 2022; 37(1): 45-50.
2. Delabary MDS, Monteiro EP, Donida RG, et al. Can Samba and Forró Brazilian rhythmic dance be more effective than walking in improving functional mobility and spatiotemporal gait parameters in patients with Parkinson's disease? BMC Neurol 2020; 20: 305.
3. Duarte JDS, Alcantara WA, Brito JS, et al. Physical activity based on dance movements as complementary therapy for Parkinson's disease: Effects on movement, executive functions, depressive symptoms, and quality of life. PLoS ONE 2023; 18(2): e0281204.
4. Feenstra W, Nonnekes J, Rahimi T, et al. Dance classes improve self-esteem and quality of life in persons with Parkinson's disease. J Neurol 2022; 269(11): 5843-7.
5. Fisher M, Kuhlmann N, Moulin H, et al. Effects of improvisational dance movement therapy on balance and cognition in Parkinson's disease. Phys Occup Ther Geriatr 2020; 38(4): 385-99.
6. Fontanesi C, De Souza JF. Beauty that moves: Dance for Parkinson's effects on affect, self-efficacy, Gait symmetry, and dual task performance. Front Psychol 2021; 11: 600440.
7. Frisaldi E, Bottino P, Fabbri M, et al. Effectiveness of a dance-physiotherapy combined intervention in Parkinson's disease: a randomized controlled pilot trial. Neurol Sci 2021; 42(12): 5045-53.
8. Haas AN, Delabary MDS, Passos-Monteiro E, et al. The effects of Brazilian dance, deep-water exercise and nordic walking, pre- and post-12 weeks, on functional-motor and non-motor symptoms in trained PwPD. Arch Gerontol Geriatr 2024; 118: 105285.
9. Haputhanthirige NKH, Sullivan K, Moyle G, et al. Effects of dance on gait and dual-task gait in Parkinson's disease. PLoS ONE 2023; 18(1): e0280635.
10. Harrison EC, Earhart GM, Leventhal D, et al. A walking dance to improve gait speed for people with Parkinson disease: a pilot study. Neurodegener Dis Manag 2020; 10(5): 301-8.
11. Jola C, Sundström M, McLeod J. Benefits of dance for Parkinson's: The music, the moves, and the company. PLoS ONE 2022; 17: e0265921.
12. Lihala S, Mitra S, Neogy S, et al. Dance movement therapy in rehabilitation of Parkinson's disease - A feasibility study. J Bodyw Mov Ther 2021; 26: 12-7.
13. Moratelli J, Alexandre KH, Boing L, et al. Binary dance rhythm or quaternary dance rhythm which has the greatest effect on non-motor symptoms of individuals with Parkinson's disease? Complement Ther Clin Pract 2021; 43: 101348.
14. Moratelli JA, Alexandre KH, Boing L, et al. Dance Rhythms Improve Motor Symptoms in Individuals with Parkinson's Disease: A Randomized Clinical Trial. J Dance Med Sci 2022; 26(1): 1-6.
15. Moratelli JA, Delabary MDS, Curi VS, et al. An Exploratory Study on the Effect of 2 Brazilian Dance Protocols on Motor Aspects and Quality of Life of Individuals with Parkinson's Disease. J Dance Med Sci 2023; 27(3): 153-9.
16. Park E, Boutsen F, Kollia B, et al. Effect of vocal-dance program on speech, voice quality, and quality of life in persons with Parkinson's disease [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 154.
17. Peter S, Crock ND, Billings BJ, et al. Argentine Tango Reduces Fall Risk in Parkinson's Patients. J Am Med Dir Assoc 2020; 21(2): 291-2.
18. Pinto C, Figueiredo C, Mabilia V, et al. A Safe and Feasible Online Dance Intervention for Older Adults With and Without Parkinson's Disease. J Dance Med Sci 2023; 27(4): 253-67.
19. Rabinovich DB, Garretto NS, Arakaki T, et al. A high dose tango intervention for people with Parkinson's disease (PwPD). Adv Integr Med 2021; 8(4): 272-7.
20. Tillmann AC, Swarowsky A, Correa CL, et al. Feasibility of a Brazilian samba protocol for patients with Parkinson's disease: a clinical non-randomized study. Arq Neuropsiquiatr 2020; 78(1): 13-20.
21. Valverde-Guijarro E, Alguacil-Diego IM, Vela-Desojo L, et al. Effects of contemporary dance and physiotherapy intervention on balance and postural control in Parkinson's disease. Disabil Rehabil 2022; 44(12): 2632-9.
22. Walton L, Domellof ME, Astrom AN, et al. Digital Dance for People With Parkinson's Disease During the COVID-19 Pandemic: A Feasibility Study. Front Neurol 2021; 12: 743432.

Music therapy (n=3)

1. Bastepe-Gray S, Wainwright L, Lanham DC, et al. GuitarPD: A Randomized Pilot Study on the Impact of Nontraditional Guitar Instruction on Functional Movement and Well-Being in Parkinson's Disease. Parkinsons Dis 2023; 2022: 1061045.
2. Pohl P, Wressle E, Lundin F, et al. Group-based music intervention in Parkinson's disease-findings from a mixed-methods study. Clin Rehabil 2020; 34(4): 533-44.
3. Shah-Zamora D, Anderson S, Barton B, et al. Virtual Group Music Therapy for Apathy in Parkinson's Disease: A Pilot Study. J Geriatr Psychiatry Neurol 2024; 37(1): 49-60.

Singing (n=10)

1. Brooks C, Porter DB, Furnas D, et al. The effects of therapeutic group singing on voice, cough and quality of life in Parkinson's disease. Clinical Archives of Communication Disorders 2021; 6(2): 79-88.
2. Butala A, Li K, Swaminathan A, et al. Parkinsonics: A Randomized, Blinded, Cross-Over Trial of Group Singing for Motor and Nonmotor Symptoms in Idiopathic Parkinson Disease. Parkinsons Dis 2022; 2022: 4233203.
3. Good A, Earle E, Vezer E, et al. Community Choir Improves Vocal Production Measures in Individuals Living with Parkinson's Disease. J Voice 2023; e-pub ahead of print, https://doi.org/10.1016/j.jvoice.2022.12.001.
4. Lee SJ, Dvorak AL, Manternach JN. Therapeutic Singing and Semi-Occluded Vocal Tract Exercises for Individuals with Parkinson's Disease: A Randomized Controlled Trial of a Single Session Intervention. J Music Ther 2024; e-pub ahead of print, https://doi.org/10.1093/jmt/thae004.
5. Lewellen R, Meyer D, Van Leer E. The effects on acoustic voice measures and the perceived benefits of a group singing therapy for adults with Parkinson's disease. Australian Voice 2020; 21: 39-48.
6. Stegemöller EL, Diaz K, Craig J, et al. The Feasibility of Group Therapeutic Singing Telehealth for Persons with Parkinson's Disease in Rural Iowa. Telemed J E Health 2020; 26(1): 66-70.
7. Stegemöller EL, Zaman A, Shelley M, et al. The Effects of Group Therapeutic Singing on Cortisol and Motor Symptoms in Persons With Parkinson's Disease. Front Hum Neurosci 2021; 15: 703382.
8. Stegemoller EL, Forsyth E, Patel B, et al. Group therapeutic singing improves clinical motor scores in persons with Parkinson's disease. BMJ Neurol Open 2022; 4(2): e000286.
9. Stegemoller E. Sing a new song: Results from research on group therapeutic singing for people with Parkinson's disease [Abstract]. J Parkinsons Dis 2023; 13(S1): 156.
10. Tamplin J, Morris ME, Marigliani C, et al. ParkinSong: Outcomes of a 12-Month Controlled Trial of Therapeutic Singing Groups in Parkinson's Disease. J Parkinsons Dis 2020; 10(3): 1217-30.

Supplementary file 3. Full list of full text excluded studies with reasons

Total = 37.

Duplicate (n=3)

1. Amaro Moratelli et al. An Exploratory Study on the Effect of 2 Brazilian Dance Protocols on Motor Aspects and Quality of Life of Individuals with Parkinson's Disease. J Dance Med Sci 2023; 27(3): 153-9.
2. Amaro Moratelli et al. Dance Rhythms Improve Motor Symptoms in Individuals with Parkinson's Disease: A Randomized Clinical Trial. J Dance Med Sci 2022; 26(1): 2-7.
3. Irons et al. Group singing improves quality of life for people with Parkinson's: an international study. Aging Ment Health 2021; 25(4): 650-6. Duplicates a study from the 2020 review (was originally included in e-pub ahead of print form).

Intervention (n=13)

1. Arontes et al. Music therapy improves strength and gait in Parkinson's disease patients: A pilot study and clinical case analysis [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 156-7.
2. Bragstad et al. The OPTIM-PARK project: A feasibility study assessing acceptability and feasibility of a cross-national multisectoral intervention for people affected by Parkinson's disease [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 352-3.
3. Cassidy et al. Rhythmic connections: A pilot interdisciplinary music therapy group programme for people with Parkinson's in a day hospital. Age Ageing 2023; 52 (Suppl 3): iii30.
4. Cohen et al. Multidisciplinary intensive outpatient rehabilitation program for patients with moderate-to-advanced Parkinson's disease. Neurorehabiliation 2021; 49(1): 47-55.
5. Ettinger et al. Art therapy as a comprehensive complementary treatment for Parkinson's disease. Front Human Neurosci 2023; 17: 1110531.
6. Feldman et al. The impact of three distinct exercise types on fatigue, anxiety, and depression in Parkinson's disease. Mov Disord Clin Pract 2020; 7 (Suppl 1): S54-5.
7. Fodor et al. Music as add-on therapy in the rehabilitation program of Parkinson's disease patients-a Romanian pilot study. Brain Sci 2021; 11(5): 569.
8. Gondo. Immediate effects of music therapy on gait disturbance in Parkinson's disease, and possibility to reduce the risk of freezing by analyzing the trajectory of center of body [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 213.
9. Mohseni Z, Mohamadi R, Habibi SAH, et al. Voice improvement following conventional speech therapy combined with singing intervention in people with Parkinson's disease: A three-arm randomised controlled trial. Int J Lang Commun Disord 2023; 58(5): 1752-67.
10. Mohseni Z, Saffarian A, Mohamadi R, et al. Effect of Conventional Speech Therapy Combined with Music Therapy on Swallowing in Patients with Parkinson's Disease (Telerehabilitation): A Randomized-Controlled Trial. Middle East J Rehabil Health Stud 2023; 10(1): e131572.
11. Park. Say "AH~": Vocal Analysis in Parkinson's Disease and Essential Tremor [Abstract]. Mov Disord 2020; 35 (Suppl 1): S139-40.
12. Rieders et al. Remote Art Therapy is feasible and may benefit individuals with Parkinson's disease. Mov Disord 2021; 36(Suppl 1): S192.
13. Shah et al. Effect of physical therapy with music therapy on gait, balance and quality of life in Parkinson's disease. Ind J Public Health Res Dev 2020; 11(6): 1064-9.

Outcomes (n=11)

1. Barnstaple et al. Dancing modifies activations in brain regions associated with movement, mood and reward in people with Parkinson's [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 316-7.
2. Barnstaple et al. Weekly dance training over eight months reduces depression and correlates with fMRI brain signals in subcallosal cingulate gyrus (SCG) for people with Parkinson's Disease: An observational study. bioRxiv 2022; 18: doi: https://doi.org/10.1101/2022.10.14.512180.
3. Bek et al. Moving online: Experiences and potential benefits of digital dance for older adults and people with Parkinson's disease. PLoS ONE 2022; 17(11): e0277645.

4. Bek et al. Modulation of neural activity in response to dance training in Parkinson's: a case study [Abstract]. J Parkinsons Dis 2023; 12 (Suppl 1): 136.
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Supplementary file 4. Study characteristics

First author, year	Country	Design	Participants	Inclusion criteria	Outcomes
Dance					
Bouquiaux, 2022	Belgium	Non-randomised controlled trial.	14 (8 male, mean age 68 intervention, 65 control). Recruitment method not stated.	Diagnosis of PD, able to stand and walk for 6 minutes without help, no premorbid neurological, cardiovascular, psychological disorders. No uncorrected visual issues. Able to hear music. No surgery affecting motor function in past 6 months. Attending at least 80% of sessions.	Tinetti test, 10-metre test, 6MWT, fingertip-to-floor test, MoCA.
Delabary, 2020	Brazil	Non-randomised controlled trial.	18 (7 male, mean age 69 intervention, 64 control). Recruitment via social media, flyers in Parkinson's groups and health services and telephone calls using waiting lists for other Parkinson's activities.	PD diagnosed by neurologist (Queen Square Brain Bank criteria), H&Y staging 1-3, on anti-Parkinson drugs, able to walk independently, aged at least 50 years. No risk factors such as recent surgery, deep brain stimulation, other associated neurological or chronic diseases, missing more than 25% of classes or changing established exercise routine.	TUG, gait kinematic analysis.
Duarte, 2023	Brazil	Single group repeated measures study.	13 (5 male, mean age 66). Recruited through social media announcements.	Diagnosis of PD (UK Parkinson's Disease Society Brain Bank criteria), H&Y 1-3, physically able to participate. No other neurologic or neuropsychiatric conditions or comorbidities that	POMA, FAB, PDQ-39, MDS-UPDRS total.

				are a risk for physical activities.	
Feenstra, 2022	Nether lands	Longitudinal cohort study (single arm).	49 (18 male, mean age 68). Recruitment method NS.	PD diagnosis, able to follow instructions. No recent (<3 months) orthopaedic surgery or other neurological conditions affecting mobility.	Rosenberg self-esteem scale, PDQ-39, Activity-Specific Balance Confidence Scale, MDS-UDPRS part III.
Fisher, 2020	Canada	Single-arm repeated measures study.	11 (5 male, mean age 64 males, 68 females). Recruited from neurology outpatients in Montreal. One participant did not complete the study – it is not stated whether their data were analysed.	Mid-to-severe stage PD (H&Y 1.5 to 4).	BesTEST, MoCA, SCOPA-COG, TULIA, REMT. Administered in English or French as per participant preference.
Fontanesi, 2021	USA	Cross-over design with a single group	7 (gender NS, mean age 71). Active members of the Dance for Parkinson's disease community in Brooklyn, NY.	Diagnosis of PD or Parkinsonism Age between 55 and 85. Able to understand and communicate in English.	BSE, 6MWT, TUG.
Frisaldi, 2021	Italy	Randomised controlled trial.	38 (23 male, mean age 61). Recruited through regional movement disorders centres in Turin.	Classified as mild PD, H&Y 1-2, MDS-UPDRS-III 1-32, on stable dopaminergic therapy for at least 4 weeks. No cognitive impairment, severe orthopaedic comorbidities, walking aids, or unable to guarantee presence for entire study period.	MDS-UPDRS-III total, upper, lower and axial body subscores, 6MWT, TUG, Mini-BESTest, NFOG-Q, MoCA, TUG-DT, PDQ-39, FESI-I.
Haas, 2024	Brazil	Randomised controlled trial.	83 (50 male, mean age 72 dance, 68 Nordic walking, 67 deep-water exercise). Recruited from another study.	PD (London Brain Bank Criteria), aged over 50, H&Y 1-3, on regular anti-Parkinsonian drugs, able to	TUG, MDRS-UPDRS-III, 6MWT, FES-I, Sit-to-stand, handgrip test, PDQ-39, MoCA.

				walk independently and understand instructions, MoCA >=21, no lower-limb surgery in the past year, deep-brain stimulation surgery, severe heart disease, uncontrolled hypertension, myocardial infarction within the past year, pacemaker, stroke, or other associated neurological diseases or gait disturbances.	
Haputhanthirige, 2023	Australia	Quasi-experimental parallel group pre-post design.	33 (13 male, mean age 65 intervention, 67 control). Note that there was a statistically significant difference in gender between the groups – those in the dance group were more likely to be female (p=0.013). Recruited from PD support groups in Queensland, advertising on the Parkinson's Queensland website, flyers at an existing Dance for Parkinson's class at Queensland Ballet, through the radio and the university email system.	Clinical diagnosis of PD (Racette criteria), age 40-85, H&Y 1-3, no dementia (ACE score >82), no other medical, neurological, musculoskeletal, cardiovascular or respiratory abnormalities, able to walk for at least 3m without an assistive device, on stable medication.	Dual tasks, spatiotemporal gait analysis.
Harrison, 2020	USA	Single-arm pilot study	10 (7 male, mean age 69). Recruited from a movement disorders clinic at a hospital in St Louis. Demographics table says n=10,	Diagnosis of definite PD (Racette criteria), age above 30, no other neurological diagnoses, orthostatic hypertension,	MDS-UPDRS-III, nFOGq, FHQ, LSQ, PDQ-39.

			while text says 11 completed (inconsistency).	history of deep brain stimulation surgery, inability to stand independently for at least 30 minutes or dementia (MMSE >=24).	
Jola, 2022	UK	Within-participants design (single-arm).	26 (11 male, mean age 71 for males and 72 for females). Recruited from six established dance programmes across the UK.	Diagnosed PD, age 50-84, average TUG time before intervention of at least one SD higher than age-matched general population.	TUG.
Lihala, 2021	India	Single-arm pre-post feasibility study.	9 (7 male). 6 completed study (median age 67). NS whether analysis was only conducted on completers.	Diagnosis of PD (UK Brain Bank criteria), age 40-80, H&Y 1-3, no severe auditory or visual impairment or uncontrolled arthritis. No uncontrolled medical or surgical conditions or previous experience of dance movement therapy.	MoCA total and subs-cores, PDQ-39 and sub-scores, H&Y, UPDRS III.
Moratelli, 2021, 2022	Brazil	Randomised trial.	31 (gender NS, mean age binary 68, quaternary 64). Recruited from local Parkinson's association in Santa Catarina.	Clinical diagnosis of PD (UK Brain Bank criteria), aged at least 50 years, stable doses and no medication change in past 2 weeks, no dance for at least 3 months. No dementia (MMSE), no H&Y stage 5 PD, practice of other physical activity or exercise during intervention. Those who did not attend 75% of classes were excluded.	MDS-UPDRS-I, II,III, Mini-BESTest, FOG, TUG, MoCA, PDQ-39.
Moratelli, 2023	Brazil	Non-randomised trial	69 (34 male, mean age between 67 and 73 in each group).	Clinical diagnosis of PD (London Brain Bank criteria), on stable	UPDRS-III, PDQ-39.

			Individuals from the cities of Porto Alegre and Florianopolis were recruited through the Parkinson's Association of Santa Catarina, social media and institutions providing health services.	medication, aged at least 40 years, able to follow verbal instructions for the tasks, no H&Y stage 5 (wheelchair use), recent surgical procedures, deep brain stimulation, other associated neurological conditions or inability to ambulate independently.	
Park, 2023	USA	Single group repeated measures study.	6 (gender NS, mean age 71). Recruitment route NS. Also 5 general population controls.	PD. No further details.	PDQ-39, VHI, V-RQOL.
Peter, 2020	USA	Non-randomised controlled trial.	15 (gender and age NS). Recruited from balance disorders clinic in North Florida. Those in the tango group were those who wanted to learn tango. There was also a group of general population tango controls.	PD. No further details.	FAPS, UPDRS, PDQ-39, FOG.
Pinto, 2023	Brazil	Non-randomised feasibility trial.	12 (2 male, mean age 69). Recruited from publicity on university media channels, social media, radio stations, and calls to nursing homes and PD associations nationwide. There were also 14 older adults without PD.	Diagnosis of PD (UK Brain Bank criteria), aged over 45, sufficient cognition to understand instructions (according to MMSE), on stable dopamine medication for at least 6 weeks, access to a portable device with internet connection, no severe visual or auditory difficulties, other neurological conditions, or several	SF-36, ABC, FTSTST, PDQ-8.

				neuromuscular conditions.	
Rabinovich, 2021	Argentina	Within-participants pre-post study (single arm).	8 (gender and age NS). Recruited from the movement disorders section of a hospital in Buenos Aires.	Idiopathic PD (UK Parkinson's Society brain bank criteria). A profile of the participants is presented (in the methods), but no other inclusion criteria stated.	MDS-UPDRS-III, 15-item Likert scale questionnaire on motor and non-motor aspects.
Tillmann, 2020	Brazil	Non-randomised controlled trial.	20 (16 male, mean age 66). Recruited from the telephone list of a local Parkinson's association.	PD (London Brain Bank criteria), mild-to-moderate PD, being in "on" phase, aged at least 50, not danced for at least 3 months. Not participating in physical activity or exercise programmes, attending less than 75% of classes, insufficient cognitive status on MMSE, H&Y stage 5 or disabilities in daily or social life activities for reasons other than PD.	H&Y scale 18, UPDRS, BBS, PDQ-39, perceived change in PD symptoms.
Valverde-Guijarro, 2022	Spain	Within-participants A-B-A design.	27 (18 male, mean age 67). Recruited from the neurology unit of a hospital in Madrid.	IPD (UK Parkinson's Disease Society Data Bank criteria), H&Y 1-3, MMSE >=27, no other neurological, rheumatic or orthopaedic conditions affecting postural control, no fractures, or recent surgery on upper or lower limbs or pre-surgery treatment for PD.	BBS, TUG, SOT, MCT, RWS.
Walton, 2022	Sweden	Single group within-participants design.	23 (6 male, mean age 70). Recruited from Dance for Parkinson's	Self-reported PD diagnosis. Member of Dance for Parkinson's	PRMQ, two questions from MFS, PDQ-39.

			classes at the ballet academy in Stockholm.	disease class at the ballet academy in Stockholm. There was a registration fee for dance classes of 400 Swedish Krona (approximately £30).	
Music therapy					
Bastepe-Gray, 2022	USA	Randomised controlled trial (stepped wedge cluster randomised)	24 (17 male, mean age 68 intervention, 67 control). Recruitment route NS.	Idiopathic PD (UK Brain Bank criteria). Absence of any other neurological disorder or injury that would affect the upper extremities and prevent participant or cause discomfort or pain. Required to score at least 17 on MoCA and be fluent in English. No recent experience of guitar lessons.	MDS-UPDRS, PPT, BPT, Q-DASH, PDQ-39.
Pohl, 2020	Sweden	Randomised controlled trial.	46 (32 male, mean age 70). Recruited from neurological clinics in Linköping.	Community-dwelling individuals aged 18 or older with a diagnosis of PD, H&Y up to stage 3, capacity to walk 10m unaided.	TUG (dual task), FES, PDQ-39, MoCA, 3 parts of CAB, MiniBEST, FOG.
Shah-Zamora, 2024	USA	Cohort study (single arm).	16 (15 male, mean age 68). Recruited from a university medical centre in Chicago. 16 caregivers were also analysed.	Clinical diagnosis of PD, age at least 18, primarily English-speaking, access to an electronic device with internet capabilities and current apathy (screened using ICD codes, confirmed using item 1.5 from MDS-UPDRS). No severe hearing or vision loss, diagnosis of atypical Parkinsonism, participation in music-based	PDQ-8, SE-ADL, MoCA-B.

				interventions in past 12 months, or lack of a caregiver.	
Singing					
Brooks, 2021	USA	Non-randomised controlled trial (prospective repeated measures design with control group)	19 (10 male, median age intervention 68, control 69). Recruited from local PD support groups and exercise classes in Florida.	Mild-to-moderate PD as per H&Y, stable PD medication for at least 30 days prior to enrolment. No significant cognitive impairment (MMSE<24), not >18 on BDI, no smoking in past 5 years, history of head or neck cancer, asthma or other neurological disorders or untreated hypertension.	Vowel duration, vowel intensity, maximum pitch, minimum pitch, perceptual ratings of breathiness/ weakness, appropriate pitch level by gender, appropriate prosody, hoarseness, appropriate loudness, loudness decay, consistent rate, appropriate rate, precision of consonants, intelligibility of speech, cough, VHI, CES (both classified as QoL measures by original study authors (but considered communication measures by the review authors).
Butala, 2022	USA	Crossover randomised controlled trial	26 (16 male, mean age intervention 71, control 67). Recruited from multiple regional medical centres in Maryland.	Idiopathic PD (UK Brain Bank criteria), no dementia (MoCA >24), no psychiatric conditions precluding participation.	Objective measures of vocal function (loudness, held vowel duration, jitter, shimmer, HNR), PDQ-39, VRQOL, MDS-UPDRS, MoCA, SF-36, LSE.
Good, 2023	Canada	Cohort study (two singing groups both	22 (13 male, mean age 70 group A and 73 group B). Recruited from	Idiopathic PD diagnosed at age 50 or above, aged at least 50, within	Vocal measures: maximum pitch,

		intervention arms)	local PD support organisations in Toronto (Group A) and Winnipeg (Group B).	mild-to-moderate PD range, no other movement disorders, no recent participation in singing-based programmes. No dementia (MoCA >=21), self-reported normal or corrected-to-normal hearing and vision.	minimum pitch, duration, loudness, jitter, shimmer.
Lee, 2024	USA	Randomised controlled trial	27 (13 male, mean age 73). Convenience sample of singers with PD recruited from Treble Clefs, Arizona.	Diagnosis of PD, at least 3 months' experience of singing with Treble Clefs, Arizona, able to read, write and speak English.	VHI, VRQOL, AVQI, perceived voice quality.
Lewellen, 2020	USA	Single-group pre-post study	15 (11 male, mean age 67). Convenience sample, details NS. 7 caregivers/ partners also took part.	PD, H&Y stage 2-3, exhibiting deficits in verbal communication and mobility warranting supportive interventions.	Vocal duration, mean intensity, maximum intensity, cepstral peak prominence (cepstrum refers to the inverse Fourier transform of the logarithm of the spectrum), jitter, shimmer, hypophonia, and harmonic to noise ratio.
Stegemöller, 2020	USA	Single-arm study	8 (7 male, mean age 74). Recruited from Rockwell City (method unclear) then later Storm Lake region (through PD support group). Both were considered rural areas.	Diagnosis of IPD, stable PD medication regime for 30 days, current non-smokers, no speech therapy within 2 years before the study, no significant cognitive impairment (MMSE<24), major psychiatric disorder (BDI <18), history of head or neck cancer, asthma or COPD, or untreated hypertension.	Phonation duration, phonation range, vocal intensity.

Stegemöller, 2021, 2022, 2023	USA	Non-randomised controlled trial.	25 (11 male, mean age intervention 74, control 70). Recruited from ongoing singing groups in Iowa (intervention arm) and a general listserve of people with PD interested in research (control arm).	Diagnosis of PD, age 40-85, stable medication for 30 days.	MDS-UPDRS-III, voice measures (including vocal loudness, pitch range , and vocal duration), respiratory control, quality of life (measure NS).
Tamplin, 2020 (note this is an additional paper from the same Tamplin study as in the 2020 review)	Australia	Non-randomised controlled trial.	75 (46 male, mean age 74). Recruited from local PD support groups.	PD by neurologist (MDS criteria). MMSE ≥17. No memory problems, severe language difficulties or hearing impairment.	Voice, speech, EQ-5D and VRQoL.

ABC = Activities-specific Balance Confidence scale (Powell & Myers, 1995), ACE = Addenbrooke's Cognitive Examination (Mathuranath, Nestor, Berrios, Rakowicz, & Hodges, 2000), AVQI = Acoustic Voice Quality Index (Maryn et al, 2010), BDI = Beck Depression Inventory (Beck, 1972), BBS = Berg Balance Scale (Berg, Wood-Dauphinée, Williams, & Gayton, 1989), Brain Bank criteria = UK Parkinson's Disease Society Brain Bank criteria (Gibb & Lees, 1988), BSE = Body Self-Efficacy, CAB = Cognitive Assessment Battery (Nordlund et al, 2011), EQ-5D = EuroQol 5 Dimensions Quality of Life scale (EuroQol Group, 1990), FAB = Frontal Assessment Battery (Dubois, Slachevsky, Litvan, & Pillon, 2000), FAPS = Functional Ambulatory Performance Score (Gretz et al, 1998), FES-I = Falls Efficacy Scale – International (Yardley et al, 2005), FHQ = Falls History Questionnaire, FOG = Freezing of Gait questionnaire (Giladi et al, 2000), FTSTST = Five times sit to stand test, HNR = Harmonic to noise ratio, H&Y = Hoehn and Yahr staging (Hoehn & Yahr, 1967); IPD = idiopathic Parkinson's disease, LSE = Lorig et al (1989) Self Efficiency scale, LSQ = Life Space Questionnaire (Stalvey et al, 1999), MCT = Motor Control Test (Luomajoki et al, 2008), MDS = Movement Disorders Society, MDS-UPDRS = Movement Disorders Society sponsored revision of the Unified Parkinson's Disease Rating Scale (Goetz et al, 2008), MFS = Mental Fatigue Scale (Johansson et al, 2010), Mini-BEST – Mini Balance Evaluation Systems Test (Franchignoni, Horak, Godi, Nardone, & Giordano, 2010), MMSE = Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975), MoCA = Montreal Cognitive Assessment (Nasreddine et al, 2005), MoCA-B = MoCA-Blind, NBS = National Ballet School, nFOGq = New Freezing of Gait Questionnaire (Giladi et al, 2000), NS = not stated, PD = Parkinson's disease, PDQ-39 = Parkinson's Disease Questionnaire – 39 Items (Peto, Jenkinson, Fitzpatrick, & Greenhall, 1995) , PPT = Purdue Pegboard Test (Tiffin, 1948), PRMQ = Prospective Retrospective Memory Questionnaire (Smith et al, 2000), Racette criteria = Racette, Rundle, Parsian, & Perlmutter (1999), Q-DASH = Quick Disability of the Arm, Shoulder and Hand (Beaton et al, 2005), REMT = Reading the Mind in the Eyes task (Baron-Cohen et al, 2001), RWS = Rhythmic weight shift, SE-ADL = Schwab and England Activities of Daily Living (Schwab & England, 1968), SCOPA-COG = SCales for Outcomes in PArkinson's disease-COGnition (Marinus et al, 2003), SF-36 = 36-Item Short Form Health Survey (Saris-Baglama et al, 2007), SOT = Sensory Organization Test (Clendaniel, 2000), TUG = Timed Up and Go (Podsiadlo & Richardson, 1991), TULIA = Test of Upper Limb Apraxia (Vanbellingen et al, 2010), UPDRS = Unified Parkinson's Disease Rating Scale (Fahn, Elton, & UPDRS Program Members, 1987), VHI = Voice Handicap Index (Jacobson et al, 1997), VRQoL = Voice- Related Quality of Life (Hogikyan & Sethuraman, 1999), 6MWT = Six minute walking test. Studies use a range of different terminology to refer to the Brain Bank Criteria (e.g. London, UK Parkinson's Disease Society, Queen Square), but these refer to the same set of criteria (Gibb &Lees, 1988).

Supplementary file 5. Intervention profile

First author, year	Content	Leader	Location	Duration
Dance				
Bouquiaux, 2022	Dance training. Sit warm-up, dancing adding new steps each week with increasing difficulty, adaptions where needed, seated stretching to end.	Professional dancers.	NS.	16 group sessions of 60 minutes over 4 months, then a show.
Delabary, 2020	Samba and Forró Brazilian rhythmic dance.	Qualified dance teacher with an undergraduate degree in Dance.	Appropriate room for dance classes with mirrors, chairs and a barre.	24 group sessions of 60 minutes over 12 weeks.
Duarte, 2023	Physical activity based on dance movements, called the "Baila Parkinson" method.	NS.	Suitable rooms within Laboratory of Studies in Functional Rehabilitation.	2 group sessions of 50 minutes per week for six months.
Feenstra, 2022	Dance classes. Involved aspects of ballet, modern dance and jazz. Opportunity to socialise as well.	PD-skilled dance teachers.	Seven locations in the north of the Netherlands – details about venue type NS.	1 group session of 60 minutes per week for 22 weeks.
Fisher, 2020	Improvisational dance movement therapy.	Two trained dance movement therapists.	University chapel.	One group session of 90 minutes per week for 10 weeks.
Fontanesi, 2021	Dance for Parkinson's.	Certified dance instructor.	Mark Morris Dance Center, Brooklyn, NY.	Unclear.
Frisaldi, 2021	DArT method (combined dance-physiotherapy intervention).	Dance therapist with a strong neuroscience background and experience in PD conducted dance classes. Physiotherapist conducted conventional physiotherapy.	NS.	60 minutes of conventional physiotherapy followed by 60 minutes of group dance class, 3 times a week for 5 weeks.
Haas, 2024	Brazilian dance	NS.	NS.	24 group sessions of an average of 60 minutes over 12 weeks.
Haputhanthirige, 2023	Dance for Parkinson's Disease	Dance for Parkinson's disease trained instructors.	Queensland Ballet.	Group sessions of 120 minutes twice a week for 3 months.
Harrison, 2020	Joywalk (walking dance), preceded by	Professional contemporary dancer	NS.	Two group sessions of 60 60

	warm-up and centre practice	experienced in teaching people with PD.		minutes per week for 6 weeks.
Jola, 2022	Dance for Parkinson's disease	Dance instructors. Some had been trained in Dance for Parkinson's disease and one centre was a Dance for Parkinson's disease international affiliate centre.	Six established dance classes across the UK, details of venues not provided.	All participants took part in dance classes at least once a week with an average of at least 40 dance classes. All but three participants included in the quantitative analysis took part in dance classes for at least two months.
Lihala, 2021	Dance movement therapy	Dance movement therapists.	Institute of Neurosciences.	90-minute session. Frequency NS.
Moratelli, 2021, 2022	Dance classes (2 groups: binary rhythm and quaternary rhythm)	Trained researchers.	Santa Catarina Rehabilitation Center. It is stated that the environment in which the binary and quaternary classes were held differed, but details NS.	2 group sessions of 45 minutes per week for 45 minutes.
Moratelli, 2023	Forro Brasiliero and samba, samba only	NS.	NS.	1 group session of 60 minutes of samba and 1 group session of 60 minutes of Forro Brasiliero per week for 11 weeks or 2 group sessions of 60 minutes of samba per week for 11 weeks.
Park, 2023	Vocal-dance programme	Run by Oklahoma City Ballet outreach division. NS exactly who led classes.	Run by Oklahoma City Ballet outreach division. NS if held at the ballet.	2 group sessions of 60 minutes per week for 4 weeks.
Peter, 2020	Argentine tango	NS.	Independent living retirement facility with a wooden dance floor.	3 group sessions a week for 4 weeks. Duration NS.
Pinto, 2023	Online dance intervention based on Dance for Parkinson's.	An instructor who is a professional dancer and physiotherapist.	Online (taught via Zoom software).	Two group sessions of 60 minutes per week for 8 weeks.
Rabinovich, 2021	Argentine tango	Two experienced tango instructors.	Movement disorders section	Ten group sessions of 90

			of a hospital – using a medical meeting or conference room.	minutes over a 2-week period.
Tillmann, 2020	Brazilian samba	Dance teacher/ researcher with experience in ballroom dancing, assisted by 3 researchers.	A large room with a smooth floor and chairs.	2 group sessions of 60 minutes per week for 12 weeks.
Valverde-Guijarro, 2022	Contemporary dance programme	Professional dancer specialised in dance pedagogy.	A community rehabilitation setting.	1 group session of 60 minutes twice a week for 8 weeks.
Walton, 2022	Digital Dance for Parkinson's	Professional, experienced, dance instructor, certified in Dance for Parkinson's.	Online, taught via Zoom software.	1 online group session of 60 minutes per week for 10 weeks.
Music therapy				
Bastepe-Gray, 2022	Guitar lessons (using classical guitars).	Professional guitar teachers.	Community music school.	Two group guitar classes of 60 minutes per week for 6 weeks.
Pohl, 2020	Ronnie Gardiner Method.	Two physiotherapists	Neuro rehabilitation centre.	Two group sessions of 60 minutes per week for 12 weeks.
Shah-Zamora, 2024	Virtual group music therapy – instrument kits including a harmonica, drum, tambourine, drumsticks, wrist bells and more were provided.	Board-certified neurologic music therapist.	Online.	One group session of 60 minutes per week for 12 weeks.
Singing				
Brooks, 2021	Therapeutic group singing (vocal exercises then singing of familiar songs).	Board-certified music therapist.	NS.	1 group session of 60 minutes per week for 12 weeks.
Butala, 2022	Warm-up, vocal exercises, singing well-known songs (reinforced by home exercises).	Professional choir director.	Auditorium in a community-based church space.	1 group session of 90 minutes per week for 12 weeks.
Good, 2023	Community choir. Both groups were similar, emphasising community inclusion and vocal strengthening. Songs differed between sites.	Group A: professional choir director with a musical theatre background. There was also a trained piano accompanist. Group B: Music therapist who accompanied	At the community choirs' normal venues – details NS.	1 group session of 50 minutes per week for 12 weeks (10 minutes' warm-up and 40 minutes' songs).

		herself on the guitar.		
Lee, 2024	Therapeutic group singing. A second intervention group additionally received straw phonation.	Board-certified music therapist.	Same room where Treble Clefs, Arizona, usually meets.	Single session of 30 minutes.
Lewellen, 2020	Group singing therapy (following Therapeutic Singing Protocol by Yinger and LaPointe (2012).	Board-certified music therapist (first author).	NS.	1 group session of 50 minutes per week for 8 weeks (session duration NS).
Stegemöller, 2020	Group therapeutic singing, by telemedicine.	Board-certified music therapist.	Local church in each of the two communities, with a screen to access the recorded content.	8 group sessions over a period of 9 weeks.
Stegemöller, 2021, 2022, 2023	Group therapeutic singing (vocal exercises and singing familiar songs).	Board certified music therapist.	NS.	A single session of 60 minutes.
Tamplin, 2020	Singing popular and traditional songs and rounds.	Weekly: a music therapist. Monthly: community musicians and volunteers.	NS.	1 group session of 2 hours weekly or monthly for 3 months.

Argentine tango = danced in traditional gender roles unless stated, Dance for Parkinson's Disease = a model developed by Mark Morris Dance Center and Brooklyn Parkinson Group including modern dance, choreography and partner dancing (Westheimer, 2008), NBS = National Ballet School, NS = Not stated, PD = Parkinson's disease, Ronnie Gardiner Rhythm and Music Method = musical exercises that challenge cognition and sensorimotor control.

Supplementary file 6. Control profile

First author, year	Synopsis of control arm
Dance	
Bouquiaux, 2022	Usual care (no intervention).
Delabary, 2020	Walking programme. Matched for frequency and duration. Held outdoors on a 400-metre track. Taught by qualified teachers with an undergraduate degree in Physical Education.
Fontanesi, 2021	Matched-intensity exercise.
Frisaldi, 2021	Conventional physiotherapy.
Haas, 2024	Deep-water exercise. Nordic walking. Both matched for frequency.
Haputhanthirige, 2023	Usual care.
Moratelli, 2023	Usual care (instructed to maintain their usual activities and lifestyle).
Peter, 2020	Usual care.
Tillmann, 2020	Usual care (guideline to adhere to current pattern of activities). Also invited to attend monthly lectures about maintenance of health, falls prevention and psychological care.
Valverde-Guijarro, 2022	The control formed the A in the A-B-A design. Physiotherapy programme comprising conventional physiotherapy (two sessions of 45 minutes per week), individual hydrotherapy (two sessions of 45 minutes per week) and manual techniques (two sessions of 30 minutes per month).
Music therapy	
Bastepe-Gray, 2022	The same guitar classes as the intervention group but after 6 weeks of usual care first.
Pohl, 2020	Usual care.
Singing	
Brooks, 2021	Usual care.
Butala, 2022	Discussion group, in a separate auditorium in the same building, matched for duration and frequency.
Lee, 2024	Speaking-only control group.
Stegemöller, 2021, 2022, 2023	1-hour quiet reading in a group environment.
Tamplin, 2020.	Weekly control: a weekly session of painting, dancing or tai chi. Monthly control: a monthly peer support group.

Supplementary file 7. Narrative results

First author, year	Narrative results
Dance	
Bouquiaux, 2022	There was evidence that dance training improved one measure of motor function (10-metre test), but not cognition or other motor measures.
Delabary, 2020	There was evidence that Samba and Forró Brazilian rhythmic dance improved functional mobility, although the benefit was not greater than a group walking intervention.
Duarte, 2023	There was evidence that the Baila Parkinson method improved balance and gait, executive function, abstract reasoning and inhibitory control and quality of life.
Feenstra, 2022	There was evidence that dance classes improved quality of life (including self-esteem) and motor function. However, there was no significant change in balance confidence.
Fisher, 2020	There was some evidence that improvisational dance improved motor function and cognition, although this was not shown on all measures.
Fontanesi, 2021	There was evidence that Dance for Parkinson's improved body self-efficacy, gait symmetry and motor dual task performance.
Frisaldi, 2021	There was evidence that the DArT method improved motor performance (on the primary outcome, but not all secondary outcomes). However, there was no evidence of an improvement in cognition or quality of life over and above conventional therapy.
Haas, 2024	There was some evidence that Brazilian dance improved motor function over and above deep-water exercise and Nordic walking, but not on all measures. There was no evidence of a significant difference in quality of life or cognition.
Haputhanthirige, 2023	There was evidence that Dance for Parkinson's improved dual task motor performance and most (but not all) gait analysis parameters.
Harrison, 2020	There was evidence that walking dance improved most (but not all) measures of gait. No evidence of a benefit on quality of life was shown.
Jola, 2022	There was evidence that Dance for Parkinson's improved motor function.
Lihala, 2021	There was evidence that dance movement therapy improved cognitive status and quality of life. Improvements in motor function did not reach statistical significance.
Moratelli, 2021, 2022	There was evidence that both binary and quaternary dance improved cognition, mental activity, activities of daily living and overall quality of life. Both rhythms improved motor function and balance, but only binary rhythm was shown to improve freezing of gait.
Moratelli, 2023	Evidence for a benefit of dance compared to control was stronger for samba at a higher frequency compared to the combined samba and fosso brasiliero intervention. Comparing samba and control, statistically significant benefit for samba was found for motor function and for the mobility subscale of PDQ-39. However, no overall significant benefit on quality of life was found.
Park, 2023	There was no evidence that vocal dance led to a statistically significant improvement in voice parameters, communication, voice-related or overall quality of life.
Peter, 2020	There was evidence that Argentine tango reduced falls risk. Improvements in overall motor function, freezing of gait and quality of life did not reach statistical significance.
Pinto, 2023	There was no evidence that online dance significantly improved motor function or quality of life in the PD group – however the study was primarily designed to assess feasibility not efficacy.
Rabinovich, 2021	There was evidence that high dose tango improved motor function as well as activities of daily living, sleep confidence and relatedness.
Tillmann, 2020	There was evidence that Brazilian samba improved motor function. There was some evidence of a benefit on quality of life – shown on the activities of daily living subscale of UPDRS and the mobility subscale of PDQ-39, but not on other subscales or the overall PDQ-39 score.
Valverde-Guijarro, 2022	There was evidence that the contemporary dance programme improved most (but not all) motor measures including functional mobility and balance. There was some evidence of a benefit on measures of aspects of cognitive functioning.
Walton, 2022	There was evidence that digital dance for Parkinson's improved physical functioning, memory and quality of life. It was noted however that some important elements of live dance were missing.
Music therapy	
Bastepe-Gray, 2022	There was evidence that the guitar intervention significantly improved motor function. There was a numerical improvement in quality of life, but statistical significance was not

	reached. There was no significant difference between early and late intervention groups and participants experienced benefits in motor function before the start of guitar lessons. Within the early intervention group alone, a clinically significant difference in quality of life was found (it was only statistically significant in unadjusted analysis).
Pohl, 2020	There was evidence that the Ronnie Gardiner method improved quality of life and confidence about falling in the short term, but these gains were not retained at three months. No significant improvements were shown in cognitive status, balance, dual task motor performance and freezing of gait.
Shah-Zamora, 2024	There was no evidence that virtual music therapy significantly improved quality of life (including functional abilities) or cognition.
Singing	
Brooks, 2021	There was some evidence that therapeutic group singing improved voice, although it was not shown on all measures. Around half of participants improved their voice on singing. Improvements in cough and communication did not reach statistical significance.
Butala, 2022	There was evidence that group singing significantly improved motor function, some measures of voice and quality of life domains related to emotional wellbeing and body discomfort. There was however no evidence of an improvement on other voice measures as well as both voice-related and overall quality of life or cognitive status.
Good, 2023	There was evidence that community choir signing improved some but not all measures of vocal production.
Lee, 2024	There was evidence that therapeutic group singing improved acoustic and perceived voice quality. This effect was observed for the singing intervention both alone or in combination with straw phonation compared to control. Follow-up scores were not reported for communication or voice-related quality of life.
Lewellen, 2020	There was evidence that group singing therapy improved vocal function.
Stegemöller, 2020	Improvements in vocal measures following group therapeutic singing telehealth did not reach statistical significance.
Stegemöller, 2021, 2022, 2023	There was evidence that a single session of group therapeutic singing improved respiratory control and quality of life. There were some, but not consistent, evidence of a benefit on motor function. No evidence of a significant benefit on speech and facial expression was found.
Tamplin, 2020	There was evidence that both weekly and monthly singing improved standardised and conversational speech loudness, although the benefit was greater and took effect earlier for weekly singing. There were no statistically significant differences in respiratory measures relevant to speech, although weekly singers experienced a clinically significant improvement in maximum expiratory pressure. Between-group differences were found on one measure of speech intelligibility, although this appeared largely attributable to performance declines in the monthly control group. Voice-related quality of life improved significantly for weekly singers only. No statistically significant differences in overall quality of life were observed.

Supplementary file 8. SURE critique checklist for experimental studies

Assessment could not be conducted for any studies that comprise solely a conference abstract.

Dance

SURE critical appraisal checklist questions	Bouquiaux, 2022	Delabary, 2020	Frisaldi, 2021	Haas, 2024	Moratelli, 2022	Moratelli, 2023
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	No.	Yes, computer-generated random numbers.	Yes, online randomisation tool.	Yes, using Excel software.	No.
Was allocation to intervention or comparator groups concealed?	No.	No.	No.	No.	Unclear.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No.	No.	Assessors only.	Assessors and statisticians.	Unclear.	No.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.

Was ethical approval sought and received?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was a trial protocol published?	NS.	Yes.	NS.	Yes.	Yes.	Yes.
Were the groups similar at the start of the trial?	Yes.	Unclear.	Yes.	Yes.	Yes.	Yes.
Was the sample size sufficient?	NS.	Yes.	Unclear.	Unclear.	Unclear.	Yes.
Were participants properly accounted for?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Are the statistical methods well described?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Results appropriate and clear?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	NS, no conflict.	'Funded by the authors'. Motivation for this NS. However, does say no conflicts.	Academic, no conflict.	Academic, no conflict.	Academic, no conflict.	Academic, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Yes.	Yes.	Unclear, no separate conclusion section.	Yes.	Yes.	Yes.

SURE critical appraisal checklist questions	Peter, 2020	Pinto, 2023	Tillmann, 2020
Does the study address a clearly focused question/hypothesis?	No.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	No.	No.
Was allocation to intervention or comparator groups concealed?	No.	No.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No.	No.	No.
Were interventions (and comparisons) well described and appropriate?	Not well described.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.	Yes.
Was a trial protocol published?	Unclear.	Yes.	Yes.

Were the groups similar at the start of the trial?	Unclear.	Unclear.	Yes.
Was the sample size sufficient?	Unclear.	Unclear.	Yes.
Were participants properly accounted for?	Unclear.	Yes.	Yes.
Are the statistical methods well described?	No.	Yes.	Yes.
Results appropriate and clear?	No – unclear presentation.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	Academic, no conflict.	Academic, one author declared being the director of a national Dance for Parkinson's programme	NS, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Unclear, no separate conclusions section.	No, full text stronger.	No, full text stronger.

Music therapy

SURE critical appraisal checklist questions	Bastepe-Grey, 2023	Pohl, 2020
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	Yes, stepped wedge.	Yes, random number website.
Was allocation to intervention or comparator groups concealed?	No.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	Assessors only.	Assessors only.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.
Was a trial protocol published?	NS.	Yes.

Were the groups similar at the start of the trial?	Yes.	Yes.
Was the sample size sufficient?	Unclear.	Yes.
Were participants properly accounted for?	Yes.	Yes.
Are the statistical methods well described?	Yes.	Yes.
Results appropriate and clear?	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	Academic, no conflicts.	Academic and charity, one conflict declared regarding being a non-practising certified practitioner of Ronnie Gardiner method (the person was blind to outcome assessments).
Did the authors identify any limitations?	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Yes.	Unclear, no separate conclusion.

Singing

SURE critical appraisal checklist questions	Brooks, 2021	Butala, 2022	Lee, 2024	Stegemoller, 2021/2022/2023
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	Yes, Excel random number generator.	Yes, NS.	No.
Was allocation to intervention or comparator groups concealed?	No.	No.	NS.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No.	Assessors only.	NS.	No.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.	Yes.	Yes.

Was a trial protocol published?	NS.	Yes.	NS.	NS.
Were the groups similar at the start of the trial?	Yes.	Yes.	Yes.	Yes.
Was the sample size sufficient?	Unclear.	Unclear.	Unclear.	No.
Were participants properly accounted for?	Yes.	Yes.	Yes.	Yes.
Are the statistical methods well described?	No.	Yes.	Yes.	Yes.
Results appropriate and clear?	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	NS.	NS, no conflicts.	NS.	Museum, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	No, full text stronger.	Yes.	Yes.	No, abstract stronger.

Supplementary file 9. SURE critique checklist for cohort studies

Dance

SURE critical appraisal checklist questions	Duarte, 2023	Feenstra, 2022	Fisher, 2020	Fontanes, 2021	Haputhanthirige, 2023
Is the study design clearly stated?	Yes.	Yes.	No.	Yes.	Yes.
Does the study address a clearly focused question?	Yes.	Yes.	Yes.	Yes.	Yes.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.	Partly.	Partly.
Were participants fairly selected?	Unclear.	Unclear.	Unclear.	Unclear.	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.
Was bias considered?	Yes.	Unclear.	Unclear.	Yes.	Unclear.
Is there a description of how the study size was arrived at?	No.	No.	No.	No.	Yes.

Are the statistical methods well described?	No.	No.	Partly.	Yes.	Yes.
Is information provided on participant flow?	Yes.	Yes.	No.	No.	Yes.
Are the results well described?	Yes.	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/ conflict of interest reported?	Academic, no conflict.	Academic, one author developed the dance classes.	Academic, no conflict.	Academic, no conflict.	Academic, one author declares being national director of Dance for Parkinson's.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.

SURE critical appraisal checklist questions	Harrison, 2020	Jola, 2022	Lihala, 2021	Rabanovich, 2021	Valverde-Guijarro, 2022
Is the study design clearly stated?	Yes.	Yes.	Yes.	Yes.	Yes.

Does the study address a clearly focused question?	Yes.	Yes.	Yes.	Yes.	Yes.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.	Partly.	Partly.
Were participants fairly selected?	Unclear.	No.	No.	Unclear.	Yes (consecutive).
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.
Was bias considered?	Yes.	Unclear.	Unclear.	Yes.	Yes.
Is there a description of how the study size was arrived at?	No.	No – says 'not practical' to define a sample size.	No.	No.	No.
Are the statistical methods well described?	No.	Yes.	No.	No.	Yes.
Is information provided on participant flow?	Partly.	No.	Yes.	Partly.	Partly.
Are the results well described?	Yes.	Yes.	Yes.	Yes.	Yes.

Is there any sponsorship/ conflict of interest reported?	No funding declared, no conflicts.	Academic, no conflicts.	Institutional, no conflicts.	Academic, no conflicts.	NS, no conflicts.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.

SURE critical appraisal checklist questions	Walton, 2022
Is the study design clearly stated?	Yes.
Does the study address a clearly focused question?	Yes.
Are the setting, locations and relevant dates provided?	Partly.
Were participants fairly selected?	Unclear.

Are the measures of exposures and outcomes appropriate?	Yes.
Was bias considered?	Unclear.
Is there a description of how the study size was arrived at?	No.
Are the statistical methods well described?	Yes.
Is information provided on participant flow?	Yes.
Are the results well described?	Yes.
Is there any sponsorship/ conflict of interest reported?	Academic, no conflict.
Did the authors identify any limitations?	Yes.

Music therapy

SURE critical appraisal checklist questions	Shah-Zamora, 2024
Is the study design clearly stated?	Yes.
Does the study address a clearly focused question?	Yes.
Are the setting, locations and relevant dates provided?	Yes.
Were participants fairly selected?	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.
Was bias considered?	Yes.
Is there a description of how the study size was arrived at?	Yes.
Are the statistical methods well described?	Yes.

Is information provided on participant flow?	Yes.
Are the results well described?	Yes.
Is there any sponsorship/ conflict of interest reported?	Academic, no conflict.
Did the authors identify any limitations?	Yes.

Singing

SURE critical appraisal checklist questions	Good, 2023	Lewellen, 2020	Stegemoller, 2020
Is the study design clearly stated?	No.	Yes.	No.
Does the study address a clearly focused question?	Yes.	Yes.	Yes.

Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.
Were participants fairly selected?	Unclear.	No.	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.
Was bias considered?	Unclear.	Unclear.	Unclear.
Is there a description of how the study size was arrived at?	No.	No.	No.
Are the statistical methods well described?	Yes.	No.	No.
Is information provided on participant flow?	Partly.	No.	Partly.
Are the results well described?	Yes.	Yes.	Yes.
Is there any sponsorship/ conflict of interest reported?	Academic, conflicts NS.	NS.	NS, no conflict.

Did the authors identify any limitations?	Yes.	NS.	Yes, but not clearly stated.

Supplementary file 10. Meta-analysis

Part A. **Assessment of feasibility**

Following the narrative assessment of available evidence, the following standardised scales were considered for use in meta-analysis:

- Quality of life: PDQ-39 total, VRQoL
- Functional communication: VHI, CES
- Speech: Intelligibility, jitter, shimmer
- Motor function: UPDRS-III, TUG.
- Cognitive function: MMSE, FAB and MoCA

Meta-analysis was considered feasible where there were at least two studies assessing the same outcome measure comparing the same intervention-comparator pair. 6MWT was considered as another possible outcome measure for motor function, but was not selected, to maintain consistency with the approach taken by Barnish et al (2020) and as there were already two standardised motor measures under consideration.

Singing and music therapy were considered unitary interventions due to limited available evidence to consider sub-types. Based on the available evidence, dance was sub-divided into:

- Brazilian/Samba-based dance
- PD-specific dance forms
- Tango-based dance

The following studies from the present review were available to inform potential meta-analyses:

Dance (only list Dance for PD; Tango; Brazilian)

- Delabary, 2020 – Brazilian dance vs walking; TUG
- Fontanesi, 2021 – Dance for Parkinson's vs exercise; TUG
- Haas, 2024 – Brazilian vs deep water exercise; Nordic walking; UPDRS-III, TUG, PDQ-39, MoCA
- Haputhanthirige, 2023 – Dance for PD vs usual care; TUG
- Moratelli, 2023 – Brazilian vs usual care; UPDRS-III, PDQ-39
- Peter, 2020 – Tango vs usual care; UPDRS-III, PDQ-39 – following investigation, reporting was insufficient to include in meta-analyses
- Tillmann, 2020 – Brazilian vs usual care; UPDRS-III, PDQ-39

Music therapy

- Bastepe-Gray, 2022 – waitlist (then intervention before assess); UPDRS-III, PDQ-39
- Pohl, 2020 – usual care; PDQ-39, MoCA.

Singing

- Brooks, 2021 – usual care; voice measures, VHI, CES
- Butala, 2022 – discussion group (no other studies with this comparator)
- Lee, 2024 – speaking (no other studies with this comparator)
- Stegemoller, 2021, 2022, 2023 – reading (no other studies with this comparator)

The following analysis sets were feasible:

1. Brazilian/Samba dance vs usual care UPDRS-III (Moratelli et al, 2023; Tillmann et al, 2020)
2. Brazilian/Samba dance vs usual care PDQ-39 (Moratelli et al, 2023; Tillmann et al, 2020)
3. PD-specific dance vs exercise TUG (Hashimoto et al, 2015; Fontanesi et al, 2021)
4. PD-specific dance vs usual care TUG. (Ventura et al, 2016; Hashimoto et al, 2015)
5. PD-specific dance vs usual care PDQ-39. (Ventura et al, 2016; Kalyani et al, 2019)
6. Tango-based dance vs exercise UPDRS-III. (De Natale et al, 2017; Romenets et al, 2015; Hackney et al, 2007 a,b).

7. Tango-based dance vs usual care UPDRS-III. (Hackney and Earhart, 2009 a,b,c; Duncan and Earhart, 2012/Foster et al, 2013)
8. Tango-based dance vs exercise TUG. (Romenets et al, 2015; Hackney et al, 2007 a,b)

There were no two singing studies using a sufficiently similar comparator to conduct meta-analysis.

All analyses that were conducted on follow-up scores in the Barnish et al (2020) review, as there were not two studies for this particular combination of intervention, comparator and outcome that reported change scores plus a measure of variability, were reproduced using follow-up scores for comparability. These results were entered into the comparison table in Part D below. Where data permitted, analyses were also run using change scores, to protect against confounding due to baseline imbalances. However, the ability to do this was very limited.

This was because while a change score was provided or could be calculated, for very few studies was a standard deviation provided for the change score, or anything that could be converted into a standard deviation. Most obviously, this could be a standard error, a variance or 95% confidence intervals, however variance itself could be calculated as variance of difference equals the sum of the variances less twice the covariance. However, studies did not report the covariance. Incompatibility in results presentation, such as between Pohl et al (2020) and Pantelyat et al (2016) for MoCA further restricted the meta-analysis sets that could be conducted. Furthermore, for some studies, potentially valuable measures, such as UPDRS motor in Pohl et al (2020) were only reported for baseline and not follow-up time points. Evidence in usable form for meta-analysis was too sparse to consider a network meta-analysis.

Analyses were not repeated where analysis sets remained unchanged from the 2020 review, therefore forest plots are only provided for analysis sets that are either new or have changed since 2020 (no analysis sets changed, as there were no additional studies with the required data for the specific intervention-comparator-outcome configurations.

In the 2020 review, only 10 out of 56 included studies (18%) could be used in the meta-analysis. Four out of the 32 included studies (13%) identified through the present systematic review could be used in the meta-analysis. In total, out of the 88 studies available across the two reviews to address the present research question, only 14 (16%) could be used in the meta-analysis. Therefore, there is a disjoint where on the one hand the evidence available for the primary analysis method of narrative synthesis is rich and has developed considerable since 2020, although not all evidence gaps have been fully resolved; whereas on the other hand evidence for the secondary analysis method of meta-analysis remains very limited, due to methodological differences limiting the number of studies that can be used in the meta-analysis. While the meta-analysis in itself is limited, and should not drive the conclusions of the paper, it is presented for comparability with the 2020 review and to highlight the challenges still facing meta-analysis in this area.

Looking forward, considerable development in terms of standardisation of comparator arms, outcome measures and ways in which statistical results are presented (in particular an increased focus on change scores with a measure of variability around them) would be necessary to facilitate future more extensive meta-analyses, and potentially network meta-analyses in the area of the performing arts as therapy for PD.

Part B. **Tabulation of data**

Analysis set 1: Brazilian/Samba dance vs usual care UPDRS-III (Moratelli et al, 2023; Tillmann et al, 2020) – new for 2024

Study	**Intervention**			**Control**		
	N	Mean	SD	N	Mean	SD
Moratelli et al, 2023	23	14.04	9.4	23	20.04	13.1
Tillmann et al, 2020	10	12.0	2.8	10	25.1	2.8

Comparison conducted on follow-up scores. For Moratelli et al (2023), Samba group scores were used as the intervention rather than the forro and Samba group.

Analysis set 2: Brazilian/Samba dance vs usual care PDQ-39 (Moratelli et al, 2023; Tillmann et al, 2020) – new for 2024

Study	**Intervention**			**Control**		
	N	Mean	SD	N	Mean	SD

Moratelli et al, 2023	23	49.73	26.1	23	65.21	32.1
Tillmann et al, 2020	10	49.0	27.9	10	66.4	9.3

Comparison conducted on follow-up scores. For Moratelli et al (2023), Samba group scores were used as the intervention rather than the forro and Samba group.

Analysis set 3: PD-specific dance vs exercise TUG (Hashimoto et al, 2015; Fontanesi et al, 2021) – new for 2024

Study	**Intervention**			**Control**		
	N	Mean	SD	N	Mean	SD
Hashimoto et al, 2015	15	9.7	2.1	14	9.1	1.9
Fontanesi et al, 2021	7	13.04	1.89	7	12.30	0.66

Comparison conducted on follow-up scores. Time score used for TUG (simple TUG).

Analysis set 4: PD-specific dance vs usual care TUG. (Ventura et al, 2016; Hashimoto et al, 2015) – was conducted in 2020 review

Study	**Intervention**			**Control**		
	N	Mean	SD	N	Mean	SD
Hashimoto et al (2015)	15	9.7	2.1	14	10.2	2.4
Ventura et al (2016)	8	11.3	1.9	7	16.3	6.5

Comparison conducted on follow-up scores. Time data used for TUG. This analysis set remains unchanged from the 2020 review. This is because Haputhanthirige et al, 2023 only presents data for TUG sub-components (not TUG total score) as a change score, while Hashimoto et al (2015) presents only raw scores, and Ventura et al (2016) offers both raw and change scores, but only for TUG total score.

Analysis set 5: PD-specific dance vs usual care PDQ-39. (Ventura et al, 2016; Kalyani et al, 2019) – was conducted – was conducted in 2020 review

Study	**Intervention**			**Control**		
	N	Mean	SD	N	Mean	SD
Kalyani et al (2019)	17	-4.74	6.76a	16	2.07	5.95a
Ventura et al (2016)	8	-8.1b	7.4	7	4.0c	10.4

Comparison conducted on change scores. a = converted from 95% confidence interval for input into meta-analysis. b = presented by authors as a positive value as represents an improvement, but is numerically a reduction in score, and needs to be entered as a negative value in meta-analysis. c = presented by authors as a negative value as represents a deterioration, but it is numerically an increased in score, and needs to be entered as a positive value in meta-analysis.

There were no new studies assessing PDQ-39 for the comparison of PD-specific dance and usual care, so this analysis set remains unchanged from the 2020 review.

Analysis set 6: Tango-based dance vs exercise UPDRS-III. (De Natale et al, 2017; Romenets et al, 2015; Hackney et al, 2007 a,b) – was conducted in 2020 review

Study	**Intervention**			**Control**		
	N	Mean	SD	N	Mean	SD
De Natale et al (2017)	9[a]	16.12	7.55	7[a]	14	9.9
Hackney et al (2007a,b)	9	22.6	1.3	10	20.6	1.2
Romenets et al (2015)	18[b]	19.1	10.2	15[b]	26.3	13.5

Comparison conducted on follow-up scores. a = using headline N – 2 participants dropped out, but it is not stated from which arm(s). b = the primary analysis was intention to treat, though there were 9 protocol violations, of which 7 occurred in the intervention arm. N = number, SD = standard deviation.

There were no new studies comparing tango-based dance and exercise, so this analysis set remains unchanged from the 2020 review. A comparison based on change scores could not be conducted, because there were not two studies for which change scores (with SD, or something that can be converted to SD) were reported.

Analysis set 7: Tango-based dance vs usual care UPDRS-III. (Hackney and Earhart, 2009 a,b,c; Duncan and Earhart, 2012/Foster et al, 2013) – was conducted in 2020 review

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Duncan and Earhart (2012)/Foster et al (2013)	26	31.7	2.4	26	45.0	1.9
Hackney and Earhart (2009a,b,c)	14	26.0	2.5	17	32.4	2.6

Comparison conducted on follow-up scores.

This analysis set remains unchanged from the 2020 review, as the only available additional study (Peter et al, 2020) for this combination of intervention, comparator and outcome did not present numerical results for the UPDRS-III outcome.

Analysis set 8: Tango-based dance vs exercise TUG. (Romenets et al, 2015; Hackney et al, 2007 a,b) – was conducted in 2020 review

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Hackney et al (2007a,b)	9	9.8	0.4	10	11.8	0.4
Romenets et al (2015)	18[a]	6.1	1.5	15[a]	8.0	2.2

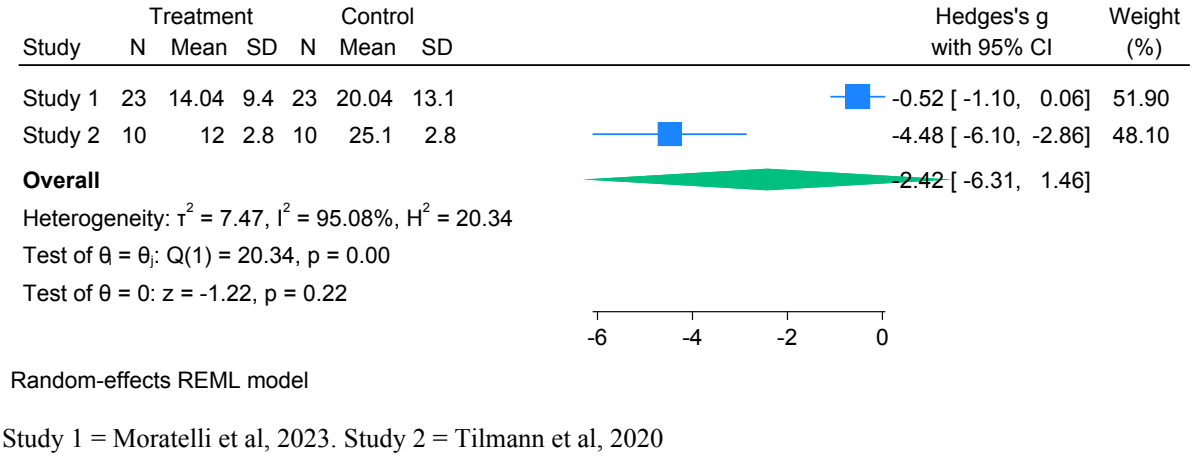
Comparison conducted on follow-up scores. Time data used for TUG. a = the primary analysis was intention to treat, though there were 9 protocol violations, of which 7 occurred in the intervention arm.

There were no new studies comparing tango-based dance and exercise, so this analysis set remains unchanged from the 2020 review. A comparison based on change scores could not be conducted, because there were not two studies for which change scores (with SD, or something that can be converted to SD) were reported.

In total, there were 8 meta-analysis sets, 5 of which came from Barnish et al (2020) and were unchanged, while 3 analysis sets (analysis sets 1, 2 and 3) were new for the present review.

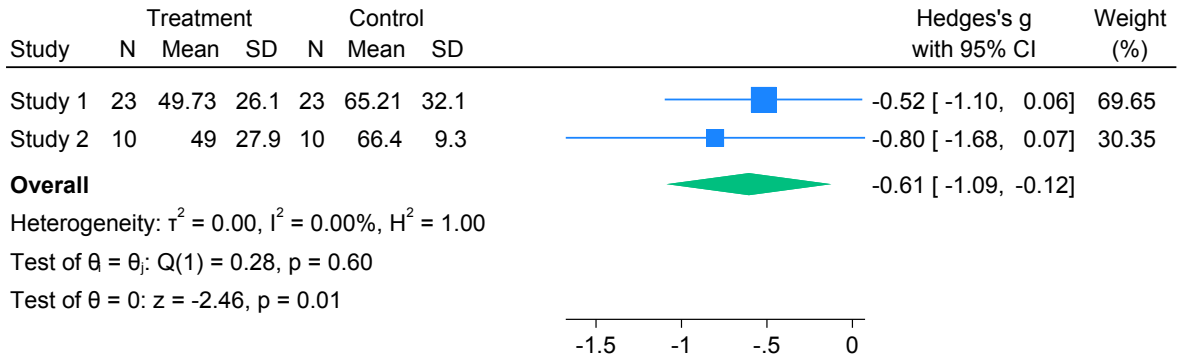
Part C. **Meta-analysis forest plots**

Analysis set 1. Brazilian/Samba dance vs usual care UPDRS-III



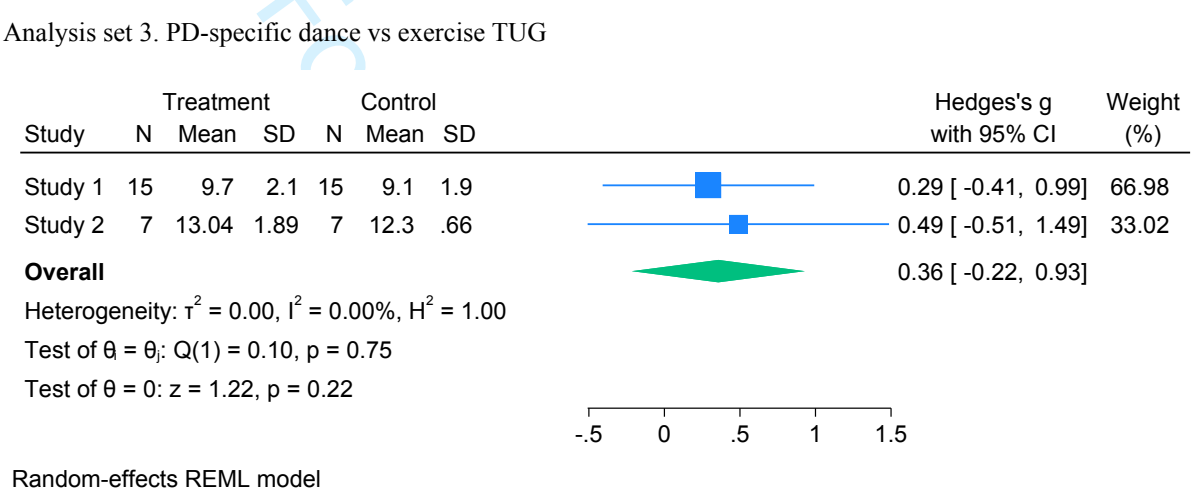
Study 1 = Moratelli et al, 2023. Study 2 = Tilmann et al, 2020

Analysis set 2. Brazilian/Samba dance vs usual care PDQ-39



Study 1 = Moratelli et al, 2023. Study 2 = Tilmann et al, 2020

Analysis set 3. PD-specific dance vs exercise TUG



Study 1 = Hashimoto et al, 2015. Study 2 = Fontanesi et al, 2021.

Part D. **Comparison of meta-analysis results with those from the 2020 review**

Only for the analysis sets that were conducted both in 2020 and 2024.

Comparison	**2020 MD (95% CI)**	**2024 MD (95% CI)**
UPDRS motor for tango-based dance vs exercise	-0.13 (-5.41, 5.14)	Unchanged, no new studies
UPDRS motor for tango-based dance vs usual care	-9.89 (-16.65, -3.13)	Unchanged, no new studies
TUG for PD-specific dance vs usual care	-2.11 (-6.33, 2.12)	Unchanged, no new studies
TUG for tango-based dance vs exercise	-1.99 (-2.34, -1.65)	Unchanged, no new studies
PDQ-39 for PD-specific dance vs usual care	-7.81 (-11.87, -3.75)	Unchanged, no new studies

CI = Confidence interval, MD = Mean difference.

Analytical code

meta esize Nint Meanint SDint Ncon Meancon SDcon

Meta-analysis setting information

Study information

No. of studies: 2

Study label: Generic

Study size: _meta_studysize

Summary data: Nint Meanint SDint Ncon Meancon SDcon

Effect size

Type: hedgesg

Label: Hedges's g

Variable: _meta_es

Bias correction: Approximate

Precision

Std. err.: _meta_se

Std. err. adj.: None

CI: [_meta_cil, _meta_ciu]

CI level: 95%

Model and method

Model: Random effects

Method: REML

. meta forestplot, random(reml)

Effect-size label: Hedges's g

Effect size: _meta_es

Std. err.: _meta_se

Supplementary file 11. Supplementary methods

Design

The only changes made from the Barnish et al (2020) review were to:

- Focus on the three artistic modalities identified as most promising in the Barnish et al review.
- Search APA Psychinfo instead of Psychinfo (this is solely a rebranding of the database and is not believed to affect underlying content).
- Use STATA/SE 18.0 for meta-analysis instead of RevMan (as access to RevMan is no longer free and the lead author's host institution has a site licence for STATA).

The changes to the search and analysis methods were not considered to be substantial. The pre-specified narrowing of scope to the most promising three artistic modalities was in order to ensure that the review could be conducted in a timely manner in the event of a substantially expanded evidence base. The construction of meta-analysis sets followed the exact same process as Barnish et al, although the sets differed as a result of new evidence published between 2020 and 2024.

Meta-analysis

To assess the current state of the evidence, as well as how to evidence base has developed since 2020, the meta-analyses integrated available data from the present review with the data from the meta-analyses presented in Barnish et al (2020).

All outcome domains were considered for meta-analysis, subject to sufficient data. As the meta-analysis was a secondary analysis, there were no sensitivity or subgroup analyses, and risk of bias was assessed at the individual study level. Meta-analysis was conducted by MSB.

Outcome measures were continuous. Therefore, meta-analyses were conducted on mean values, sample size and standard deviations. Where required, standard deviations were calculated from confidence intervals or standard errors. The preference where possible was to conduct meta-analyses based on the mean difference change score between baseline and final follow-up. However, we noted that Barnish et al (2020) found that this was seldom possible, due to studies not reporting a standard deviation for the difference between baseline and follow-up or anything that could be converted into one. Therefore, if meta-analysis based on change scores was not possible, following Barnish et al(2020), we conducted meta-analyses based on scores at the final follow-up point.

Supplementary file 12. Supplementary results

Study profile

The 32 included studies came from a total of 12 countries across five continents: Asia: India; Europe: Belgium, Netherlands, Italy, Spain, Sweden, UK; North America: Canada, USA; Oceania: Australia; South America: Argentina, Brazil. There were considerable cultural, political and health system differences between the countries studied. This could be of relevance given, for example, i) differences in cultural attitudes to Parkinson's disease, ii) differences in access to lifestyle-based interventions such as the performing arts through the health system as opposed to privately sourced memberships of organisations, iii) differences in how the arts are valued within the cultural system, iv) differences in how gender norms may influence arts participation, and v) differences in which art forms are socially preferred.

Studies were published from 2020 and 2024 – as expected given the date filter for this updated review. Studies included a total of 825 people with PD (mean sample size 25.78, median 21, range 6 to 83). Mean ages in studies, where reported, ranged from 61 to 83. Gender breakdown was available for 27 of the studies. On average, 57% of participants in a study were male (range 17% to 94%). This figure was similar (55%) for studies on dance. The percentage of male participants in studies may underestimate the PD population. This is likely to be due to a selection bias towards females in arts studies. However, this bias was not stronger in dance studies than studies on other performing arts modalities. One paper (Tamplin et al, 2020) presents an additional publication from a study that was included in the Barnish et al (2020) review. The principal reason for the limited number of studies available to inform meta-analysis (Supplementary file 10, part A) was a lack of consistency between studies in the outcome measures assessed and comparator arms used.

Among the 21 studies on dance, the most studied dance types were Parkinson's-specific dance, Brazilian or Samba-based dance and Argentine or tango-based dance. Ten of the dance studies (48%) included a non-dance comparator arm. The most common comparator was usual care (5 studies) followed by various exercise or physiotherapy-based interventions (4 studies). There were three randomised controlled trials and six non-randomised trials – the remaining studies using a variety of observational designs. Among the nine trials, all included measures of motor function, seven (78%) assessed quality of life and four (44%) assessed cognition. No dance studies assessed other eligible outcomes.

Among the eight singing studies, five (63%) included a comparator arm, although each study used a different comparator. There were two randomised controlled trials and three non-randomised trials. Among the five trials, all assessed speech, four (80%) assessed quality of life, two each (40%) assessed communication and motor function and one assessed cognitive function (20%). Among the three music therapy studies, two (67%) included a comparator, one being usual care and the other being a delayed intervention. Both studies were trials, both randomised. Among the two trials, both assessed motor function and quality of life, while one assessed cognitive function. Neither assessed other eligible outcomes. Measures used to assess outcomes within a domain varied considerably for all artistic modalities.

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Active group-based performing arts interventions in Parkinson's disease: an updated systematic review and meta-analysis

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Active group-based performing arts interventions in Parkinson's disease: an updated systematic review and meta-analysis

Maxwell S. Barnish,[1] Sarah E. Reynolds[2] and Rebecca V. Nelson-Horne[2]

[1] Peninsula Technology Assessment Group (PenTAG), School of Public Health and Sport Sciences, University of Exeter, Exeter, UK.

[2] Independent Scholar, Glasgow, UK.

Correspondence to: Dr Maxwell S. Barnish; m.s.barnish@exeter.ac.uk

4,000 words

ABSTRACT

Objectives: To assess the evidence for active group-based performing arts interventions for people with Parkinson's disease (PD).

Setting: Scholarly literature (published in English) from any country or countries (last search February 2025). This systematic review was not registered and received no funding.

Data sources: Five bibliographic databases: AMED (Ebsco), APA PsycINFO (Ovid), CINAHL (Ebsco), EMBASE (Ovid) and MEDLINE (Ovid), plus supplementary searches.

Primary and secondary outcome measures: Eligible studies used a quantitative design to assess the benefit of active group-based performing arts interventions on quality of life, functional communication, speech, motor function and cognitive status in PD. Risk of bias was assessed using SURE, University of York Centre for Reviews and Dissemination and Newcastle-Ottawa Scale checklists. Data were synthesised using narrative synthesis and random-effects meta-analysis.

Results: A total of 94 studies were included: total 2,453 people with PD (mean age 68, 55% male) from 18 countries. Narrative synthesis supported nine combinations of performing arts modalities and outcome domains, including a benefit for dance on motor function (supported by 50 out of 54 studies), dance on quality of life (supported by 24 out of 37 studies), and singing on speech (supported by 17 out of 20 studies). Meta-analysis supported five combinations of performing arts modalities, comparators and outcomes, including a clinically significant benefit for PD-specific dance vs usual care PDQ-39, MD -7.81, 95% CI -11.87 to -3.75 and tango-based dance vs usual care on UPDRS-III, MD -9.89, 95% CI -16.65 to -3.13.

Conclusions:

Evidence from both the narrative synthesis and the meta-analysis supports a benefit for some combinations of performing arts modalities and outcomes. Limitations of the evidence base included differences in comparators and outcomes, heterogeneity, lack of control arms,

and male underrepresentation. Future studies should compare the effectiveness of different performing art modalities, assess functional communication, and consider clinical significance.

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STRENGTHS AND LIMITATIONS

- Systematic review methods minimised subjectivity and bias
- A standardised outcome set was used
- Independent dual review was conducted
- It was not possible to conduct PPI
- Only English-language studies could be included

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INTRODUCTION

Parkinson's disease

Parkinson's disease (PD) is among the most common age-related neurodegenerative conditions and its societal burden is increasing internationally.[1] PD has a widespread and diverse range of motor and non-motor symptoms.[2] It typically exerts a significant impact upon the quality of life of people with PD[3] and their caregivers.[4] Quality of life, functional communication, speech, motor function and cognitive status have been identified as a set of five key outcomes in PD.[5]

Treatment options for PD

Levodopa-based pharmacotherapy has been the mainstay of treatment for PD for several decades and is generally effective for controlling motor symptoms.[6] However, a relative lack of evidence for a benefit on speech and non-motor symptoms has stimulated interest in other therapeutic mediums, including lifestyle interventions, that can be used alongside pharmacotherapy. Group-based performing arts have been identified as one potentially beneficial approach.[7,8]

Evidence for the performing arts in PD

Systematic reviews on the performing arts in PD prior to 2020 typically focused on dance.[5] Barnish and Barran[5] (search date February 2020) published the first systematic review to take a comparative perspective across all available active, group-based performing arts interventions. It[5] included 56 studies of which 38 were on dance, 12 were on singing, four on music therapy and two on theatre. Some evidence of each of these intervention modalities was observed on at least some of the eligible outcomes: quality of life, speech, functional communication, cognitive status and motor function. Key uncertainties in the evidence base included: i) no studies comparing different artistic modalities (e.g. dance vs singing), ii) lack of a control arm in 16 (42%) dance studies and 10 (83%) singing studies, iii) a relative lack of evidence on functional communication

(only two studies, both on singing), iv) underrepresentation of men in studies compared to the PD population and v) lack of standardisation of outcome measures. We have identified nine[9-17] further systematic reviews or comprehensive reviews (Table 1) on the performing arts in PD since the Barnish and Barran[5] review. None of these reviews, except Li et al,[14] included more than one performing arts modality (e.g. dance and singing). As such, they did not offer a broad evaluation of the potential benefits of the arts for PD comparable with Barnish and Barran.[5] While Li et al,[14] which was not pre-registered and was published after our April 2024 searches, addresses a range of arts modalities, it is a comprehensive review not a systematic review, does not include a meta-analysis and did not structure the narrative synthesis in a way that included all the Barnish and Barran[5] outcome domains.

Aims and rationale

The key rationale for this work is that there is no available systematic review comparable to Barnish and Barran,[5] whose searches (February 2020) are now five years old and cannot be seen to reflect an up-to-date view of the literature on the potential benefit of performing arts for PD. The present work offers an updated systematic review of evidence up to February 2025 that assessed the potential benefit of active group-based performing arts interventions on quality of life, functional communication, speech, motor function or cognitive status in people with PD. Additionally, we assess the extent to which key uncertainties identified in Barnish and Barran[5] have been resolved.

METHODS

D*esign*

A systematic review and meta-analysis was conducted following PRISMA 2020 guidelines.[18] Completed PRISMA 2020 and PRISMA for abstracts checklists are provided as Supplementary files 1 and 2. A pre-specified protocol was used (Supplementary file 3) and includes a log of protocol changes. While the review was not

pre-registered, it followed the methods of the Barnish and Barran review[5] as closely as feasible. Any changes are detailed in Supplementary file 4. In summary, one search database was rebranded without impact on underlying content and the meta-analysis was expanded to include sensitivity and subgroup analysis. We used the search, screening, data extraction and risk of bias assessment from Barnish and Barran[5] for studies published up to February 2020 and conducted these steps afresh for studies published after the Barnish and Barran[5] search in February 2020 until February 2025.

Data sources

Searches were conducted in February 2020, February 2024 and February 2025 using five pivotal bibliographic databases: AMED (Ebsco), APA PsycINFO (Ovid), CINAHL (Ebsco), EMBASE (Ovid) and MEDLINE (Ovid). The same search strategy was used for each search timepoint. As databases do not always index publication month, all update searches started at the start of a year, with any overlap in search periods addressed through deduplication. Supplementary searches were conducted on Google Scholar and through forward and backward citation chasing on studies identified for full-text review. Searches were designed to retrieve articles on Parkinson's disease and the performing arts (strategies for all databases are shown in Supplementary file 5) and were designed and conducted by the lead author MSB.

Inclusion criteria

Screening was initially conducted based on title and abstract. Potentially relevant articles were screened at the full-text stage to determine inclusion (Supplementary file 6) or exclusion (Supplementary file 7) in the systematic review. Screening was conducted independently by two reviewers MSB and RVN-H or SER and any disagreements resolved through discussion. Eligibility criteria are shown in Table 2. No automation tools were used.

Data extraction

Information extracted is shown in Table 3. All data extraction processes were conducted independently by two reviewers (MSB and RVN-H or SER) and any disagreements resolved through discussion. No automation tools were used. The appendix provides additional information on study characteristics (Supplementary file 8), interventions (Supplementary file 9), controls (Supplementary file 10) and narrative results (Supplementary file 11).

Risk of bias assessment

The Specialist Unit for Review Evidence (SURE) Experimental Studies Critical Appraisal Checklist[15] (Supplementary file 12) was used for the assessment of all randomised and non-randomised trials. The SURE Cohort Studies Critical Appraisal Checklist[15] (Supplementary file 13) was used for the assessment of observational longitudinal designs. Additionally, the University of York Centre for Reviews and Dissemination (CRD) tool[19] (Supplementary file 14) was used for all RCTs included in the meta-analysis, and the Newcastle-Ottawa Scale (NOS)[20] (Supplementary file 15) for all non-randomised trials and observational studies in the meta-analysis. Risk of bias assessment was conducted independently by two reviewers (MSB and RVN-H or SER) and any disagreements resolved through discussion. No automation tools were used. RVN-H was involved in all screening, data extraction and risk of bias, except for the February 2025 search update, where due to maternity leave, she was replaced by SER.

Narrative synthesis

Thematic narrative synthesis was used to analyse all studies that met the inclusion criteria. The inclusion of a detailed thematic narrative synthesis was pre-specified in advance due to the high levels of observed methodological and clinical heterogeneity in the Barnish and Barran[5] review. Synthesis was initially by outcome domain: quality of life, functional communication, speech, motor function and cognitive status. Within

outcome domains, synthesis was by arts modality. The primary focus of the narrative synthesis was to assess the totality of the available evidence to assess the potential benefit of active, group-based, performing arts interventions for quality of life, functional communication, speech, motor function and cognitive status in people with PD. The secondary focus was on the extent to which the evidence has progressed over 2020-2025 and addressed key uncertainties identified in the Barnish et al[5] review.

Meta-analysis

Meta-analysis was also conducted using Review Manager (RevMan) 5.4.1 (Cochrane Collaboration) for combinations of key scale outcomes and interventions for which there were at least two studies using a common comparator. Meta-analysis included studies from the entire time period of the updated systematic review, including studies that featured in the Barnish and Barran[5] meta-analyses. In addition to updating the meta-analysis sets from this review,[5] new meta-analysis sets were constructed where available evidence permitted. Singing and music therapy were assessed as unitary categories in the meta-analysis. The higher number of studies on dance facilitated the creation of three dance categories: i) Brazilian or tango-based dance, ii) PD-specific dance, and iii) Argentine or adapted tango-based dance. Meta-analysis was conducted on mean differences.

The choice of meta-analysis model was pre-specified in the protocol rather than based on the results of heterogeneity tests, as recommended by Nikolakopoulou et al.[21] Random effects models were chosen, since heterogeneity was expected, based on the Barnish and Barran[5] review. Random effects meta-analysis considers heterogeneity by assuming that treatment effects differ between studies in a distribution of true effect sizes.[22] Heterogeneity was quantified by Cochran Q test and I^2 statistics, with values for the latter interpreted following Cochrane guidelines.[23]

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Where feasible (i.e. at least two studies remained in the analysis set), leave-one-out sensitivity analysis and subgroup analysis only including RCTs were conducted in order to further explore heterogeneity. Clinical significance was considered, as well as statistical significance, in the interpretation of meta-analysis findings, using established Minimally Clinically Important Differences (MCIDs)[24] for the appropriate population where available. Publication bias could not be assessed as there were fewer than ten studies in each meta-analysis.[25]

Further details on the meta-analysis method are shown in Supplementary file 4 and results of sensitivity and subgroup analyses in Supplementary file 16. Due to methodological and clinical heterogeneity, and the fact that due to differences in intervention-comparator-outcome combinations a relatively small proportion of available studies can contribute to the meta-analysis, the meta-analysis and the narrative synthesis should be seen as complementary to each other.

Certainty assessment

Certainty assessment was conducted using GRADE[26] for each meta-analysis set as well as for each combination of performing arts modality and outcome domain in the narrative synthesis.

Patient and public involvement

Patient and public involvement could not be conducted for this systematic review assessing a broad range of performing arts interventions due to a lack of funding. The corresponding author will respond to any reputable media enquiries.

RESULTS

Search results

Database searches returned a total of 7,703 records (AMED 152, PsycINFO/APA PsycINFO 376, CINAHL 499, EMBASE 2,880, and MEDLINE 796), plus 15 from

supplementary searches. A total of 7,199 records preceded to title and abstract screening. Two-hundred and ten unique records were assessed at full text screening, 109 records (94 unique studies) were included in the systematic review (Figure 1) and 13 studies were included in the meta-analysis. Included studies assessed 2,453 people with PD from 18 countries (mean age 68, 55% male). Sixty-three studies assessed dance, twenty assessed singing, eight assessed music therapy and three assessed theatre. No studies compared different performing arts modalities. Further details are in Supplementary file 17.

Narrative synthesis

As there are ninety-four included studies, a summary of the narrative synthesis is provided here (further details in Supplementary file 17). A numerical summary of the evidence landscape for each combination of performing arts modality and outcome domain is provided in Table 4.

There were nine combinations of performing arts modality and outcome that were overall supported by the evidence base.

- A benefit of dance on quality of life was supported by 24 out of 37 (65%) studies including multiple RCTs across different dance forms – the greatest evidence of benefit was found for tango-based and PD-specific dance forms. GRADE High.
- A benefit of music therapy on quality of life was supported by six out of eight (75%) studies, including five RCTs. GRADE High.
- A benefit of singing on quality of life was supported by six out of eight (75%) studies, including one parallel group RCT,[27] and one cross-over RCT[28] which found a significant effect on some but not all quality-of-life measures. GRADE Moderate.
- A benefit of theatre on quality of life was shown by two out of three (67%) studies, including one RCT. GRADE Moderate.

- A benefit of singing on speech was shown by 17 out of 20 (85%) studies, including multiple RCTs. GRADE Moderate.
- A benefit of dance on motor function was shown by 50 out of 54 (93%) studies, including multiple RCTs, nine of which supported tango-based dance. GRADE High.
- A benefit of music therapy on motor function was shown by five out of seven (71%) studies, including three RCTs. GRADE High.
- A benefit of singing on motor function was shown by three out of four (75%) studies, including a cross-over RCT. GRADE Low.
- A benefit of dance on cognitive status was shown by 15 out of 20 (75%) studies, including multiple RCTs across different dance forms. GRADE Moderate.

Overall, across outcomes, where dance was considered, the evidence was greatest for tango-based and PD-specific dance forms. There was either no or limited evidence for the following: dance, music therapy, singing, and theatre for functional communication; dance, music therapy, and theatre for speech; theatre for motor function; music therapy, singing and theatre for cognitive status. GRADE calculations are shown in Supplementary file 16. The risk of bias profile as well as the potential impact of risk of bias on the outcomes of the narrative synthesis are shown in Supplementary file 17.

An assessment of the extent to which key uncertainties identified by Barnish and Barran[5] have been resolved is presented in Table 5. This shows that none the five key uncertainties have been fully resolved. Three uncertainties have been partially addressed. These are a lack of control arms, a lack of research into functional communication, and a lack of standardisation of outcome measures. However, it should be noted that despite increased research on this outcome, there remains no evidence for a benefit of the performing arts on functional communication. It is unclear whether underrepresentation of men has been addressed – while the percentage of men in included studies in this review (55%) was higher than in the Barnish and Barran[5] review

(53%), it is unclear whether this difference is meaningful. One uncertainty – a lack of studies comparing different performing art modalities (e.g. music and dance) – has not been addressed.

Meta-analysis

We searched for MCIDs for the meta-analysed outcomes in a PD population and found the following:

- UPDRS-III – MCID for improvement 3.25 units[29] or 4.83 units.[30] Both studies were conducted in a European setting and posited plausible MCIDs. We preferred the 3.25 units value from Horvath et al,[29] because it was a more controlled study environment where all participants had been diagnosed according to the UK Brain Bank Criteria,[31] compared to the more pragmatic and 'naturalistic' setting of Sanchez-Ferro et al.[30]
- PDQ-39 – MCID for improvement -4.72 units.[32]
- TUG – No Parkinson's-specific MCID was identified for TUG, although an MCID of 3.4 seconds[33] was available in a degenerative disc disease population, which we considered to be likely relatively generalisable.

The meta-analysis results for each analysis set are as follows:

- Analysis set 1, Brazilian/Samba dance vs usual care on UPDRS-III, mean difference (MD) -10.24, 95% CI -17.06 to -3.41, p=0.003 in favour of dance, I^2 = 74%, clinically significant, GRADE Very low.
- Analysis set 2, Brazilian/Samba dance vs usual care on PDQ-39, MD -16.37, 95% CI -28.76 to -3.97, p=0.010 in favour of dance, I^2 = 0%, clinically significant, GRADE Moderate.
- Analysis set 3, PD-specific dance vs exercise on TUG, MD 0.67, 95% CI -0.36 to 1.70, p=0.20, I^2 = 0%, not clinically significant (NCS), GRADE Moderate.

- Analysis set 4, PD-specific dance vs usual care on TUG, MD -2.11, 95% CI -6.33 to 2.12, p=0.33, I^2 = 64%, NCS, GRADE Very low.
- Analysis set 5, PD-specific dance vs usual care on PDQ-39, MD -7.81, 95% CI -11.87 to -3.75, p=0.0002 in favour of dance, I^2 = 3%, clinically significant, GRADE Very low.
- Analysis set 6, tango-based dance vs exercise on UPDRS-III, MD = -0.13, 95% CI -5.41 to 5.14, p=0.96, I^2 = 57%, NCS, GRADE Low.
- Analysis set 7, tango-based dance vs usual care on UPDRS-III, MD -9.89, 95% CI -16.65 to -3.13. p=0.004 in favour of dance, I^2 = 97%, clinically significant, GRADE Low.
- Analysis set 8, tango-based dance vs exercise on TUG, MD -1.99, 95% CI -2.34 to -1.65, p<0.00001 in favour of dance, I^2 = 0%, NCS, GRADE Moderate.
- Analysis set 9, theatre vs physiotherapy on UPDRS-III, MD 1.01, 95% CI -4.33 to 6.34, p=0.71, I^2 = 0%, NCS, GRADE Low.

Results for subgroup and sensitivity analyses as well as GRADE[26] calculations are shown in Supplementary file 16.

DISCUSSION

Summary

This paper presents an updated systematic review of evidence on the benefit of dance, music therapy and singing on five standard outcomes. This offers five years additional evidence compared to the Barnish and Barran[5] review, which addressed the same research question. Furthermore, as a secondary focus, we assessed how the field has evolved since February 2020. The narrative synthesis supported a benefit for nine combinations of performing arts modality and outcome, covering four performing arts modalities: dance, music therapy, singing, and theatre. Within dance, the greatest support was for tango-based and PD-specific dance forms. Furthermore, we

demonstrated that while the evidence base has gained 38 studies since Barnish and Barran,[5] strengthening the evidence for many combinations of performing arts modalities and outcomes, key uncertainties identified by Barnish et al[5] have only been partially addressed. Issues remain with a lack of studies comparing different performing arts modalities, lack of control arms in a significant minority of studies, a lack of focus on functional communication, underrepresentation of men compared to the PD population, and inconsistency in outcome measures used. The meta-analysis, while limited by differences in comparators and outcomes that limit the number of studies that can be pooled, showed statistically significant benefits of Brazilian/Samba dance vs usual care on PDQ-39 (quality of life), tango-based dance vs exercise on TUG (motor function), PD-specific dance vs usual care on PDQ-39, Brazilian/Samba dance vs usual care on UPDRS-III (motor function), and tango-based dance vs usual care on UPDRS-III, the latter three also being clinically significant. Certainty assessed by GRADE was stronger when assessed across all studies in the narrative synthesis than when assessed on the meta-analysis sets. This is likely because relatively few studies could be pooled in the meta-analyses due to differences in comparators and outcome measures.

Interpretation of findings

Our work updates the findings of Barnish and Barran[5] by five years using a comparable design. Unlike most other recent reviews,[9-13, 15-17] we provide a broad comparative perspective across performing arts modalities. The new evidence gathered since February 2020[5] is generally consistent with the earlier evidence, but the addition of 38 new studies in the narrative synthesis strengthens the evidence base and permits the development of nine combinations of performing arts modalities and outcomes supported by the narrative synthesis. Consistent with Barnish and Barran,[5] evidence for dance is greatest for tango-based and PD-specific dance forms. As in Table 5, progress has been made on some key uncertainties identified by Barnish and Barran,[5] but they remain unresolved. Greater standardisation of intervention-comparator-outcome combinations

has facilitated the development of additional meta-analysis sets. However, as in Barnish and Barran,[5] the meta-analysis remains limited as only a small proportion of studies from the systematic review can be pooled. Therefore, the narrative synthesis and meta-analysis have to be seen as complementary to each other. The meta-analysis offers the benefit of demonstrating clinical significance for benefits of PD-specific dance versus usual care on quality of life, Brazilian/Samba dance vs usual care on motor function and tango-based dance versus usual care on motor function.

Some broader contextual factors need to be considered. Some of the studies identified published since the Barnish and Barran[5] review were conducted during or towards the end of the COVID-19 period. People with PD may be considered a vulnerable group, leading to challenges in carrying out group activities during this period and potential selection biases and group dynamic differences. Different art forms may be complementary rather than be seen in opposition to each other. For example, dance interventions typically involve some form of musical accompaniment, while singing activities may involve some degree of movement. Art forms may relate to the symptoms of PD, for example arts activities that foster a positive group identity[34-35] may help address social isolation in PD,[36] while arts interventions may in particular target speech, cognitive and motor function.

Strengths and limitations

Use of a comparable design to Barnish and Barran,[5] use of a standardised outcome set, inclusion of a meta-analysis, and a thorough search strategy are key strengths of our work. Use of standardised data extraction forms minimises inconsistency in the information collected between studies, the use of standardised risk of bias tools maintain a standardised objective approach to assessing study quality, and the use of two independent reviewers minimises any effect of the preferences of individual reviewers when selecting studies for inclusion.

There are however limitations in the review process. Only one suitably experienced researcher was available to design and run searches. It was not possible to convene a PPI panel with an appropriate membership that can provide insight into the dilemma about male under recruitment in performing arts studies. PROSPERO registration was not possible because data collection had already started, as a result of using the data extraction forms from Barnish and Barran[5] for studies identified in their review. Non-English-language articles could not be included, as they were not included in the review[5] we are updating and its search strategy was not designed to identify non-English-language articles, which are also harder to retrieve as full texts through academic libraries. Limitations of the evidence base included differences in comparators and outcome measures; clinical, methodological and statistical heterogeneity; studies without a control arm, and male underrepresentation (discussed in Supplementary file 17) compared to the PD population. Furthermore, pooling randomised and non-randomised studies in the meta-analysis is a limitation resulting from lack of RCTs with the same comparators and outcomes and means that pooled analyses may be fully benefit from the protective effect of randomisation against bias.

Implications for research and practice

Future research should focus on addressing methodological limitations identified through risk of bias assessment as well as key remaining uncertainties as shown in Table 5. Studies should look at comparing the effectiveness of different performing arts modalities (e.g. singing vs dance) at look at combinations of performing arts modalities and outcomes which have to date not been assessed (e.g. the benefit of dance for speech). Greater standardisation of control arms and outcome measures and reporting of change scores with a measure of variance will make meta-analyses more robust and may enable a network meta-analysis to be used. Randomised controlled trials and high-quality comparative real-world evidence studies should be prioritised. Future studies should include a greater focus on functional communication – this should not be limited to

singing studies, as it is possible for example that expressive dance forms may offer a communicative benefit. Studies should attempt to recruit a sample that is more reflective of the PD population in terms of gender – or if this is not possible, alternatively to offer analyses stratified by or adjusted for gender. Furthermore, studies should consider clinical significance as well as statistical significance to ensure relevance to decision-making, to facilitate confirmation of whether the observed benefits in the narrative synthesis for a range of combinations between performing arts modalities and outcome domains are clinically significant. The evidence is not sufficiently mature and robust to make specific recommendations for clinical practice, however there is preliminary evidence to support a benefit of performing arts, especially dance, and healthcare providers may wish to incorporate the arts into their service provision.

CONCLUSION

We present a five-year update of the first systematic review to assess the benefit of dance, music therapy and singing on five key outcomes in PD - quality of life, functional communication, speech, motor function and cognitive status. Evidence from the narrative synthesis shows that the new evidence since the Barnish and Barran I[5] review has generally strengthened the case for a benefit of the performing arts in PD and allowed the development of nine supported combinations of performing arts modalities and outcome domains. However, methodological limitations remain, and key uncertainties are only partially resolved. While limited by differences in outcome measures and comparators between studies, meta-analysis identified five combinations of performing arts modality, comparator and outcome measures that showed a statistically significant benefit for the performing arts. This included clinically significant benefits for PD-specific dance vs usual care on quality of life, tango-based dance vs usual care on motor function, and Brazilian/Samba dance vs usual care on motor function.

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DECLARATIONS

Contributors. The work was managed and directed by MSB, who had the initial idea for the work. All authors contributed to the acquisition, reviewing and interpretation of data. MSB wrote the first draft of the manuscript and RVN-H and SER revised the manuscript for important intellectual content. All authors reviewed the final submission version of the manuscript and approved the submission. All authors take appropriate responsibility for the work they undertook. Overall responsibility for the work rests with MSB, who is guarantor.

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Competing interests. MSB and RVN-H are experienced recreational musicians and have been involved in promoting the arts to the public. MSB declares having received expenses but not payment for arts promotion activities (this is not within the past 5 years). SER declares no conflicts of interest.

Patient and public involvement. Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication. Not applicable.

Data availability statement. All data relevant to the study are included in the article or uploaded as online supplemental material. The presented work is a systematic review. All relevant information is provided in the manuscript and appendices. This includes the data extraction form completed with the data from all included studies and analytical code for the meta-analyses.

ORCID iD: Maxwell S Barnish http://orcid.org/0000-0003-0139-6548

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Tables

Table 1. Systematic reviews and comprehensive reviews on the performing arts and PD since 2020

Authors, year	Search date	Method	Interventions	Outcomes	Key results
Alqutub et al, 2024[9]	May 2024	Systematic review and meta-analysis	Singing	Voice	Singing improved a range of physical speech outcomes, including vocal frequency range (MD 2.60, 95% CI: 1.17, 4.03, P = 0.0004), maximum expiratory pressure (MD 14.28, 95% CI: 9.57, 18.96, P < 0.00001), although there was no benefit on other measures including voice-related quality of life.
Cheng et al, 2024[10]	December 2022	Systematic review and meta-analysis	Dance	Mental health, quality of life	Dance had a positive impact on mental health (g = 0.43, 95 % CI = [0.11, 0.75]) and quality of life (g = 0.46, 95 % CI = [-0.04, 0.95]) when compared to passive control groups.
De Almeida et al, 2021[11]	April 2019	Systematic review and meta-analysis	Dance	Postural control	Evidence was identified for a statistically significant effect of dance on balance (SMD = 0.82, 95% CI [0.52, 1.12].
Gil et al, 2024[12]	August 2023	Systematic review and meta-analysis	Dance	Cognition	There was high heterogeneity (90%), reflecting pooling across a variety of dance forms, and as such, the random effects model was not statistically significant (MD 0.24, 95% CI -0.86,1.34).
Lee and Ko, 2023[13]	June 2022	Systematic review and meta-analysis	Music-based interventions	Motor and non-motor symptoms	Evidence was identified for a statistically significant benefit on walking velocity (Mean difference (MD) = 0.12, 95% CI = 0.07~0.16, p < 0.00001), stride length (MD = 0.04, 95% CI = 0.02~0.07, p = 0.002), and mobility (MD = −1.05, 95% CI = −1.53~−0.57, p < 0.0001. However, no significant effect was found for cadence (MD = 3.21, 95% CI = −4.15~10.57, p = 0.39),

					cognitive flexibility (MD = 20.91, 95% CI = −10.62~52.44, p = 0.19), inhibition (Standardised mean difference (SMD) = −0.17, 95% CI = −0.40~0.55, p = 0.76), and quality of life (SMD = −0.68, 95% CI= −1.68~0.32, p = 0.1
Li et al, 2024[14]	December 2023	Narrative comprehensive review	Arts activities including music, dance and theatre	Motor, psychological symptoms and cognition	Evidence was identified that supported the promise of the arts as a therapeutic modality in PD across a variety of intervention/outcome combinations.
Mainka and Irons, 2022[15]	December 2021	Narrative systematic review	Singing	Speech	Evidence was identified to support a benefit of singing on respiratory and vocal function.
Simpkins and Yang, 2023[16]	June 2022	Systematic review and meta-analysis	Dance	Balance	Results showed a medium effect size (0.57, 95% CI [0.29,0.84], p < 0.000 1) favouring dance over control (non-dance intervention or no intervention) for improving balance. Subgroup analyses favoured duration of intervention greater than 12 weeks and showed a potential favourable effect for Argentine tango and Sardinian folk over other dance styles. However, not all dance styles were studied equally often.
Wang et al, 2022[17]	October 2021	Systematic review and meta-analysis	Dance	Non-motor symptoms	Evidence was identified for a statistically significant benefit of dance on cognition (MD = 1.50, 95% CI [0.52, 2.48], p = 0.0003), but not depression (MD = -1.33, 95% CI [- 4.11, 1.45], p= 0.35), fatigue (MD = 0.26, 95% CI [- 0.31, 0.83], p = 0.37) or apathy (MD = 0.07, 95% CI [- 2.55, 2.69], P = 0.96).

Table 2. Inclusion criteria

Eligible studies assessed:

- Participants: people with a diagnosis of Parkinson's disease.
- Intervention: active group-based singing, dance or music therapy interventions (active in this context excludes passive arts activities such as listening to music).
- Comparator: studies with and without control arms were eligible. There were no specific requirements for what control arms could involve.
- Outcomes: quality of life, functional communication, speech, motor function and cognitive status.
- Other: quantitative studies published in an English-language peer-reviewed journal or alternatively published as an English-language conference abstract in the two years before each search.

Studies were included in the meta-analysis if they provided sufficient quantitative information on outcomes and contributed to a comparison for which there were at least two studies for a given combination of intervention, comparator, and outcome.

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Table 3. Data extracted

The following information was extracted for each included study:

- Bibliographic details (authors, year, citation)
- Country of study
- Study design
- Participants (sample size, gender profile, mean age,
- Inclusion criteria
- Outcomes
- Content of intervention
- Professional background of intervention leader
- Location of intervention (e.g. community centre, outpatient clinic)
- Frequency and duration of intervention
- Content of control arm
- Professional background of control arm leader
- Location of control arm
- Frequency and duration of control arm
- Study results for narrative synthesis for all eligible reported outcomes

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- Study results for meta-analysis (for studies included in the meta-analysis – sample size, mean (SD) in change score – or follow-up score if change score not reported – for each arm)

Table 4. Evidence landscape

This table indicates the number (%) of included studies that show evidence of benefit for each performing arts modality for each outcome domain. Evidence is assessed holistically across outcomes, taking into account, but not solely relying on, statistical significance. This table should be taken as a guide with respect to which outcome domains are most likely to be improved by each artistic modalities.

	Barnish and Barran (2020)[5]	Feb 2024 search	Feb 2025 search	Totality of evidence
Quality of life				
Dance	15/22 (68%)	7/13 (54%)	2/2 (100%)	24/37 (65%)
Music therapy	4/4 (100%)	2/3 (67%)	0/1 (0%)	6/8 (75%)
Singing	4/5 (80%)	2/2 (100%)	0/1 (0%)	6/8 (75%)
Theatre	2/2 (100%)	0/1 (0%)	0/0	2/3 (67%)
Functional communication				
Dance	0/0	0/1 (0%)	0/0	0/1 (0%)
Music therapy	0/0	0/0	0/0	0/0
Singing	1/2 (50%)	0/2 (0%)	0/1 (0%)	1/5 (20%)

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Theatre	0/0	0/0	0/0	0/0
Speech				
Dance	0/0	0/0	0/0	0/0
Music therapy	0/0	0/0	0/0	0/0
Singing	10/11 (91%)	7/8 (88%)	0/1 (0%)	17/20 (85%)
Theatre	0/0	0/0	0/0	0/0
Motor function				
Dance	30/31 (97%)	16/19 (84%)	4/4 (100%)	50/54 (93%)
Music therapy	2/4 (50%)	2/2 (100%)	1/1 (100%)	5/7 (71%)
Singing	1/1 (100%)	2/2 (100%)	0/1 (0%)	3/4 (75%)
Theatre	1/2 (50%)	0/1 (0%)	0/0	1/3 (33%)
Cognitive status				
Dance	9/10 (90%)	6/9 (67%)	0/1 (0%)	15/20 (75%)
Music therapy	2/3 (67%)	0/2 (0%)	0/0	2/5 (40%)
Singing	0/0	0/1 (0%)	0/0	0/1 (0%)
Theatre	0/1 (0%)	0/0	0/0	0/1 (0%)

Table 5. Assessment of progress since February 2020 in resolving key uncertainties

- Key uncertainty 1: “no studies comparing different artistic modalities (e.g. dance vs singing)”. Review authors’ assessment: Not addressed. There remain no studies comparing any two of dance interventions, singing interventions and music therapy interventions. This is a significant limitation in assessing which performing arts modality may be most promising on PD and whether any specific demographic or clinical characteristics may influence this.
- Key uncertainty 2: “lack of a control arm in 16 (42%) dance studies and 10 (83%) singing studies”. Review authors’ assessment: Partially addressed. Of the newly available studies over the period 2020-2025, 42% of dance studies lack a control (no change), but this is only 38% for singing studies (major improvement). More than half of the newly available studies across modalities have a control arm.
- Key uncertainty 3: “a relative lack of evidence on functional communication (only two studies, both on singing)”. Review authors’ assessment: Partially addressed. One new dance study and three new singing studies were available for functional communication. However, there remains no substantive evidence supporting a benefit of the performing arts on this outcome.
- Key uncertainty 4: “underrepresentation of men in studies compared to the PD population”. Review authors’ assessment: Unclear. The mean percentage of men in included studies (database inception to February 2025) was 55%. This is higher than in the 2020 review (53%), although it is unclear if this difference is meaningful. Furthermore, both values appear to

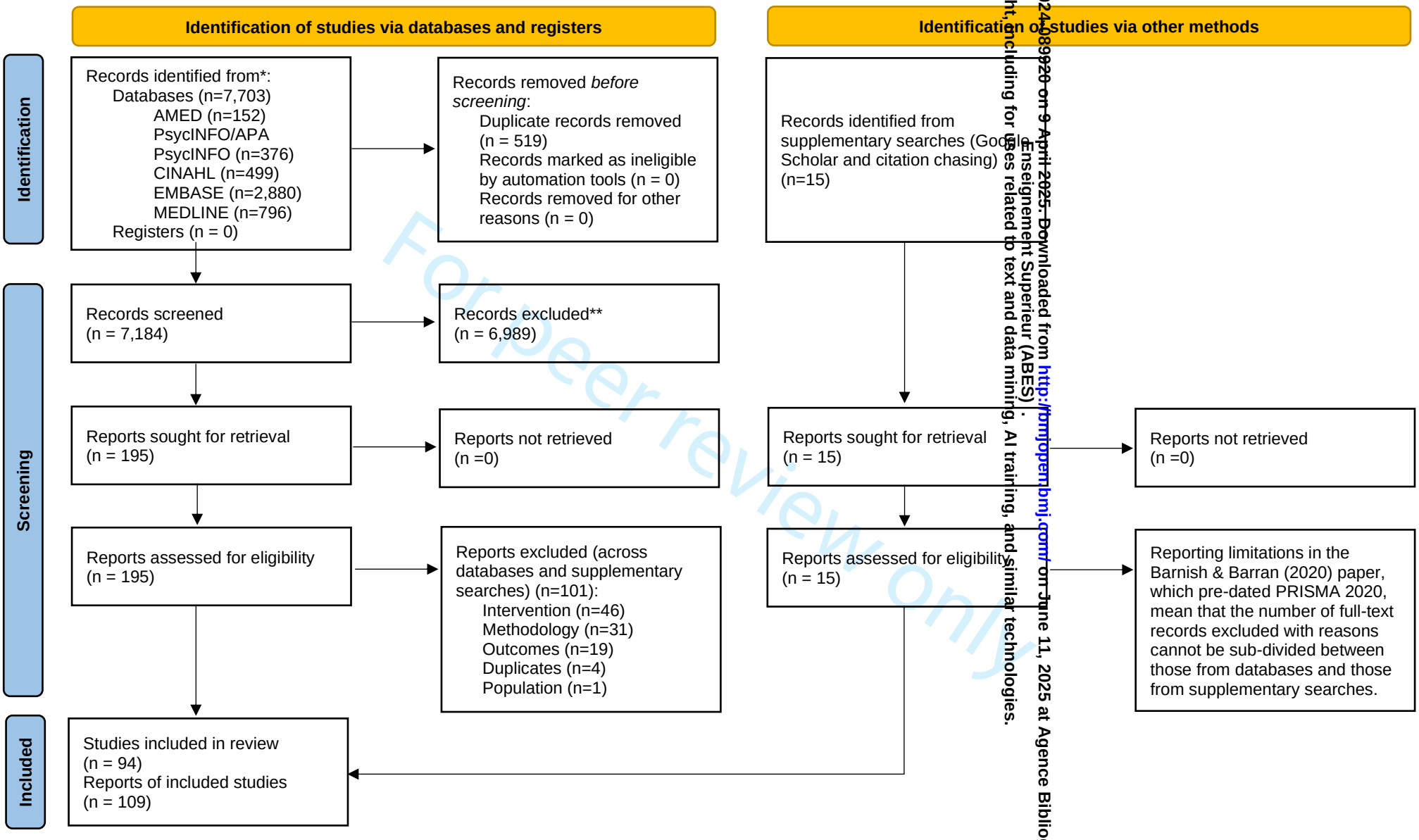
underestimate the proportion of men in the PD population. According to a review by Cerri et al,[37] PD is twice as common in men than women, while women tend to have more rapidly progressing disease.

- Key uncertainty 5: “lack of standardisation of outcome measures”. Review authors’ assessment: Partially addressed. Progress noted on using key measures more frequently for assessed concepts, facilitating more meta-analysis sets. However, some inconsistency remains in measures used.

Figure legends

Figure 1. PRISMA 2020 flow diagram

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

Supplementary files.

Supplementary file 1. Completed PRISMA 2020 checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	p.1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	p.2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p.6
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p.6
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the synthesses.	Table 2, p.8-10
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p.7
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Suppl. file 5
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p.7
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p.8
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Table 3.
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Table 3.
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	p.8
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	p.9
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	p.9, Suppl. file 16
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	p.9-10, Suppl. file

Section and Topic	Item #	Checklist item	Location where item is reported
			4, Suppl. file 16
	13c	Describe any methods used to tabulate or visually display results of individual studies and synthes	p.9-10, Suppl file 16
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	p.9-10, Suppl file 16
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	p.9-10, Suppl file 16
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	p.9-10, Suppl file 16
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Not possible to assess publication bias as fewer than 10 studies in each meta-analysis
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	p.10, Suppl. file 16
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	p.10-11, Fig 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Suppl. file 7
Study characteristics	17	Cite each included study and present its characteristics.	Suppl. files 6, 8, 9, 9, 10
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Suppl. files 12-15, 17

Section and Topic	Item #	Checklist item	Location where item is reported
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Suppl. file 16
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Suppl. files 16, 17
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	p.12-14, Suppl. file 16
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Suppl. file 16
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Supp.file 16.
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Not possible to assess publication bias as fewer than 10 studies in each meta-analysis
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	p.12-14, Suppl. file 16
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p.15-16
	23b	Discuss any limitations of the evidence included in the review.	p.16-17
	23c	Discuss any limitations of the review processes used.	p.16-17
	23d	Discuss implications of the results for practice, policy, and future research.	p.17
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	p.7
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	p.7, Suppl. file 3

Section and Topic	Item #	Checklist item	Location where item is reported
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Suppl. file 3
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	p.18
Competing interests	26	Declare any competing interests of review authors.	p.18
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	p.18-19

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. This work is licensed under CC BY 4.0. To view a copy of this license, visit https://creativecommons.org/licenses/by/4.0/

Supplementary file 2. Completed PRISMA for Abstracts checklist

Section and Topic	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	p.2
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	p.2
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	p.2
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	p.2
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	p.2
Synthesis of results	6	Specify the methods used to present and synthesise results.	p.2
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	p.2
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	p.2
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	p.2-3
Interpretation	10	Provide a general interpretation of the results and important implications.	p.2-3
OTHER			

Section and Topic	Item #	Checklist item	Reported (Yes/No)
Funding	11	Specify the primary source of funding for the review.	p.2
Registration	12	Provide the register name and registration number.	p.2

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Supplementary file 3. Pre-specified protocol with amendments

Presented in PROSPERO format.

PD-ARTS 2024: Updated systematic review on the performing arts in Parkinson's disease

Maxwell Barnish, Rebecca V. Nelson-Horne

Review question

1. How has the evidence base for dance, music therapy and singing for Parkinson's disease (PD) changed since the Barnish & Barran (2020) review?
2. Present an updated review of the evidence published 2020-2024 on dance, music therapy and singing for quality of life, motor function, cognitive status, speech and communication in PD.

Searches

AMED (Ebsco), APA PsycINFO (Ovid), CINAHL (Ebsco), EMBASE (Ovid) and MEDLINE (Ovid). Supplementary searches will be conducted on Google Scholar and through forward and backward citation chasing on studies identified for full-text review. Searches will be conducted using the same search strategy as published by Barnish & Barran (2020) and cover the period 2020 to February 2024.

Types of study to be included

Randomised controlled trials, non-randomised controlled trials, observational studies with or without a control arm. Reported in peer-reviewed English-language journals as full texts (or conference abstracts within 2 years before search).

Condition or domain being studied

Parkinson's disease. Quality of life, motor function, cognitive status, speech and communication in people with PD.

Participants/population

People with a diagnosis of PD. This can be clinical diagnosis or meeting a recognised set of diagnostic criteria, e.g. UK Brain Bank or Calne criteria.

Intervention(s), exposure(s)

Dance, music therapy or singing. The intervention had to be an active rather than passive performing arts intervention and be delivered in a group setting.

Comparator(s), control(s)

Any other intervention to address PD symptoms, usual care, or no control arm.

Main outcome(s)

Quality of life, motor function, cognitive status, speech or functional communication – using any recognised assessment tool.

Additional outcome(s)

None

Data extraction (selection and coding)

Data will be extracted by two independent reviewers and any disagreements resolved by discussion. Information about the study characteristics, intervention, control and outcome data (narrative results and where appropriate numerical data for meta-analysis) will be extracted.

Risk of bias (quality) assessment

Studies will be assessed using the SURE bias of bias checklists for experimental and cohort studies. Assessment will be conducted by two independent reviewers and any disagreements resolved by discussion.

Strategy for data synthesis

The principal data synthesis strategy will be thematic narrative synthesis initially by outcome domain and then by arts modality, due to a priori expected clinical, methodological and statistical heterogeneity between studies based on Barnish & Barran (2020). This shall be supplemented by random effects meta-analysis, based on mean difference, updating the analysis sets in Barnish and Barran and creating new analysis sets where evidence is available.

Analysis of subgroups or subsets

None planned.

Contact details for further information

Dr Maxwell Barnish

m.s.barnish@exeter.ac.uk

Organisational affiliation of the review

University of Exeter, UK

Review team members and their organisational affiliations

Dr Maxwell Barnish, Senior Research Fellow, University of Exeter, UK

Ms Rebecca Nelson-Horne, Independent Scholar, Glasgow, UK

Type and method of review

Intervention

Anticipated or actual start date

1 January 2024

Anticipated completion date

1 July 2024

Funding sources/sponsors

None

Conflicts of interest

None known

Language

English

Country

United Kingdom

Stage of review

Review Ongoing

Protocol amendments following reviewer comments

1. Re-focus so that the primary aim is to present an updated review of all available evidence (not just 2020-2024) to address our research question (PICO) and so that assessing what has changed since 2020 is now a secondary aim.
2. Conduct a further search update (February 2025).
3. Add CRD checklist and Newcastle-Ottawa Scale risk of bias assessment (as appropriate to study design) for studies including in meta-analysis, in addition to SURE checklists
4. Position the narrative synthesis and meta-analysis as complementary to each other rather than the narrative synthesis as primary. To this end, conduct appropriate sensitivity analyses as well as subgroup analysis (by study design) to further explore the meta-analysis results.
5. Add a 'certainty assessment' using GRADE.
6. Add Sarah E. Reynolds as a reviewer (Independent Scholar, Glasgow, UK)

References

Barnish MS, Barran SM. A systematic review of active group-based dance, singing, music therapy and theatrical interventions for quality of life, functional communication, speech, motor function and cognitive status in people with Parkinson's disease. BMC Neurol 2020; 20(1): 371.

Supplementary file 4. Supplementary methods

Design

The changes made from the Barnish & Barran (2020) review in this review were to:

- Search APA PsycINFO instead of PsycINFO (this is solely a rebranding of the database and is not believed to affect underlying content).
- Expand the meta-analysis including the addition of subgroup analysis, sensitivity analysis and certainty assessment (detailed in the main manuscript) and additional risk of bias assessment using CRD and NOS.

Construction of meta-analysis sets followed the exact same process as Barnish & Barran (2020), although new evidence published between 2020 and 2024 facilitated the creation of additional analysis sets.

Meta-analysis

All available data from database inception to February 2025 were analysed, including data from the meta-analyses presented in Barnish & Barran (2020).

All outcome domains were considered for meta-analysis, subject to sufficient data. As the meta-analysis was a secondary analysis, there were no sensitivity or subgroup analyses, and risk of bias was assessed at the individual study level. Meta-analysis was conducted by MSB.

Outcome measures were continuous. Therefore, meta-analyses were conducted on mean values, sample size and standard deviations. Where required, standard deviations were calculated from confidence intervals or standard errors. The preference where possible was to conduct meta-analyses based on the mean difference change score between baseline and final follow-up. However, we noted that Barnish & Barran (2020) found that this was seldom possible, due to studies not reporting a standard deviation for the difference between baseline and follow-up or anything that could be converted into one. Therefore, if meta-analysis based on change scores was not possible, following Barnish & Barran (2020), we conducted meta-analyses based on scores at the final follow-up point.

References

Barnish MS, Barran SM. A systematic review of active group-based dance, singing, music therapy and theatrical interventions for quality of life, functional communication, speech, motor function and cognitive status in people with Parkinson's disease. BMC Neurol 2020; 20(1): 371.

Supplementary file 5. Detailed search strategies

Search results from Barnish & Barran[5] were used for the period from database inception to February 2024. Therefore, search results from February 2024 and February 2025 updates are presented here. The same search strategy was used for the original Barnish & Barran search and both the updates.

February 2024 search

The same search strategy was used as in the 2020 review. All databases were searched on 15 February 2024, using the most up-to-date available version of each database.

A date filter of January 2020 onwards was applied. No other filters or limits were applied in the search. Instead, eligibility was handled in the screening process.

AMED (Ebsco)

Expanders: Apply equivalent subjects

Search modes: Boolean/Phrase

Limiters: Publication date: 20200101 – 20241231

(Parkinson's disease (2167 hits) OR Parkinson disease (2167 hits)) AND (singing (104 hits) OR sing* (15,029 hits) OR music* (1,768 hits) OR music ther* (1,191 hits) OR danc* (981 hits) OR dram* (1,278 hits) OR theat* (160 hits) OR performing art* (101 hits) OR art* (43,162 hits) OR art ther* (1,766 hits))

Combining disease terms using OR = 2,167 hits

Combining performing arts terms using OR = 58, 830 hits

Combining disease and performing arts terms using AND = 408 hits

Applying publication date filter = 97 hits

APA PsycINFO (Ovid)

Limit: publication date: yr "2020-2024"

(exp Parkinson's disease/ (29, 549 hits) AND (singing.mp (4,941 hits) OR exp Singing/ (1, 629 hits) OR music.mp (42, 884 hits) OR exp Music/ (21,285 hits) OR music therapy.mp (6, 981 hits) OR exp Music Therapy/ (5, 784 hits) OR dance.mp (8,211 hits) OR dancing.mp (2,659 hits) OR exp Dance/ (3,056 hits) OR drama.mp (6,833 hits) OR exp Drama/ (2,281 hits) OR theatre.mp (3,321 hits) OR theater.mp (2,784 hits) OR theatrical.mp (1,074 hits) OR performing art*.mp (893 hits) OR art.mp (58,898 hits) OR arts (27,329 hits) OR exp Art/ (15, 175 hits) OR art therapy.mp (6,878 hits) OR exp Art Therapy/ (5,733 hits))

Combining performing arts terms using OR = 138, 572 hits

Combining disease and performing arts terms using AND = 370 hits

Applying publication date filter = 111 hits

CINAHL (Ebsco)

Expanders: Apply equivalent subjects

Search modes: Boolean/Phrase

Limiters: Publication date: 20200101 – 20241231

(MM "Parkinson Disease" (22,125 hits) AND (singing (4,895 hits) OR MM "Singing" (2,667 hits) OR music (21,585 hits) OR MM "Music" (7,279 hits) OR music therapy (7,672 hits) OR MM "Music Therapy" (5,272 hits) OR dance (5, 609 hits) OR dancing (4,398 hits) OR MM "Dancing" (3,039 hits) OR drama (2,374 hits) OR MM "Drama" (941 hits) OR theatre (6,773 hits) OR theater (6,773 hits) OR theatrical (162 hits) OR performing art* (9,372 hits) OR art (63,611 hits) OR arts (52,051 hits) OR MM "Art+" (9,308 hits) OR art therapy (10,645 hits) OR MM "Art Therapy" (3,037 hits)

Combining performing arts terms using OR = 106,104 hits

Combining disease and performing arts terms using AND = 371 hits

Applying publication date filter = 128 hits

EMBASE (Ovid)

Limit: publication date: yr "2020-2024"

(exp Parkinson disease/ (197, 451 hits)) AND (singing.mp (6,246 hits) OR exp singing/ (4,384 hits) OR music.mp (36,829 hits) OR exp music/ (22,566 hits) OR music therapy.mp (9,843 hits) OR exp music therapy/ (9,337 hits) OR dance.mp (8,378 hits) OR dancing.mp (8,042 hits) OR exp dancing/ (6,729 hits) OR drama.mp (2,306 hits) OR exp literature/ (265,430 hits) OR theatre.mp (19,631 hits) OR theater.mp (5,593 hits) OR theatrical.mp (424 hits) OR performing art*.mp (1,540 hits) OR art.mp (254,375 hits) OR arts.mp (13,218 hits) OR exp art/ (74,728 hits) OR art therapy.mp (5,635) OR exp art therapy/ (5,035 hits)

Combining performing arts terms using OR = 613,993 hits

Combining disease and performing arts terms using AND = 3,594 hits

Applying publication date filter = 1,077 hits

MEDLINE (Ovid)

Limit: publication date: yr "2020-2024"

(exp Parkinson Disease/ (84,655 hits)) AND (singing.mp (4,710 hits) OR exp Singing/ (1,397 hits) OR music.mp (31,010 hits) OR Music/ (17,226 hits) OR music therapy.mp (5,794 hits) OR exp Music Therapy/ (4,440 hits) OR dance.mp (6,194 hits) OR dancing.mp (5,215 hits) OR exp Dancing/ (3,595 hits) OR drama.mp (3, 575 hits) OR exp Drama/ (2,100 hits) OR theatre.mp (9,950 hits) OR theater.mp (4,522 hits) OR theatrical.mp (342 hits) OR performing art*.mp (945 hits) OR art.mp (170, 808 hits) OR arts.mp (16,664) OR exp Art/ (38,483 hits) OR art therapy.mp (2,515 hits) OR exp Art Therapy/ (1,753 hits))

Combining performing arts terms using OR = 263,463 hits

Combining disease and performing arts terms using AND = 750 hits

Applying publication date filter = 264 hits

Supplementary searches

Google Scholar: combining 'Parkinson disease' and 'singing', 'music', 'dance', 'dancing', 'art', 'arts' in turn. Then repeating using 'Parkinson's disease'. 4 additional potentially relevant hits identified.

Citation chasing: backwards citation chasing using reference lists of articles from full-text screening. Forwards citation chasing using 'cited by' feature on Google Scholar for articles from full-text screening. 2 additional potentially relevant hits identified.

February 2025 search

Searches were conducted on 6 and 7 February using the most up-to-date version of the database available. For AMED this was 7 February 2025, for APA PsychINFO this was January Week 4 2025 (as this database is updated less frequently), for CINAHL this was 7 February 2025, for EMBASE this was 5 February 2025, and for MEDLINE this was 6 February 2025. The same search strategy was used as for the Barnish & Barran (2020) review and the February 2024 update search. The same limiters and filters were used as above, except that the date filter for the February 2025 search was start of 2024 until the search date. There were no additional relevant records identified through supplementary searches.

AMED (Ebsco)

(Parkinson's disease (2187 hits) OR Parkinson disease (2187 hits)) AND (singing (112 hits) OR sing* (15,129 hits) OR music* (1,789 hits) OR music ther* (1,207 hits) OR danc* (979 hits) OR dram* (1,304 hits) OR theat* (164 hits) OR performing art* (103 hits) OR art* (43,358 hits) OR art ther* (1,777 hits))

Combining disease terms using OR = 2,187 hits

Combining performing arts terms using OR = 59, 117 hits

Combining disease and performing arts terms using AND = 414 hits

Applying publication date filter = 3 hits

APA PsycINFO (Ovid)

(exp Parkinson's disease/ (30, 728 hits) AND (singing.mp (5,126 hits) OR exp Singing/ (1,711 hits) OR music.mp (44,773 hits) OR exp Music/ (22,367 hits) OR music therapy.mp (7,410 hits) OR exp Music Therapy/ (6,186 hits) OR dance.mp (8,627 hits) OR dancing.mp (2,782 hits) OR exp Dance/ (3,238 hits) OR drama.mp (7,085 hits) OR exp Drama/ (2,347 hits) OR theatre.mp (3,479 hits) OR theater.mp (2,890 hits) OR theatrical.mp (1,114 hits) OR performing art*.mp (953 hits) OR art.mp (61,318 hits) OR arts (28,501 hits) OR exp Art/ (15,691 hits) OR art therapy.mp (7,121 hits) OR exp Art Therapy/ (6,003 hits))

Combining performing arts terms using OR = 144,263 hits

Combining disease and performing arts terms using AND = 401 hits

Applying publication date filter = 21 hits

CINAHL (Ebsco)

(MM "Parkinson Disease" (21,376 hits) AND (singing (5,122 hits) OR MM "Singing" (2,801 hits) OR music (22,400 hits) OR MM "Music" (7,444 hits) OR music therapy (8,106 hits) OR MM "Music Therapy" (5,510 hits) OR dance (5,682 hits) OR dancing (4,564 hits) OR MM "Dancing" (2,532 hits) OR drama (2,419 hits) OR MM "Drama" (951 hits) OR theatre (6,972 hits) OR theater (6,972 hits) OR theatrical (167 hits) OR performing art* (9,786 hits) OR art (67,812 hits) OR arts (53,078 hits) OR MM "Art+" (17,905 hits) OR art therapy (11,187 hits) OR MM "Art Therapy" (3,225 hits)

Combining performing arts terms using OR = 115,828 hits

Combining disease and performing arts terms using AND = 389 hits

Applying publication date filter = 30 hits

EMBASE (Ovid)

(exp Parkinson disease/ (208,477 hits)) AND (singing.mp (6,522 hits) OR exp singing/ (4,600 hits) OR music.mp (38,984 hits) OR exp music/ (24,043 hits) OR music therapy.mp (10,552 hits) OR exp music therapy/ (10,057 hits) OR dance.mp (8,948 hits) OR dancing.mp (8,664 hits) OR exp dancing/ (7,313 hits) OR drama.mp (2,424 hits) OR exp literature/ (272,096 hits) OR theatre.mp (20,458 hits) OR theater.mp (5,902 hits) OR theatrical.mp (452 hits) OR performing art*.mp (1,623 hits) OR art.mp (271,347 hits) OR arts.mp (14,215 hits) OR exp art/ (74,834 hits) OR art therapy.mp (5,912) OR exp art therapy/ (5,281 hits)

Combining performing arts terms using OR = 641,980 hits

Combining disease and performing arts terms using AND = 3,885 hits

Applying publication date filter = 236 hits

MEDLINE (Ovid)

(exp Parkinson Disease/ (88,929 hits)) AND (singing.mp (4,942 hits) OR exp Singing/ (1,500 hits) OR music.mp (32,942 hits) OR Music/ (17,895 hits) OR music therapy.mp (6,315 hits) OR exp Music Therapy/ (4,774 hits) OR dance.mp (6,714 hits) OR dancing.mp (5,522 hits) OR exp Dancing/ (3,778 hits) OR drama.mp (3,685 hits) OR exp Drama/ (2,141 hits) OR theatre.mp (10,441 hits) OR theater.mp (4,792 hits) OR theatrical.mp (365 hits) OR performing art*.mp (1,018 hits) OR art.mp (187,410 hits) OR arts.mp (17,724) OR exp Art/ (38,967 hits) OR art therapy.mp (2,681 hits) OR exp Art Therapy/ (1,852 hits))

Combining performing arts terms using OR = 284,294 hits

Combining disease and performing arts terms using AND = 823 hits

Applying publication date filter = 76 hits

Supplementary file 6. Full list of included publications

Barnish & Barran 2020 search

67 publications (56 studies)

Dance (n=45 publications, n=38 studies)

1. Allen, J.L., McKay, J.L., Sawers, A., Hackney, M.E., & Ting, L.H. (2017). Increased neuromuscular consistency in gait and balance after partnered, dance-based rehabilitation in Parkinson's disease. Journal of Neurophysiology, 118, 363-373.
2. Batson, G., Migliarese, S.J., Soriano, C., Burdette, J.H., & Laurienti, P.J. (2014). Effects of improvisational dance on balance in Parkinson's disease: a two-phase fMRI case study. Physical and Occupational Therapy in Geriatrics, 2014, 32 (3), 188-197.
3. Batson, G. (2010). Feasibility of an intensive trial of modern dance for adults with Parkinson disease. Complementary Health Practice Review, 15(2), 65-83.
4. Bearss, K.A., McDonald, K.C., Bar, R.J., & DeSouza, J.F.X. (2017). Improvements in balance and gait speed after a 12 week dance intervention for Parkinson's disease. Archives in Integrative Medicine, 4, 10-13.
5. Blandy, L.M., Beevers, W.A., Fitzmaurice, K., & Morris, M.E. (2015). Therapeutic Argentine tango dancing for people with mild Parkinson's disease: a feasibility study. Frontiers in Neurology, 6, 122.
6. Clifford, M., Robey, S., & Dixon, J. (2017). Dancing with Parkinson's: a London hospice's experience of running a dance programme. International Journal of Palliative Nursing, 23, 498-500.
7. De Natale, E.R., Paulus, K.S., Aiello, E., Sanna, B., Manca, A., Sotgiu, G., Leali, P.T., & Deriu, F. (2017). Dance therapy improves motor and cognitive functions in patients with Parkinson's disease. NeuroRehabilitation, 40, 141-144.
8. Duncan, R.P., & Earhart, G.M. (2014). Are the effects of community-based dance on Parkinson disease severity, balance, and functional mobility reduced with time? A 2- year prospective pilot study. Journal of Alternative and Complementary Medicine, 20, 757-763.
9. Duncan, R.P., & Earhart, G.M. (2012). Randomized controlled trial of community-based dancing to modify disease progression in Parkinson disease. Neurorehabilitation and Neural Repair, 26(2), 132-143.
10. Foster, E.R., Golden, L., Duncan, R.P., & Earhart, G.M. (2013). A community-based Argentine tango dance program is associated with increased activity participation among individuals with Parkinson disease. Archives of Physical and Medical Rehabilitation, 94(2), 240-249.
11. Hackney, M.E., Kantorovich, S., & Earhart, G.M. (2007). A study of the effects of Argentine tango as a form of partnered dance for those with Parkinson disease and the healthy elderly. American Journal of Dance Therapy, 29(2), 109-127.
12. Hackney, M.E., Kantorovich, S., Levin, R., & Earhart, G.M. (2007). Effects of tango on functional mobility in Parkinson's disease: a preliminary study. Journal of Neurologic Physical Therapy, 31, 173-179.
13. Hackney, M.E., & Earhart, G.M. (2009). Effects of dance on movement control in Parkinson's disease: a comparison of Argentine tango and American ballroom. Journal of Rehabilitative Medicine, 41, 475-481.
14. Hackney, M.E., & Earhart, G.M. (2009). Health-related quality of life and alternative forms of exercise in Parkinson disease. Parkinsonism and Related Disorders, 15, 644-648.
15. Hackney, M.E., & Earhart, G.M. (2009). Short duration, intensive tango dancing for Parkinson disease: an uncontrolled pilot study. Complementary Therapies in Medicine, 17(4), 203-207.
16. Hackney, M.E., & Earhart, G.M. (2010). Effects of dance on gait and balance in Parkinson disease: a comparison of partnered and non-partnered dance movement. Neurorehabilitation and Neural Repair, 24, 384-392.
17. Hackney, M., Hart, A., Kim, C. (2018). It takes two to tango but following may be more beneficial for rehabilitating people with mild-moderate Parkinson's [Abstract]. Movement Disorders, 33 (S2), S149.
18. Hashimoto, H., Takabatake, S., Miyaguchi, H., Nakanishi, H., & Naitou, Y. (2015). Effects of dance on motor functions, cognitive functions, and mental symptoms of Parkinson's disease: a quasi-randomized pilot trial. Complementary Therapies in Medicine, 23, 210-219.
19. Heiberger, L., Maurer, C., Amtage, F., Mendez-Balbuena, I., Schulte-Mönting, J., Hepp- Raymond, M-C., & Kristeva, R. (2011). Impact of a weekly dance class on the functional mobility and on the quality of life of individuals with Parkinson's disease. Frontiers in Aging Neuroscience, 3, 14.

20. Hulbert, S., Ashburn, A., Roberts, L., & Verheyden, G. (2017). Dance for Parkinson's – the effects on whole body co-ordination during turning around. Complementary Therapies in Medicine, 32, 91-97.
21. Kalyani, H.H.N., Sullivan, K.A., Moyle, G., Brauer, S., Jeffrey, E.R, & Kerr, G.K. (2019). Impacts of dance on cognition, psychological symptoms and quality of life in Parkinson's disease. NeuroRehabilitation, 45, 273-283.
22. Koch, S.C., Mergheim, K., Raeke, J., Machado, C.B., Riegner, E., Nolden, J…Hillecke, T.K. (2016). The embodied self in Parkinson's disease: feasibility of a single tango intervention for assessing changes in psychological health outcomes and aesthetic experience. Frontiers in Neuroscience, 10, 287.
23. Kunkel, D., Fitton, C., Roberts, L., Pickering, R.M., Roberts, H.C., Wiles, R…Ashburn, A. (2017). A randomized controlled feasibility trial exploring partnered ballroom dancing for people with Parkinson's disease. Clinical Rehabilitation, 31, 1340-1350.
24. Lee, H-J., Kim, S-Y., Chae, Y., Kim, M-Y., Yin, C., Jung, W-S…Lee, H. (2018). Turo (Qi dance) program for Parkinson's disease patients: randomized, assessor blind, waiting- list control, partial crossover study. Explore, 14, 216-223.
25. McGill, A., Houston, S., & Lee, R.Y.W. (2019). Effects of a ballet-based dance intervention on gait variability and balance confidence of people with Parkinson's. Arts and Health, 11(2): 133-146.
26. McKay, J.L., Ting, L.H., & Hackney, M.E. (2016). Balance, body motion and muscle activity after high volume short term dance-based rehabilitation in individuals with Parkinson's disease: a pilot study. Journal of Neurologic Physical Therapy, 40, 257- 268.
27. McKee, K.E., & Hackney, M.E. (2013). The effects of adapted tango on spatial cognition and disease severity in Parkinson's disease. Journal of Motor Behavior, 45(6), doi:10.1080/00222895.2013.834288.
28. McNeely, M.E., Mai, M.M., Duncan, R,P., & Earhart, G.M. (2015). Differential effects of tango versus Dance for PD in Parkinson disease. Frontiers in Aging Neuroscience, 7, 239.
29. McRae, C., Leventhal, D., Westheimer, O., Mastin, T., Utley, J., & Russell, D. (2018). Long- term effects of Dance for PD on self-efficacy among persons with Parkinson's disease. Arts & Health, 10(1), 85-96.
30. Marchant, D., Sylvester, J.L., & Earhart, G.M. (2010). Effects of a short duration, high dose contact improvisation dance workshop on Parkinson disease: a pilot study. Complementary Therapies in Medicine, 18, 184-190.
31. Michels, K., Dubaz, O., Hornthal, E., & Bega, D. (2018). "Dance Therapy" as a psychotherapeutic movement intervention in Parkinson's disease. Complementary Therapies in Medicine, 40, 248-252.
32. Michels, K., Hornthal, E., & Bega, D. (2018). A pilot study on dance/movement therapy in Parkinson's disease [Abstract]. Neurology, 90 (15, S1).
33. Patel, R., Hart, A., Hackney, M., & Kim, C. (2018). Partnered, rhythmic, rehabilitative movement may impact medication related motor fluctuations [Abstract]. Annals of Neurology, 84 (S22), S201.
34. Prewitt, C.M., Charpentier, J.C., Brosky, J.A., & Urbscheit, N.L. (2017). Effects of dance classes on cognition, depression, and self-efficacy in Parkinson's disease. American Journal of Dance Therapy, 39, 126-141.
35. Rawson, K.S., McNeely, M.E., Duncan, R.P., Pickett, K.A., Perlmutter, J.S., & Earhart, G.M. (2019). Exercise and Parkinson's disease: comparing tango, treadmill and stretching. Journal of Neurologic Physical Therapy, 43(1), 26-32.
36. Rocha, P., Aguiar, L., McClelland, J.A., & Morris, M.E. (2018). Dance therapy for Parkinson's disease: a randomised feasibility trial. International Journal of Therapy and Rehabilitation, 25 (2), 65-72.
37. Romenets, S.R., Anang, J., Fereshtehnejad, S-M., Pelletier, A., & Postuma, R. (2015). Tango for treatment of motor and non-motor manifestations in Parkinson's disease: a randomized control study. Complementary Therapies in Medicine, 23, 175-184.
38. Shanahan, J., Morris, M.E., Ni Bhriain, O., Volpe, D., Lynch, T., & Clifford, A. (2017). Dancing for Parkinson's disease: a randomized controlled trial of Irish set dancing compared with usual care. Archives of Physical Medicine and Rehabilitation, 98, 1744-1751.
39. Shanahan, J., Morris, M.E., Ni Bhriain, O., Volpe, D., Richardson, M., & Clifford, A.M. (2015). Is Irish set dancing feasible for people with Parkinson's disease in Ireland? Complementary Therapies in Medicine, 21, 47-51.
40. Solla, P., Cugusi, L., Bertoli, M., Cereatti, A., Della Croce, U., Pani, D…Mercuro, G. (2019). Sardinian folk dance for individuals with Parkinson's disease: a randomized controlled pilot trial. Journal of Alternative and Complementary Medicine, 25, 305- 316.
41. Ventura, M.I., Barnes, D.E., Ross, J.M., Lanni, K.E., Sigvardt, K.A,, & Disbrow, E.A. (2016). A pilot study to evaluate multi-dimensional effects of dance for people with Parkinson's disease. Contemporary Clinical Trials, 51, 50-55.

42. Volpe, D., Signorini, M., Marchetto, A., Lynch, T., & Morris, M.E. (2013). A comparison of Irish set dancing and exercises for people with Parkinson's disease: a phase II feasibility study. BMC Geriatrics, 13, 54.
43. Westbrook, B.K., & McKibben, H. (1989). Dance/movement therapy with groups of outpatients with Parkinson's disease. American Journal of Dance Therapy, 11(1), 27- 38.
44. Westheimer, O., McRae, C., Henchcliffe, C., Fesharaki, A., Glazman, S., Ene, H., & Bodis- Wollner, I. (2015). Dance for PD: a preliminary investigation of effects on motor function and quality of life among persons with Parkinson's disease (PD). Journal of Neural Transmission, 122, 1263-1270.
45. Zafar, M., Bozzorg, A., & Hackney, M.E. (2017). Adapted tango improves aspects of participation in older adults versus individuals with Parkinson's disease. Disability and Rehabilitation, 39, 2294-2301.

Music therapy (n=4 publications, n=4 studies)

1. Pacchetti, C., Mancini, F., Aglieri, R., Fundarò, C., Martignoni, E.,& Nappi, G. (2000). Active music therapy in Parkinson's disease: an integrative method for motor and emotional rehabilitation. Psychosomatic Medicine, 62, 386-393.
2. Pantelyat, A., Syres, C., Reichwein, S., & Willis, A. (2016). DRUM-PD: the use of a drum circle to improve the symptoms and signs of Parkinson's disease (PD). Movement Disorders Clinical Practice, 3, 243-249.
3. Pohl, P., Didzar, N., & Hallert, E. (2013). The Ronnie Gardiner Rhythm and Music Method – a feasibility study in Parkinson's disease. Disability and Rehabilitation, 35, 2197- 2204.
4. Spina, E., Barone, P., Mosca, L.L., Lombardi, A., Longo, K., Iavarone, A., & Amboni, M. (2016). Music therapy for motor and nonmotor symptoms of Parkinson's disease: a prospective, randomized, controlled, single-blinded study. Journal of the American Geriatrics Society, 64 (9), e36-e38.

Singing (n=16 publications, n=12 studies)

1. Azekawa, M., & Lagasse, A.B. (2018). Singing exercises for speech and vocal abilities in individuals with hypokinetic dysarthria: a feasibility study. Music Therapy Perspectives, 36, 40-49.
2. Di Benedetto, P., Cavazzon, M., Mondolo, F., Rugiu, G., Peratoner, A., & Biasutti, E. (2009).Voice and choral singing treatment: A new approach for speech and voice disorders in Parkinson's disease. European Journal of Physical and Rehabilitation Medicine, 45, 13-19.
3. Elefant, C., Baker, F.A., Lotan, M., Lagesen, S.K., & Skeie, G.O. (2012). The effect of group music therapy on mood, speech, and singing in individuals with Parkinson's disease – a feasibility study. Journal of Music Therapy, 49, 278-302.
4. Elefant, C., Lotan, M., Baker, F.A., & Skeie, G.O. (2012). Effects of music therapy on facial expression of individuals with Parkinson's disease: a pilot study. Musicae Scientae, 13, 392-400.
5. Evans, C., Canavan, M., Foy, C., Langford, R., & Proctor, R. (2012). Can group singing provide effective speech therapy for people with Parkinson's disease? Arts & Health, 4, 83-95.
6. Higgins, A.N., & Richardson, K.C. (2019). The effects of a choral singing intervention on speech characteristics in individuals with Parkinson's disease: an exploratory study. Communication Disorders Quarterly, 40(4), 195-205.
7. Irons, J.Y., Hancox, G., Vella-Burrows, T., Han, E-Y., Chong, H-J., Sheffield, D., & Stewart, D.E. (2020). Group singing improves quality of life for people with Parkinson's: an international study, Aging and Mental Health, https://doi.org/10.1080/13607863.2020.1720599.
8. Irons, Y., Hancox, G., Vella-Burrows, T., Han, E-Y., Ching, H-J, Sheffield, D., & Stewart, D. (2019). Group singing improves quality of life in people with Parkinson's: an international Sing to Beat Parkinson's project [Abstract]. Journal of Parkinson's Disease, 9, 186.
9. Matthews, R., Purdy, S., & Tippett, L. (2018). Acoustic, respiratory, cognitive and wellbeing comparisons of two groups of people with Parkinson's disease participating in voice and choral singing group therapy (VCST) versus music appreciation activity [Abstract]. Movement Disorders, 33 (S2), S406.
10. Shih, L.C., Piel, J., Warren, A., Kraiscs, L., Silver, A., Vanderhorst, V., … Tarsy, D. (2012). Singing in groups for Parkinson's disease (SING-PD): A pilot study of group singing therapy for PD-related voice/speech disorders. Parkinsonism and Related Disorders, 18, 548-552.
11. Stegemöller, E.L., Hibbing, P., Radig, H., & Wingate, J. (2017). Therapeutic singing as an early intervention for swallowing in persons with Parkinson's disease. Complementary Therapies in Medicine, 31, 127-133.

12. Stegemöller, E.L., Radig, H., Hibbing, P., Wingate, J., & Sapienza, C. (2017). Effects of singing on voice, respiratory control and quality of life in persons with Parkinson's disease. Disability and Rehabilitation, 39, 594-600.
13. Tamplin, J., Morris, M.E., Marigliani, C., Baker, F.A., Vogel, A.P. (2019). ParkinSong: a controlled trial of singing-based therapy for Parkinson's disease. Neurorehabilitation and Neural Repair, 33, 453-463.
14. Tamplin, J., Vogel, A., Marigliani, C., Baker, F., Morris, M. (2018). A controlled trial of ParkinSong singing groups to improve communication and wellbeing in Parkinson's disease [Abstract]. Movement Disorders, 33 (S2), S138.
15. Tanner, M., Rammage, L., & Liu, L. (2016). Does singing and vocal strengthening improve vocal ability in people with Parkinson's disease? Arts & Health, 8(3), 199-212.
16. Yinger, O.S., & Lapointe. L.L. (2012). The effects of participation in a group music therapy voice protocol (G-MTVP) on the speech of individuals with Parkinson's disease. Music Therapy Perspectives, 30, 25-31.

Theatre (n=2 publications, n=2 studies)

1. Mirabella, G., De Vita, P., Fragola, M., Rampelli, S., Lena, F…Modugno, N. (2017). Theatre is a valid add-on therapeutic intervention for emotional rehabilitation of Parkinson's disease patients. Parkinson's Disease, 2017, 7436725.
2. Modugno, N., Iaconelli, S., Fiorelli, M., Lena, F., Kusch, I., & Mirabella, G. (2010). Active theater as a complementary therapy for Parkinson's disease rehabilitation: a pilot study. The Scientific World Journal, 10, 2301-2313.

February 2024 search

Total = 36 publications (33 unique studies)

Dance (n=22 publications, 21 studies)

1. Bouquiaux O, Thibaut A, Beaudart C, et al. Dance training and performance in patients with Parkinson disease: Effects on motor functions and patients' well-being. Sci Sports 2022; 37(1): 45-50.
2. Delabary MDS, Monteiro EP, Donida RG, et al. Can Samba and Forró Brazilian rhythmic dance be more effective than walking in improving functional mobility and spatiotemporal gait parameters in patients with Parkinson's disease? BMC Neurol 2020; 20: 305.
3. Duarte JDS, Alcantara WA, Brito JS, et al. Physical activity based on dance movements as complementary therapy for Parkinson's disease: Effects on movement, executive functions, depressive symptoms, and quality of life. PLoS ONE 2023; 18(2): e0281204.
4. Feenstra W, Nonnekes J, Rahimi T, et al. Dance classes improve self-esteem and quality of life in persons with Parkinson's disease. J Neurol 2022; 269(11): 5843-7.
5. Fisher M, Kuhlmann N, Moulin H, et al. Effects of improvisational dance movement therapy on balance and cognition in Parkinson's disease. Phys Occup Ther Geriatr 2020; 38(4): 385-99.
6. Fontanesi C, De Souza JF. Beauty that moves: Dance for Parkinson's effects on affect, self-efficacy, Gait symmetry, and dual task performance. Front Psychol 2021; 11: 600440.
7. Frisaldi E, Bottino P, Fabbri M, et al. Effectiveness of a dance-physiotherapy combined intervention in Parkinson's disease: a randomized controlled pilot trial. Neurol Sci 2021; 42(12): 5045-53.
8. Haas AN, Delabary MDS, Passos-Monteiro E, et al. The effects of Brazilian dance, deep-water exercise and nordic walking, pre- and post-12 weeks, on functional-motor and non-motor symptoms in trained PwPD. Arch Gerontol Geriatr 2024; 118: 105285.
9. Haputhanthirige NKH, Sullivan K, Moyle G, et al. Effects of dance on gait and dual-task gait in Parkinson's disease. PLoS ONE 2023; 18(1): e0280635.
10. Harrison EC, Earhart GM, Leventhal D, et al. A walking dance to improve gait speed for people with Parkinson disease: a pilot study. Neurodegener Dis Manag 2020; 10(5): 301-8.
11. Jola C, Sundström M, McLeod J. Benefits of dance for Parkinson's: The music, the moves, and the company. PLoS ONE 2022; 17: e0265921.
12. Lihala S, Mitra S, Neogy S, et al. Dance movement therapy in rehabilitation of Parkinson's disease - A feasibility study. J Bodyw Mov Ther 2021; 26: 12-7.

13. Moratelli J, Alexandre KH, Boing L, et al. Binary dance rhythm or quaternary dance rhythm which has the greatest effect on non-motor symptoms of individuals with Parkinson's disease? Complement Ther Clin Pract 2021; 43: 101348.
14. Moratelli JA, Alexandre KH, Boing L, et al. Dance Rhythms Improve Motor Symptoms in Individuals with Parkinson's Disease: A Randomized Clinical Trial. J Dance Med Sci 2022; 26(1): 1-6.
15. Moratelli JA, Delabary MDS, Curi VS, et al. An Exploratory Study on the Effect of 2 Brazilian Dance Protocols on Motor Aspects and Quality of Life of Individuals with Parkinson's Disease. J Dance Med Sci 2023; 27(3): 153-9.
16. Park E, Boutsen F, Kollia B, et al. Effect of vocal-dance program on speech, voice quality, and quality of life in persons with Parkinson's disease [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 154.
17. Peter S, Crock ND, Billings BJ, et al. Argentine Tango Reduces Fall Risk in Parkinson's Patients. J Am Med Dir Assoc 2020; 21(2): 291-2.
18. Pinto C, Figueiredo C, Mabilia V, et al. A Safe and Feasible Online Dance Intervention for Older Adults With and Without Parkinson's Disease. J Dance Med Sci 2023; 27(4): 253-67.
19. Rabinovich DB, Garretto NS, Arakaki T, et al. A high dose tango intervention for people with Parkinson's disease (PwPD). Adv Integr Med 2021; 8(4): 272-7.
20. Tillmann AC, Swarowsky A, Correa CL, et al. Feasibility of a Brazilian samba protocol for patients with Parkinson's disease: a clinical non-randomized study. Arq Neuropsiquiatr 2020; 78(1): 13-20.
21. Valverde-Guijarro E, Alguacil-Diego IM, Vela-Desojo L, et al. Effects of contemporary dance and physiotherapy intervention on balance and postural control in Parkinson's disease. Disabil Rehabil 2022; 44(12): 2632-9.
22. Walton L, Domellof ME, Astrom AN, et al. Digital Dance for People With Parkinson's Disease During the COVID-19 Pandemic: A Feasibility Study. Front Neurol 2021; 12: 743432.

Music therapy (n=3 publications, 3 studies)

1. Bastepe-Gray S, Wainwright L, Lanham DC, et al. GuitarPD: A Randomized Pilot Study on the Impact of Nontraditional Guitar Instruction on Functional Movement and Well-Being in Parkinson's Disease. Parkinsons Dis 2023; 2022: 1061045.
2. Pohl P, Wressle E, Lundin F, et al. Group-based music intervention in Parkinson's disease-findings from a mixed-methods study. Clin Rehabil 2020; 34(4): 533-44.
3. Shah-Zamora D, Anderson S, Barton B, et al. Virtual Group Music Therapy for Apathy in Parkinson's Disease: A Pilot Study. J Geriatr Psychiatry Neurol 2024; 37(1): 49-60.

Singing (n=10 publications, 8 studies)

1. Brooks C, Porter DB, Furnas D, et al. The effects of therapeutic group singing on voice, cough and quality of life in Parkinson's disease. Clinical Archives of Communication Disorders 2021; 6(2): 79-88.
2. Butala A, Li K, Swaminathan A, et al. Parkinsonics: A Randomized, Blinded, Cross-Over Trial of Group Singing for Motor and Nonmotor Symptoms in Idiopathic Parkinson Disease. Parkinsons Dis 2022; 2022: 4233203.
3. Good A, Earle E, Vezer E, et al. Community Choir Improves Vocal Production Measures in Individuals Living with Parkinson's Disease. J Voice 2023; e-pub ahead of print, https://doi.org/10.1016/j.jvoice.2022.12.001.
4. Lee SJ, Dvorak AL, Manternach JN. Therapeutic Singing and Semi-Occluded Vocal Tract Exercises for Individuals with Parkinson's Disease: A Randomized Controlled Trial of a Single Session Intervention. J Music Ther 2024; e-pub ahead of print, https://doi.org/10.1093/jmt/thae004.
5. Lewellen R, Meyer D, Van Leer E. The effects on acoustic voice measures and the perceived benefits of a group singing therapy for adults with Parkinson's disease. Australian Voice 2020; 21: 39-48.
6. Stegemöller EL, Diaz K, Craig J, et al. The Feasibility of Group Therapeutic Singing Telehealth for Persons with Parkinson's Disease in Rural Iowa. Telemed J E Health 2020; 26(1): 66-70.
7. Stegemöller EL, Zaman A, Shelley M, et al. The Effects of Group Therapeutic Singing on Cortisol and Motor Symptoms in Persons With Parkinson's Disease. Front Hum Neurosci 2021; 15: 703382.
8. Stegemoller EL, Forsyth E, Patel B, et al. Group therapeutic singing improves clinical motor scores in persons with Parkinson's disease. BMJ Neurol Open 2022; 4(2): e000286.

9. Stegemoller E. Sing a new song: Results from research on group therapeutic singing for people with Parkinson's disease [Abstract]. J Parkinsons Dis 2023; 13(S1): 156.
10. Tamplin J, Morris ME, Marigliani C, et al. ParkinSong: Outcomes of a 12-Month Controlled Trial of Therapeutic Singing Groups in Parkinson's Disease. J Parkinsons Dis 2020; 10(3): 1217-30.

Theatre (n=1 publication, 1 study)

1. Bega D, Palmentera P, Wagner A, et al. Laughter is the best medicine: The Second City improvisation as an intervention for Parkinson's disease. Parkinsonism Relat Disord 2017; 34: 62-65. Identified through citation chasing of February 2024 search results.

February 2025 search

Total = 6 publications (6 unique studies)

Dance

1. Haas AN, Smith T, Peyre-Tartaruga LA, et al. Can dance improve turning in people with Parkinson's disease? J Dance Med Sci 2024; 28(3): 179-89.
2. Kristen L, Ziegert K, Karlsson P, et al. The impact of Dance for Parkinson's Disease on subjective well-being and functioning as experienced by dancers and their relatives - A descriptive study. J Bodyw Mov Ther 2024; 40: 520-4.
3. Kunte T, Barretto M, D'souza N. The effects of a culturally informed community-based dance movement therapy programme for persons with Parkinson's disease in India. Body Mov Dance Psychother 2024; 19(3): 268-87.
4. Mehta A, Dugani P, Mahale R, et al. Garba dance is effective in Parkinson's disease patients: a pilot study. Parkinsons Dis 2024; 2024: 558068.

Music therapy

1. Wainwright L, Kang K, Dayanim G, et al. Drumming-PD/HD: The impact of a pilot group drumming-based music therapy intervention on people living with Parkinson's disease and Huntington's disease and their caregivers. Nord J Music Ther 2024; doi: 10.1080/08098131.2024.2435875.

Singing

1. Tamplin J, Haines SJ, Baker FA, et al. ParkinSong online: feasibility of telehealth delivery and remote data collection for a therapeutic group singing study in Parkinson's. Neurorehabil Neural Repair 2024; 38(2): 122-33.

Theatre

None.

Supplementary file 7. Full list of full text excluded studies with reasons

Barnish & Barran (2020) search

We are using the Barnish & Barran (2020) search for articles published prior to February 2020. Due to the age of this search and computer systems changes in the meantime, the Endnote library is no longer available, so we must rely on publicly available information. This is common when updating systematic reviews. Barnish & Barran (2020) did not publish a full list of excluded studies. The Barnish & Barran (2020) paper states that 32 articles were excluded at the full text stage for intervention, 17 for methodology, 8 for abstracts, 3 for publication type (abstracts published more than two years before the search), 1 for population, and 1 duplicate.

February 2024 search

Total = 38.

Duplicate (n=3)

1. Amaro Moratelli et al. An Exploratory Study on the Effect of 2 Brazilian Dance Protocols on Motor Aspects and Quality of Life of Individuals with Parkinson's Disease. J Dance Med Sci 2023; 27(3): 153-9.
2. Amaro Moratelli et al. Dance Rhythms Improve Motor Symptoms in Individuals with Parkinson's Disease: A Randomized Clinical Trial. J Dance Med Sci 2022; 26(1): 2-7.
3. Irons et al. Group singing improves quality of life for people with Parkinson's: an international study. Aging Ment Health 2021; 25(4): 650-6. Duplicates a study from the 2020 review (was originally included in e-pub ahead of print form).

The two 'Amaro Moratelli' duplicates made it through to full-text screening because they were incorrectly indexed in the online bibliographic databases we searched – they were both 'Moratelli' papers. The duplicates were identified during full-text screening and excluded.

Intervention (n=13)

1. Arontes et al. Music therapy improves strength and gait in Parkinson's disease patients: A pilot study and clinical case analysis [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 156-7.
2. Bragstad et al. The OPTIM-PARK project: A feasibility study assessing acceptability and feasibility of a cross-national multisectoral intervention for people affected by Parkinson's disease [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 352-3.
3. Cassidy et al. Rhythmic connections: A pilot interdisciplinary music therapy group programme for people with Parkinson's in a day hospital. Age Ageing 2023; 52 (Suppl 3): iii30.
4. Cohen et al. Multidisciplinary intensive outpatient rehabilitation program for patients with moderate-to-advanced Parkinson's disease. Neurorehabiliation 2021; 49(1): 47-55.
5. Ettinger et al. Art therapy as a comprehensive complementary treatment for Parkinson's disease. Front Human Neurosci 2023; 17: 1110531.
6. Feldman et al. The impact of three distinct exercise types on fatigue, anxiety, and depression in Parkinson's disease. Mov Disord Clin Pract 2020; 7 (Suppl 1): S54-5.
7. Fodor et al. Music as add-on therapy in the rehabilitation program of Parkinson's disease patients-a Romanian pilot study. Brain Sci 2021; 11(5): 569.
8. Gondo. Immediate effects of music therapy on gait disturbance in Parkinson's disease, and possibility to reduce the risk of freezing by analyzing the trajectory of center of body [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 213.
9. Mohseni Z, Mohamadi R, Habibi SAH, et al. Voice improvement following conventional speech therapy combined with singing intervention in people with Parkinson's disease: A three-arm randomised controlled trial. Int J Lang Commun Disord 2023; 58(5): 1752-67.
10. Mohseni Z, Saffarian A, Mohamadi R, et al. Effect of Conventional Speech Therapy Combined with Music Therapy on Swallowing in Patients with Parkinson's Disease (Telerehabilitation): A Randomized-Controlled Trial. Middle East J Rehabil Health Stud 2023; 10(1): e131572.
11. Park. Say "AH~": Vocal Analysis in Parkinson's Disease and Essential Tremor [Abstract]. Mov Disord 2020; 35 (Suppl 1): S139-40.

12. Rieders et al. Remote Art Therapy is feasible and may benefit individuals with Parkinson's disease. Mov Disord 2021; 36(Suppl 1): S192.
13. Shah et al. Effect of physical therapy with music therapy on gait, balance and quality of life in Parkinson's disease. Ind J Public Health Res Dev 2020; 11(6): 1064-9.

Outcomes (n=11)

1. Barnstaple et al. Dancing modifies activations in brain regions associated with movement, mood and reward in people with Parkinson's [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 316-7.
2. Barnstaple et al. Weekly dance training over eight months reduces depression and correlates with fMRI brain signals in subcallosal cingulate gyrus (SCG) for people with Parkinson's Disease: An observational study. bioRxiv 2022; 18: doi: https://doi.org/10.1101/2022.10.14.512180.
3. Bek et al. Moving online: Experiences and potential benefits of digital dance for older adults and people with Parkinson's disease. PLoS ONE 2022; 17(11): e0277645.
4. Bek et al. Modulation of neural activity in response to dance training in Parkinson's: a case study [Abstract]. J Parkinsons Dis 2023; 12 (Suppl 1): 136.
5. Hadley et al. "Dance Like Nobody's Watching": Exploring the Role of Dance-Based Interventions in Perceived Well-Being and Bodily Awareness in People With Parkinson's. Front Psychol 2020; 11: 531567.
6. Moratelli JA, Alexandre KH, Boing L, et al. Effects of binary dance rhythm compared with quaternary dance rhythm in fatigue, sleep, and daily sleepiness of individuals with Parkinson's disease: A randomized clinical trial. Motriz Rio Claro 2022; 28: e10220020621.
7. Morris et al. Dancing for Parkinson's Disease Online: Clinical Trial Process Evaluation. Healthcare (Basel) 2023; 11(4): 604.
8. Morris et al. Online Dance Therapy for People With Parkinson's Disease: Feasibility and Impact on Consumer Engagement. Neurorehabil Neural Repair 2021; 35(12): 1076-87.
9. Pandya. Dance movement therapy, yoga, and older adults with parkinson's disease: Balance confidence, anxieties, and wellbeing. Body Mov Dance Psychother 2023; e-pub ahead of print, doi:10.1080/17432979.2023.2242444.
10. Robichaud. Evaluating dancing with Parkinson's (DWP) online dance classes [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 146.
11. Sistarelli et al. Effects of Popping For Parkinson's dance class on the mood of people with Parkinson's disease. Int J Ther Rehabil 2023; 30(2): 1-12.

Study design/article type (n=11)

1. Brierley. Live well with Parkinson's through connective dance/movement practices that promote changing flow states [Abstract]. J Parkinsons Dis 2023; 13 (Suppl 1): 339.
2. Delabary et al. Brazilian dance self-perceived impacts on quality of life of people with Parkinson's. Front Psychol 2024; 15: 1356553.
3. Emmanouilidis et al. Dance Is an Accessible Physical Activity for People with Parkinson's Disease. Parkinsons Dis 2021; 2021: 7516504.
4. Gyrling et al. The impact of dance activities on the health of persons with Parkinson's disease in Sweden. Int J Qual Stud Health Wellbeing 2021; 16(1): 1992842.
5. Hasan SM, Alshafie S, Hasabo EA, et al. Efficacy of dance for Parkinson's disease: a pooled analysis of 372 patients. J Neurol 2022; 269(3): 1195-208.
6. Koh & Noh. Tango therapy for Parkinson's disease: Effects of rush elemental tango therapy. Clin Case Rep 2020; 8(6): 970-7.
7. Mondolfi et al. Designing short-term drama therapy with people who have Parkinson's disease in Vigo, Spain. Drama Ther Rev 2021; 7(1): 37-59.
8. Morris. Dance as Rehabilitation for Parkinson's Disease. Neuroepidemiology 2022; 56 (Suppl 1): 52.
9. Pinto et al. Feasibility of dance therapy through synchrony videoconference in Parkinson's disease and elderly people [Abstract]. Mov Disord 2021; 36(Suppl 1): S190-1.
10. Shams et al. Feasibility of the basic movements of Azeri dance in the balance and posture of a person with Parkinson's disease: ABA single-subject design. Int J Ther Rehabil 2021; 28(12): 1-8.

11. Shokhimardonov & Shakhnoza. Impacts of classical music and dancing on cognitive functions in Parkinson's disease [Abstract]. J Neurol Sci 2021; 429 (Suppl): 119517. Insufficient information to assess method.

February 2025 search

Total = 1

Intervention n=1

1. Brown & Stegemoller. Therapeutic singing and expiratory muscle strength training in Parkinson's disease: a mixed methods comparison. Front Rehabil Sci 2024; 5: 1478490

Supplementary file 8. Study characteristics

Rows for studies included in the Barnish & Barran (2020) were originally published in the Barnish & Barran (2020) paper.[5] This paper is open access (Creative Commons Attribution 4.0 International License) and the copyright rests with the authors. The corresponding author – Dr Barnish – who is also the corresponding author of this manuscript – grants permission for the replication of these rows to aid clarity of reporting.

Barnish & Barran 2020 search

First Author, year	Country	Design	Participants	Inclusion criteria	Outcomes
Dance					
Allen, 2017; McKay, 2016	USA	Single group repeated measures study.	22 (7 male, mean age 65). Recruited at outreach events, day centres and/or care homes for senior citizens, and an outpatient movement disorders clinic.	IPD (Racette criteria). H&Y 1-4 ABC 4-35. No DBS, significant comorbidities or significant musculoskeletal impairment.	UPDRS-motor, dyskinesia, BBS, DGI, FABS, two-footed jump test, 6MWT, functional reach, single/dual TUG, gait analysis, ABC, FOG and response to perturbation.
Batson, 2010	USA	Single group repeated measures study.	11 (6 male, mean age 73). Convenience sample from a wellness centre at a teaching hospital.	IPD. Ages 50-85. Living independently in the community. No other neurological, cognitive or hearing problems.	TUG and FABS.
Batson, 2014	USA	Single group repeated measures study.	7 (2 male, mean age 67). Recruited from local area support groups and doctors.	NS.	FABS and TUG (including cognitive).
Bearss, 2017	Canada	Single group repeated measures study.	9 (5 male, mean age 68). Members of a new Dancing with Parkinson's Program at NBS.	NS.	BBS, TUG, Oregon QoL, Westheimer QoL and Heiberger QoL.

Blandy, 2015	Australia	Single group repeated measures study.	6 (3 male, mean age 64). Recruited from local and national PD support groups and movement disorder clinics.	IPD by neurologist. H&Y 1-3. Living in the community. Age 18-75. Medically safe to participate. MMSE ≥24.	EQ-5D.
Clifford, 2017	UK	Single group repeated measures study (service evaluation).	7 (1 male, mean age 70). Recruited via local newspapers, local PD specialist services and a hospice.	PD.	PDQ-39.
De Natale, 2017	Italy	Non-randomised controlled trial.	16 (11 male, mean age 68). Recruited consecutively, but source NS.	PD (Gelb criteria). Responder to levodopa. MMSE >25.	UPDRS, BBS, DGI, TUG, 4SST, 6MWT, FAB, Stroop Test and TMT.
Duncan, 2014	USA	Randomised controlled trial.	10 (8 male, mean age 66). Recruited through a university movement disorders centre.	PD. Age ≥40. Receiving levodopa. No other serious medical condition.	MDS-UPDRS, Mini-BEST, gait analysis, TUG, 6MWT and FOG.
Duncan, 2012; Foster, 2013	USA	Randomised controlled trial.	52 (30 male, mean age 69). Recruited through a university movement disorders centre and	PD. H&Y 1-4. No other serious medical condition. Willing to miss doses for assessment.	MDS-UPDRS, Mini-BEST, gait analysis, FOG, 9HPT and ACS.

			advertisements in a local PD newsletter.		
Hackney, 2007 a,b	USA	Randomised controlled trial.	19 (12 male, mean age 71). Recruited from a university movement disorders centre. There were additionally age- and gender-matched 19 controls without PD.	PD (Racette criteria). No other serious medical conditions. Vision corrected to 20/40 or better. Stand independently ≥30 minutes and walk independently ≥3m. MMSE >25.	ABC, mFES, functional reach, OLST, gait analysis, UPDRS, BBS and TUG.
Hackney, 2009 a,b,c	USA	Randomised controlled trial	61 (45 male, mean age 66). Community recruitment, including through a university movement disorders centre, local support groups and local community events.	IPD. Age ≥40. Stand ≥ 30 minutes and walk independently ≥3m. H&Y 1-3. No other neurological conditions. Benefit from levodopa. No serious uncorrected hearing or vision problems.	UPDRS-motor, BBS, TUG, 6MWT, FOG, gait analysis and PDQ-39.
Hackney, 2010	USA	Randomised trial.	39 (28 male, mean age 70). Community recruitment, including through a university movement disorders centre, local support groups and local community events.	IPD. H&Y 1-3. No other neurological conditions. Age ≥40. Stand ≥30 minutes and walk independently ≥3m. Benefit from levodopa.	BBS, tandem stance, one leg stance, TUG, 6MWT and gait analysis.

Hackney, 2018	USA	Randomised controlled trial.	83 (gender NS, mean age 70). Recruitment route NS.	PD.	6MWT, Corsi Blocks, MDS-UPDRS, ToL and PDQ-39.
Hashimoto, 2015	Japan	Randomised controlled trial.	46 (12 male, mean age 66). Recruitment through local PD associations.	PD. Living at home. Walk independently. Able to dance or exercise for an hour.	BBS, TUG, FAB, MRT and UPDRS.
Heiberger, 2011	Germany	Single group repeated measures study.	11 (5 male, mean age 71). Recruitment route NS.	Moderate to severe PD according to ICD-10 criteria.	UPDRS, TUG, Semitandem Test, Westheimer QoL and Oregon QoL.
Hulbert, 2017; Kunkel, 2017	UK	Randomised controlled trial.	51 (25 male, mean age 71). Recruited through PD support networks, consultants, regional research networks, newspaper advertisements and word of mouth.	PD by consultant. H&Y 1-3. Following commands and remember instructions. No uncorrected visual or hearing impairments. No other neurological conditions.	Standing start 180 TT, BBS, Spinal mouse, ABC, 6MWT, TUG and PDQ-39.
Kalyani, 2019	Australia	Non-randomised controlled trial.	33 (13 male, mean age 65). Recruited through local PD support groups and websites, radio advertisements, an existing PD dance class and a university email list.	IPD (self-reported clinical diagnosis). Age 40-85. H&Y 1-3. ACE >82. No other serious medical conditions. Walk independently >3m.	NIH-COG, TMT, MDS-UPDRS ADL and PDQ-39.

Koch, 2016	Germany	Single group repeated measures study.	34 (8 male, mean age 61). Recruited through local PD support groups.	PD.	HSI and BSE.
Lee, 2018	South Korea	Randomised controlled trial.	32 (17 male, mean age 66). Recruited from a Korean Medicine hospital.	PD by neurologeon. Age 50-80. H&Y 3. No other neurological or cognitive conditions. No exercise therapy within 3 months.	UPDRS, PDQL and BBS.
McGill, 2019	UK	Non-randomised controlled trial.	32 (15 male, mean age 72). Intervention group recruited from an ongoing PD dance class. Control group recruited from local PD support groups and family members of intervention group.	PD. Age >55. No dementia (MMSE). Walk independently. No recent back surgery. No DBS.	Gait analysis and ABC.
McKee, 2013	USA	Non-randomised controlled trial.	33 (20 male, mean age 68 intervention and 74 controls). Recruited through flyers, referral, PD newsletters, PD support groups and websites.	IPD (Racette criteria). Aged over 50. H&Y 1-3. Benefit from PD. No other neurological conditions. Walk ≥3m.	MoCA, Reverse Corsi Blocks, BST, BBS, CPF and UPDRS motor.
McNeely, 2015	USA	Non-randomised trial.	22 (8 male, mean age 67). Recruited from a	PD by neurologist e.g. Racette criteria. Benefit from	MMSE, MDS-UPDRS motor, Mini-BEST, 6MWT,

			university movement disorders centre.	levodopa. Stand independently for 30 minutes. No evidence of dementia (MMSE ≥26). No other serious medical conditions for DBS. No recent surgery or injuries affecting movement.	5TSS, 4SST, gait analysis, TUG, and PDQ-39.
McRae, 2018	USA	Single group repeated measures study.	61 (21 male, mean age 67). Recruited from well- established Dance for Parkinson's Disease classes.	People with PD.	8-item self-efficacy scale adapted from Lorig and a single item from SF-36.
Marchant, 2010	USA	Single group repeated measures study.	11 (7 male, mean age 71). Recruited from a university movement disorders centre and from the local area.	IPD (Racette criteria). Benefit from PD medication. Visual acuity of 20/40 with or without correction. Walk 3 m and stand 30 minutes. Normal somatosensory function in the feet. No other serious medical conditions.	UPDRS motor, BBS, TUG, 5TSS, 6MWT, gait analysis, FOG, ABC and PDQ-39.
Michels, 2018 a,b	USA	Randomised controlled trial.	13 (6 male, mean age 69). Recruited from a university movement disorders centre.	IPD by movement disorders expert. Stable medication regimen, no recent	H&Y, MDS- UPDRS, BBS, TUG, MoCA and PDQ-39.

				therapeutic dance or new PD treatments. MoCA ≥24.	
Patel, 2018	USA	Randomised controlled trial.	36 (25 male, mean age 68). Recruitment route NS.	PD. Experienced off time on the MDS-UPDRS medication-related motor fluctuation.	MDS-UPDRS-motor and medication- related motor fluctuations. Cognition and psychosocial function (tools NS).
Prewitt, 2017	USA	Single group repeated measures study.	6 (3 male, age range 62-87, mean NS). Recruited through routes including a local PD support group.	PD by physician. H&Y 1-3.	SCOPA-COG, S&E ADL, S&E ADL and GSE.
Rawson, 2019	USA	Non-randomised controlled trial.	74 in analysis (40 male, mean age 67)	IPD (Racette criteria). Age ≥30. Benefit from levodopa. H&Y 1-4. Walk 3m. No history of vestibular disease or dementia.	Gait analysis, Mini-BEST, MDS-UPDRS motor, H&Y, 6MWT and PDQ-39.
Rocha, 2018	Australia	Randomised trial.	21 (8 male, mean age 72). Recruited through PD support groups and medical clinics.	IPD. Modified H&Y 1-4. Stand ≥2 minutes. Walk independently ≥3m. Medical approval. MMSE ≥24. No comorbidities preventing exercise. No DBS.	Modified TUG, BBS, FGA, FOG, MDS-UPDRS and PDQ- 39.

Romenets, 2015	Canada	Randomised controlled trial.	33 (19 male, mean age 63). Recruitment from a regional PD website and from a local movement disorders clinic.	IPD. H&Y 1-3. Stand ≥30 minutes. Walk ≥3 m. No dementia (MDS criteria), no severe hearing and vision problems, no change in PD medication in the past 3 months, no serious medical conditions or >3 falls in the past 12 months.	MDS-UPDRS motor and medication- related motor fluctuations, Mini- BEST, TUG, CCH, FOG, Purdue Pegboard, MoCA, and PDQ-39 – all in English or French..
Shanahan, 2017	Ireland	Randomised controlled trial.	41 in analysis (26 male, mean age 69). Recruited through clinicians and voluntary groups.	IPD. Modified H&Y 1-2.5. Walk 3m. No serious medical conditions or hearing problem.	UPDRS motor, 6MWT, Mini-BEST and PDQ-39.
Shanahan, 2015	Ireland	Single group repeated measures study.	9 (7 male, mean age 66). Recruited through public talks.	IPD. Modified H&Y 1-2.5. Walk 3m. No serious medical conditions or hearing problem.	UPDRS motor and PDQ-39.
Solla, 2019	Italy	Randomised controlled trial.	20 (13 male, mean age 67). Recruited from a hospital outpatient clinic.	PD (Gelb criteria). H&Y <=3. Walk independently. Stable medication regimen for 4 weeks. MMSE >=24. No recent falls or history of other serious medical conditions.	UPDRS motor, 6MWT, BBS, TUG, 5TSS, back scratch, sit and reach, gait analysis and MoCA.

Ventura, 2016	USA	Non-randomised controlled trial.	15 (2 male – both in control group, mean age 71). Intervention group recruited from an existing PD dance program. Control group recruited from community-led PD support groups.	PD (self-reported diagnosis, not atypical). Aged 55-80. No previous dance experience, other serious medical conditions. MMSE ≥ 25.	TUG, TGST, SBT, TEA, FES-I, VET, AF, AUT, WDS and PDQ-39.
Volpe, 2013	Italy	Randomised controlled trial.	24 (13 male, mean age 63). Recruited from a local PD association.	IPD by doctor. H&Y 0-2.5. No comorbidities that prevent dancing, mobility or safe exercise. No DBS.	UPDRS motor, TUG, BBS, modified FOG and PDQ-39.
Westbrook, 1989	USA	Non-randomised crossover study.	37 (group 1: 86% male, mean age 73, group 2: 40% male, mean age 70). Recruited from a local PD association.	PD.	Movement initiation.
Westheimer, 2015	USA	Single group repeated measures study.	12 (6 male, mean age 66). From a PD dance class, to which recruitment was through referral by other patients and from neurologists.	IPD by movement disorders specialist. H&Y 1-4. Age ≥ 30. Mobility with or without assistance. Ability to consent. Medical clearance.	H&Y, UPDRS motor, BBS and PDQ-39.
Zafar, 2017	USA	Non-randomised controlled trial.	35 (22 male, mean age 69). Recruited through flyers, referral, PD	IPD (Racette criteria). Benefit from PD medication.	IPA.

			newsletters, support groups and websites in the local area. There were additionally 74 older adults without PD.		
Music therapy					
Pacchetti, 2000	Italy	Randomised controlled trial	32 (23 male, mean age 63). Recruitment route NS.	IPD. Benefiting from PD medication. H&Y 2-3. No cognitive impairment, visual or auditory deficits or other conditions affecting movement.	UPDRS and PDQ- 39.
Pantelyat, 2016	USA	Non-randomised controlled trial	18 (7 male, mean age 71). Recruitment route from drum circle NS. Controls were recruited from an outpatient clinic.	IPD (Brain Bank criteria) and MDS-UPDRS motor. Having objective bradykinesia. Able to consent. Walk and stand, and to sit for 45-60 minutes.	MDS-UPDRS, TUG, PST, MoCA and PDQ-39.
Pohl, 2013	Sweden	Randomised controlled trial	18 (8 male, mean age 68). Recruited from a local PD support group.	Diagnosis of PD (not secondary or atypical). Stable treatment regimen. Able to squat. Walk ≥10m. Correctable auditory and visual	UPDRS, TUG, motion analysis based on the Posturo- Locomotion-Manual method, Cognitive Assessment Battery

				capability. No colour blindness, severe depression or severe disability on UPDRS motor.	and PDQ-39
Spina, 2016	Italy	Randomised controlled trial	25 (gender NS, mean age 68 intervention, 62 control, overall mean age and n per group NS). Recruitment route NS.	PD (Hughes criteria). Mild disability. On stable treatment. No dementia, depression, serious comorbidity, treatment that would affect cognition.	MDS-UPDRS, FAB, and PDQ-39.
Singing					
Azekawa, 2018	USA	Single group repeated measures study	5 (3 male, mean age 71). Recruited from a local PD support group.	PD. H&Y score 1-3. Age >50. No co- morbidity with other neurological or cognitive impairments. English as native language.	Sustained vowel phonation test, diadochokinesis test, Rainbow Passage reading – vocal function, voice quality, articulatory control ability and connected speech intelligibility.
Di Benedetto, 2009	Italy	Single group repeated measures study	20 (13 male, mean age 66). Consecutive referrals from a single rehabilitation centre.	PD (Brain Bank criteria). No history of substance abuse, psychiatric illness or head injury. MMSE ≥24.	Maximum phonation time, acoustic data from sustained vowel /ɑ/ production, quality of voice

					analysis prosody and fatigue ratings.
Elefant, 2012a,b	Norway	Single group repeated measures study	10 (7 male, mean age 64). Recruited from the neurology clinic of a single hospital.	PD. Stable levodopa response. H&Y score 2 or 3.	Fluency and acoustic data taken from a spoken passage and VHI. Facial expressions.
Evans, 2012	UK	Single group repeated measures study	17 (11 male, mean age 67). Recruited from the caseload of a county PD nurse specialist.	PD by doctor. Not requiring clinical assistance during the session (unless a carer willing to attend).	FDA and PDQ-39.
Higgins, 2019	USA	Single group repeated measures study	10 (5 male, mean age 74). Recruited from a local PD support group.	Hypokinetic dysarthria secondary to IPD. Native speaker of Standard American English. Normal cognition. No depression or neurological comorbidity. No voice therapy within 12 months.	VSA and SIT.
Irons, 2020,2019	Australia, UK and South Korea	Single group repeated measures study	95 (43 male, mean age 70). Convenience sample recruited through PD support groups, social networks and radio advertising.	PD. No cognitive impairment.	PDQ-39.

Matthews, 2018	New Zealand	Randomised controlled trial	Sample size, characteristics and recruitment method NS.	NS.	Phonatory measures, PDQ-39 and cognitive function (tool NS).
Shih, 2012	USA	Single group repeated measures study	13 (11 male, mean age 66). Recruitment route NS.	PD (Brain Bank criteria). H&Y 1-5, >8 and MMSE ≥24. No other voice therapy or involvement in other singing g	Acoustic data from Rainbow Passage and cookie theft picture description, VHI and VRQoL.
Stegemöller, 2017a,b	USA	Two group repeated measures study	27 (10 male, median age 69 in 'low dosage' group and 64 in 'high dosage' group). Recruitment method NS.	IPD. Non-smoking. Stable medication regimen. No other serious medical conditions. MMSE ≥24. Beck ≥1	Voice measures, UPDRS, SWAL-QoL, VRQoL and WHO-QoL.
Tamplin, 2019,2018	Australia	Non-randomised controlled trial	75 (46 male, mean age 74). Recruited from local PD support groups.	PD by neurologist (MDS criteria). MMSE ≥27. No memory problems, severe language difficulties or hearing impairment.	Voice, speech and VRQoL.
Tanner, 2016	Canada	Single group repeated measures study	28 (14 male, mean age 65). Recruited from community groups.	PD by neurologist, H&Y≤3 and sufficient skills to participate.	Acoustic data including from spontaneous monologue and reading Grandfather Passage.

Yinger, 2016	USA	Single group repeated measures study	10 (7 male, mean age 70). Convenience sample.	PD. Not reporting medication change during study.	Acoustic data from Rainbow Passage.
Theatre					
Mirabella, 2017	Italy	Non-randomised controlled trial	24 (10 male, mean age 60). Recruited from hospital clinics and local PD associations.	IPD, H&Y 2-4, on a stable medication regimen. MMSE >24. Absence of severe sensory deficit or motor disability.	UPDRS, GFQ, S&E, PDQ-39 and a neuropsychological battery.
Modugno, 2010	Italy	Randomised controlled trial	20 (10 male, mean age 63). Recruited from hospital outpatient clinics.	IPD, H&Y 2-4, on a stable medication regimen. No severe visual or auditory deficits or movement dysfunctions.	UPDRS, S&E and PDQ-39.

ABC = Activities-specific Balance Confidence scale (Powell & Myers, 1995), ACE = Addenbrooke's Cognitive Examination (Mathuranath, Nestor, Berrios, Rakowicz, & Hodges, 2000), ACS = Activity Card Sort (Baum & Edwards, 2008), ADL = Activities of Daily Living, AF = action fluency, AUT = Alternative Uses Test (Guilford, 1967), Beck = Beck Depression Inventory (Beck, 1972), BBS = Berg Balance Scale (Berg, Wood-Dauphinée, Williams, & Gayton, 1989), Brain Bank criteria = UK Parkinson's Disease Society Brain Bank criteria (Gibb & Lees, 1988), BSE = Body Self-Efficacy, BST = Brooks Spatial Test (Brooks, 1967), CCH = Canadian Community Health Survey Falls Questionnaire – Health Ageing adapted (Statistics Canada, 2008), CPF = Composite Physical Function Index (Rikli & Jones, 2001), DGI = Dynamic Gait Index (Shumway-Cook & Woollacott, 1995), DBS = deep brain stimulation, EQ-5D = EuroQol 5 Dimensions Quality of Life scale (EuroQol Group, 1990), FAB = Frontal Assessment Battery (Dubois, Slachevsky, Litvan, & Pillon, 2000), FABS = Fullerton Advanced Balance Scale (Rose, Lucchese, & Wiersma, 2006), FDA = Frenchay Dysarthria Assessment (Enderby, 1983), FES-I = Falls Efficacy Scale – International (Yardley et al, 2005), FGA = Functional Gait Assessment (Wrisley, Marchetti, Kuharsky, & Whitney, 2004), FOG = Freezing of Gait questionnaire (Giladi et al, 2000), Gelb criteria = Gelb, Oliver, & Gilman, 1999, GFQ = Gait and Falls Questionnaire, GSE = General Self-Efficacy, Heiberger QoL = Heiberger et al (2011) Quality of Life Scale, HSI = Heidelberg State Inventory (Koch et al, 2016), Hughes criteria = Hughes, Daniel, Kilford, & Lees, 1992, H&Y = Hoehn and Yahr staging (Hoehn & Yahr, 1967); IPA = Impact on Participation and Autonomy questionnaire (Sibley et al, 2006), IPD = idiopathic Parkinson's disease, Lorig = Lorig, Chastain, Ung, Shoor, & Holman, 1989, MDS = Movement Disorders Society, MDS-UPDRS = Movement Disorders Society sponsored revision of the Unified Parkinson's Disease Rating Scale (Goetz et al, 2008), mFES = Modified Falls Efficacy Scale (Edwards & Lockett, 2008), Mini-BEST – Mini Balance Evaluation Systems Test (Franchignoni, Horak, Godi, Nardone, & Giordano, 2010), MMSE = Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975), MoCA = Montreal Cognitive Assessment (Nasreddine et al, 2005), MRT = Mental rotation test, NBS = National Ballet School, NIH-COG = National Institutes of Health Toolbox Cognition Battery (Weintraub et al, 2013), NS = not stated, OLST = One leg stand test, Oregon QoL = Oregon Health and Sciences University Quality of Life scale (Bearss, McDonald, Bar, & DeSouza, 2017), PD = Parkinson's disease, PDQ-39 = Parkinson's Disease Questionnaire – 39 Items (Peto, Jenkinson, Fitzpatrick, & Greenhall, 1995) , PDQL = Parkinson's Disease Quality of Life questionnaire (de Boer, Wijker, Speelman, & de Haes, 1996), PST = Postural sway test, Racette criteria = Racette, Rundle, Parsian, & Perlmutter (1999), SBT = Standing balance test, S&E = Schwab & England (Schwab & England,1969), SCOPA-COG = SCales for Outcomes in PArkinson's disease-COGnition (Marinus et al, 2003), SF-36 = 36-Item Short Form Health Survey (Saris-Baglama et al, 2017), SIT = Sentence Intelligibility Test (Yorkston, Beukelman, & Tice, 1996), SLT = Speech and Language Therapy/ist, SWAL-QoL = Swallow-Related Quality of Life (McHorney et al, 2002), TEA = Test of Everyday Attention (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994), TGST = Timed gait speed test, TMT = Trail Making Test (Army Individual Test Battery, 1944), ToL = Tower of London (Shallice, 1982), TUG = Timed Up and Go (Podsiadlo & Richardson, 1991), UPDRS = Unified Parkinson's Disease Rating Scale (Fahn, Elton, & UPDRS Program Members, 1987), VET = Visual elevator test, VHI = Voice Handicap Index (Jacobson et al, 1997), VRQoL = Voice-Related Quality of Life (Hogikyan & Sethuraman, 1999), VSA = Vowel space area, WDS = Wechsler Digit Span (Wechsler, 1997), Westheimer QoL = Westheimer (2008) Quality of Life Scale, WHO-QoL = World Health Organization Quality of Life scale (WHOQOL Group, 1994), 4SST = Four square step test, 5TSS = Five times sit to stand, 6MWT = Six minute walking test, 9HPT = Nine hole peg test, 180 TT = 180 degrees turn test.

February 2024 search

First author, year	Country	Design	Participants	Inclusion criteria	Outcomes
Dance					
Bouquiaux, 2022	Belgium	Non-randomised controlled trial.	14 (8 male, mean age 68 intervention, 65 control). Recruitment method not stated.	Diagnosis of PD, able to stand and walk for 6 minutes without help, no premorbid neurological, cardiovascular, psychological disorders. No uncorrected visual issues. Able to hear music. No surgery affecting motor function in past 6 months. Attending at least 80% of sessions.	Tinetti test, 10-metre test, 6MWT, fingertip-to-floor test, MoCA.
Delabary, 2020	Brazil	Non-randomised controlled trial.	18 (7 male, mean age 69 intervention, 64 control). Recruitment via social media, flyers in Parkinson's groups and health services and telephone calls using waiting lists for other Parkinson's activities.	PD diagnosed by neurologist (Queen Square Brain Bank criteria), H&Y staging 1-3, on anti-Parkinson drugs, able to walk independently, aged at least 50 years. No risk factors such as recent surgery, deep brain stimulation, other associated neurological or chronic diseases, missing more than 25% of classes or changing established exercise routine.	TUG, gait kinematic analysis.
Duarte, 2023	Brazil	Single group repeated measures study.	13 (5 male, mean age 66). Recruited through social media announcements.	Diagnosis of PD (UK Parkinson's Disease Society Brain Bank criteria), H&Y 1-3, physically able to participate. No other neurologic or neuropsychiatric conditions or comorbidities that are a	POMA, FAB, PDQ-39, MDS-UPDRS total.

				risk for physical activities.	
Feenstra, 2022	Netherlands	Longitudinal cohort study (single arm).	49 (18 male, mean age 68). Recruitment method NS.	PD diagnosis, able to follow instructions. No recent (<3 months) orthopaedic surgery or other neurological conditions affecting mobility.	Rosenberg self-esteem scale, PDQ-39, Activity-Specific Balance Confidence Scale, MDS-UDPRS part III.
Fisher, 2020	Canada	Single-arm repeated measures study.	11 (5 male, mean age 64 males, 68 females). Recruited from neurology outpatients in Montreal. One participant did not complete the study – it is not stated whether their data were analysed.	Mid-to-severe stage PD (H&Y 1.5 to 3).	BesTEST, MoCA, SCOPA-COG, TULIA, REMT. Administered in English or French as per participant preference.
Fontanesi, 2021	USA	Cross-over design with a single group	7 (gender NS, mean age 71). Active members of the Dance for Parkinson's disease community in Brooklyn, NY.	Diagnosis of PD or Parkinsonism. Age between 55 and 85. Able to understand and communicate in English.	BSE, 6MWT, TUG.
Frisaldi, 2021	Italy	Randomised controlled trial.	38 (23 male, mean age 61). Recruited through regional movement disorders centres in Turin.	Classified as mild PD, H&Y 1-2, MDS-UPDRS-III 1-32, on stable dopaminergic therapy for at least 4 weeks. No cognitive impairment, severe orthopaedic comorbidities, walking aids, or unable to guarantee presence for entire study period.	MDS-UPDRS-III total, upper, lower and axial body subscores, 6MWT, TUG, Mini-BESTest, NFOG-Q, MoCA, TUG-DT, PDQ-39, FESI-I.
Haas, 2024a	Brazil	Randomised controlled trial.	83 (50 male, mean age 72 dance, 68 Nordic walking, 67 deep-water exercise). Recruited from another study.	PD (London Brain Bank Criteria), aged over 50, H&Y 1-3, on regular anti-Parkinsonian drugs, able to walk independently and understand instructions, MoCA >=21, no lower limb surgery in the past year, deep-brain stimulation surgery, severe heart	TUG, MDRS-UPDRS-III, 6MWT, FES-I, Sit-to-stand, handgrip test, PDQ-39, MoCA.

				disease, uncontrolled hypertension, myocardial infarction within the past year, pacemaker, stroke, or other associated neurological diseases or gait disturbances.	
Haputhanthirige, 2023	Australia	Quasi-experimental parallel group pre-post design.	33 (13 male, mean age 65 intervention, 67 control). Note that there was a statistically significant difference in gender between the groups – those in the dance group were more likely to be female (p=0.013). Recruited from PD support groups in Queensland, advertising on the Parkinson's Queensland website, flyers at an existing Dance for Parkinson's class at Queensland Ballet, through the radio and the university email system.	Clinical diagnosis of PD (Racette criteria), age 40-85, H&Y I-III, no dementia (MoCA score >82), no other medical, neurological, musculoskeletal, cardiovascular or respiratory abnormalities, able to walk for at least 3m without an assistive device, on stable medication.	Dual tasks, spatiotemporal gait analysis.
Harrison, 2020	USA	Single-arm pilot study	10 (7 male, mean age 69). Recruited from a movement disorders clinic at a hospital in St Louis. Demographics table says n=10, while text says 11 completed (inconsistency).	Diagnosis of definite PD (Racette criteria), age above 30, no other neurological diagnoses, orthostatic hypotension, history of deep brain stimulation surgery, inability to stand independently for at least 30 minutes or dementia (MMSE >=24).	MDS-UPDRS-III, nFOGq, FHQ, LSQ, PDQ-39.
Jola, 2022	UK	Within-participants design (single-arm).	26 (11 male, mean age 71 for males and 72 for females). Recruited from six established dance programmes across the UK.	Diagnosed PD, age 50-84, average TUG time before intervention of at least one SD higher than age-matched general population.	TUG.

Lihala, 2021	India	Single-arm pre-post feasibility study.	9 (7 male). 6 completed study (median age 67). NS whether analysis was only conducted on completers.	Diagnosis of PD (UK Brain Bank criteria), age 40-80, H&Y 1-3, no severe auditory or visual impairment or uncontrolled arthritis. No uncontrolled medical or surgical conditions or previous experience of dance movement therapy.	MoCA total and subs-cores, PDQ-39 and sub-scores, H&Y, UPDRS III.
Moratelli, 2021, 2022	Brazil	Randomised trial.	31 (gender NS, mean age binary 68, quaternary 64). Recruited from local Parkinson's association in Santa Catarina.	Clinical diagnosis of PD (UK Brain Bank criteria), aged at least 40 years, stable dose and no medication change in past 2 weeks, no use for at least 3 months. No dementia (MMSE), no H&Y stage 5 PD, practice of other physical activity or exercise during intervention. Those who did not attend 75% of classes were excluded.	MDS-UPDRS-I, II,III, Mini-BESTest, FOG, TUG, MoCA, PDQ-39.
Moratelli, 2023	Brazil	Non-randomised trial	69 (34 male, mean age between 67 and 73 in each group). Individuals from the cities of Porto Alegre and Florianopolis were recruited through the Parkinson's Association of Santa Catarina, social media and institutions providing health services.	Clinical diagnosis of PD (London Brain Bank criteria), on stable medication, aged at least 40 years, able to follow verbal instructions for the tasks, no H&Y stage 5 (wheelchair user), recent surgical procedures, deep brain stimulation, other associated neurological conditions or inability to ambulate independently.	UPDRS-III, PDQ-39.
Park, 2023	USA	Single group repeated measures study.	6 (gender NS, mean age 71). Recruitment route NS. Also 5 general population controls.	PD. No further details.	PDQ-39, VHI, V-RQOL.
Peter, 2020	USA	Non-randomised controlled trial.	15 (gender and age NS). Recruited from balance disorders clinic in North	PD. No further details.	FAPS, UPDRS, PDQ-39, FOG.

			Florida. Those in the tango group were those who wanted to learn tango. There was also a group of general population tango controls.		
Pinto, 2023	Brazil	Non-randomised feasibility trial.	12 (2 male, mean age 69). Recruited from publicity on university media channels, social media, radio stations, and calls to nursing homes and PD associations nationwide. There were also 14 older adults without PD.	Diagnosis of PD (UK Brain Bank criteria), aged over 45, sufficient cognition to understand instructions (according to MMSE), on stable dopamine medication for at least 6 weeks, access to a portable device with internet connection, no severe visual or auditory difficulties, other neurological conditions, or several neuromuscular conditions.	SF-36, ABC, FTSTST, PDQ-8.
Rabinovich, 2021	Argentina	Within-participants pre-post study (single arm).	8 (gender and age NS). Recruited from the movement disorders section of a hospital in Buenos Aires.	Idiopathic PD (UK Parkinson's Society brain bank criteria). A profile of the participants is presented (in the methods), but no other inclusion criteria stated.	MDS-UPDRS-III, 15-item Likert scale questionnaire on motor and non-motor aspects.
Tillmann, 2020	Brazil	Non-randomised controlled trial.	20 (16 male, mean age 66). Recruited from the telephone list of a local Parkinson's association.	PD (London Brain Bank criteria), mild-to-moderate PD, living in "on" phase, aged at least 50, not danced for at least 3 months. Not participating in physical activity or exercise programmes, attending less than 75% of classes, insufficient cognitive status on MMSE, H&Y stage 5 or disabilities in daily or social life activities for reasons other than PD.	H&Y scale 18, UPDRS, BBS, PDQ-39, perceived change in PD symptoms.

Valverde-Guijarro, 2022	Spain	Within-participants A-B-A design.	27 (18 male, mean age 67). Recruited from the neurology unit of a hospital in Madrid.	IPD (UK Parkinson's Disease Society Data Bank criteria), H&Y 1-3, MMSE >=27, no other neurological, rheumatic or orthopaedic conditions affecting postural control, no fracture or recent surgery on upper or lower limbs or pre-surgery treatment for.	BBS, TUG, SOT, MCT, RWS.
Walton, 2022	Sweden	Single group within-participants design.	23 (6 male, mean age 70). Recruited from Dance for Parkinson's classes at the ballet academy in Stockholm.	Self-reported diagnosis. Member of Dance for Parkinson's disease class at the ballet academy in Stockholm. There was a registration fee for dance classes of 400 Swedish Kr ona (approximately £30).	PRMQ, two questions from MFS, PDQ-39.
Music therapy					
Bastepe-Gray, 2022	USA	Randomised controlled trial (stepped wedge cluster randomised)	24 (17 male, mean age 68 intervention, 67 control). Recruitment route NS.	Idiopathic PD (UK Brain Bank criteria). Absence of any other neurological disorder or injury that would affect the upper extremities and prevent participant or cause discomfort or pain. Required to score at least 17 on MoCA and be fluent in English. No recent experience of guitar lessons.	MDS-UPDRS, PPT, BPT, Q-DASH, PDQ-39.
Pohl, 2020	Sweden	Randomised controlled trial.	46 (32 male, mean age 70). Recruited from neurological clinics in Linköping.	Community-dwelling individuals aged 18 or older with a diagnosis of PD, H&Y up to stage 3, capacity to walk 10m unaided.	TUG (dual task), FES, PDQ-39, MoCA, 3 parts of CAB, MiniBEST, FOG.
Shah-Zamora, 2024	USA	Cohort study (single arm).	16 (15 male, mean age 68). Recruited from a university medical centre.	Clinical diagnosis of PD, age at least 18, primarily English-speaking, access to an electronic device	PDQ-8, SE-ADL, MoCA-B.

			in Chicago. 16 caregivers were also analysed.	with internet capabilities and current apathy (screened using ICD codes, confirmed using item 1.5 from MDS-UPDRS). No severe hearing or vision loss, diagnosis of atypical Parkinsonism, participation in music-based interventions in past 12 months, or lack of a caregiver.	
Singing					
Brooks, 2021	USA	Non-randomised controlled trial (prospective repeated measures design with control group)	19 (10 male, median age intervention 68, control 69). Recruited from local PD support groups and exercise classes in Florida.	Mild-to-moderate PD as per H&Y, stable PD medication for at least 30 days prior to enrolment. No significant cognitive impairment (MMSE<24), not >18 on BDI, no smoking in past 5 years, history of head or neck cancer, asthma or other neurological disorders or untreated hypertension.	Vowel duration, vowel intensity, maximum pitch, minimum pitch, perceptual ratings of breathiness/ weakness, appropriate pitch level by gender, appropriate prosody, hoarseness, appropriate loudness, loudness decay, consistent rate, appropriate rate, precision of consonants, intelligibility of speech, cough, VHI, CES (both classified as QoL measures by original study authors (but considered communication measures by the review authors).
Butala, 2022	USA	Crossover randomised controlled trial	26 (16 male, mean age intervention 71, control 67). Recruited from multiple regional medical centres in Maryland.	Idiopathic PD (UK Brain Bank criteria), no dementia (MoCA >24), no psychiatric conditions precluding participation.	Objective measures of vocal function (loudness, held vowel duration, jitter, shimmer, HNR), PDQ-39, VRQOL, MDS-UPDRS, MoCA, SF-36, LSE.

Good, 2023	Canada	Cohort study (two singing groups both intervention arms)	22 (13 male, mean age 70 group A and 73 group B). Recruited from local PD support organisations in Toronto (Group A) and Winnipeg (Group B).	Idiopathic PD diagnosed at age 50 or above, aged at least 50, within mild-to-moderate PD range, no other movement disorders, consistent participation in singing-based programmes. No dementia (MoCA >=21), self-reported normal or corrected-to-normal hearing and vision.	Vocal measures: maximum pitch, minimum pitch, duration, loudness, jitter, shimmer.
Lee, 2024	USA	Randomised controlled trial	27 (13 male, mean age 73). Convenience sample of singers with PD recruited from Treble Clefs, Arizona.	Diagnosis of PD, at least 3 months' experience of singing with Treble Clefs, Arizona, able to read, write and speak English.	VHI, VRQOL, AVQI, perceived voice quality.
Lewellen, 2020	USA	Single-group pre-post study	15 (11 male, mean age 67). Convenience sample, details NS. 7 caregivers/ partners also took part.	PD, H&Y stage 2-3, exhibiting deficits in verbal communication and mobility warranting supportive interventions.	Vocal duration, mean intensity, maximum intensity, cepstral peak prominence (cepstrum refers to the inverse Fourier transform of the logarithm of the spectrum), jitter, shimmer, hypophonia, and harmonic to noise ratio.
Stegemöller, 2020	USA	Single-arm study	8 (7 male, mean age 74). Recruited from Rockwell City (method unclear) then later Storm Lake region (through PD support group). Both were considered rural areas.	Diagnosis of IPD, stable PD medication regime for 30 days, current non-smokers, no speech therapy within 2 years before the study, no significant cognitive impairment (MMSE<24), major psychiatric disorder (BDI >18), history of head or neck cancer, asthma or COPD, or untreated hypertension.	Phonation duration, phonation range, vocal intensity.
Stegemöller, 2021, 2022, 2023	USA	Non-randomised controlled trial	25 (11 male, mean age intervention 74, control 70). Recruited from	Diagnosis of PD, age 40-85, stable medication for 30 days.	MDS-UPDRS-III, voice measures (including vocal loudness, pitch

			ongoing singing groups in Iowa (intervention arm) and a general listserve of people with PD interested in research (control arm).		range , and vocal duration), respiratory control, quality of life (measure NS).
Tamplin, 2020 (note this is an additional paper from the same Tamplin study as in the 2020 review)	Australia	Non-randomised controlled trial.	75 (46 male, mean age 74). Recruited from local PD support groups.	PD by neurologist (MDS criteria). MMSE ≥17. No memory problems, severe language difficulties or hearing impairment.	Voice, speech, EQ-5D and VRQoL.
Theatre					
Bega, 2017*	USA	Randomised controlled crossover trial	22 (14 male, mean age 68 intervention start, 69 control start). Recruited from a local movement disorders clinic.	Idiopathic PD by neurologist (UK Brain Bank criteria), stable medication for 30 days. No other interventions during study.	UPDRS-III, Neuro-QoL, PDQ-39

* Identified through citation chasing of February 2024 search results. Included to ensure the evidence base is as complete as possible. ABC = Activities-specific Balance Confidence scale (Powell & Myers, 1995), ACE = Addenbrooke's Cognitive Examination (Mathuranath, Nestor, Berrios, Rakowicz, & Hodges, 2000), AVQI = Acoustic Voice Quality Index (Maryn et al, 2010), BDI = Beck Depression Inventory (Beck, 1972), BBS = Berg Balance Scale (Berg, Wood-Dauphinée, Williams, & Gayton, 1989), Brain Bank criteria = UK Parkinson's Disease Society Brain Bank criteria (Gibb & Lees, 1988), BSE = Body Self-Efficacy, CAB = Cognitive Assessment Battery (Nordlund et al, 2011), EQ-5D = EuroQol 5 Dimensions Quality of Life scale (EuroQol Group, 1990), FAB = Frontal Assessment Battery (Dubois, Slachevsky, Litvan, & Pillon, 2000), FAPS = Functional Ambulatory Performance Score (Gretz et al, 1998), FES-I = Falls Efficacy Scale – International (Yardley et al, 2005), FHQ = Falls History Questionnaire, FOG = Freezing of Gait questionnaire (Giladi et al, 2000), FTSTST = Five times sit to stand test, HNR = Harmonic to noise ratio, H&Y = Hoehn and Yahr staging (Hoehn & Yahr, 1967); IPD = idiopathic Parkinson's disease, LSE = Lorig et al (1989) Self Efficiency scale, LSQ = Life Space Questionnaire (Stalvey et al, 1999), MCT = Motor Control Test (Luomajoki et al, 2008), MDS = Movement Disorders Society, MDS-UPDRS = Movement Disorders Society sponsored revision of the Unified Parkinson's Disease Rating Scale (Goetz et al, 2008), MFS = Mental Fatigue Scale (Johansson et al, 2010), Mini-BEST – Mini Balance Evaluation Systems Test (Franchignoni, Horak, Godi, Nardone, & Giordano, 2010), MMSE = Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975), MoCA = Montreal Cognitive Assessment (Nasreddine et al, 2005), MoCA-B = MoCA-Blind, NBS = National Ballet School, nFOGq = New Freezing of Gait Questionnaire (Giladi et al, 2000), NS = not stated, PD = Parkinson's disease, PDQ-39 = Parkinson's Disease Questionnaire – 39 Items (Peto, Jenkinson, Fitzpatrick, & Greenhall, 1995) , PPT = Purdue Pegboard Test (Tiffin, 1948), PRMQ = Prospective Retrospective Memory Questionnaire (Smith et al, 2000), Racette criteria = Racette, Rundle, Parsian, & Perlmutter (1999), Q-DASH = Quick Disability of the Arm, Shoulder and Hand (Beaton et al, 2005), REMT = Reading the Mind in the Eyes task (Baron-Cohen et al, 2001), RWS = Rhythmic weight shift, SE-ADL = Schwab and England Activities of Daily Living (Schwab & England, 1968), SCOPA-COG = SCales for Outcomes in PArkinson's disease-COGnition (Marinus et al, 2003), SF-36 = 36-Item Short Form Health Survey (Saris-Baglama et al, 2007), SOT = Sensory Organization Test (Clendaniel, 2000), TUG = Timed Up and Go (Podsiadlo & Richardson, 1991), TULIA = Test of Upper Limb Apraxia (Vanbellingen et al, 2010), UPDRS = Unified Parkinson's Disease Rating Scale (Fahn, Elton, & UPDRS Program Members, 1987), VHI = Voice Handicap Index (Jacobson et al, 1997), VRQoL = Voice- Related Quality of Life (Hogikyan & Sethuraman, 1999), 6MWT = Six minute walking test. Studies use a range of different terminology to refer to the Brain Bank Criteria (e.g. London, UK Parkinson's Disease Society, Queen Square), but these refer to the same set of criteria (Gibb &Lees, 1988).

February 2025 search

First author, year	Country	Design	Participants	Inclusion criteria	Outcomes
Dance					
Haas, 2024b	UK	Non-randomised controlled trial	15 (8 male, mean age 72 intervention, 64 control). Recruited from Dance for Parkinson's groups as well as Parkinson's support groups.	PD diagnosis (UK Brain Bank criteria). Understand verbal instructions, walk unaided, no recent surgery, DBS, severe heart disease,	TUG, girdle dissociation

				uncontrolled hypertension, MI within 1 year, pacemaker, lower leg prostheses, stroke or other neurological disease.	
Kristen, 2024	Sweden	Descriptive single-arm mixed methods study	24 (demographics NR). Recruited from Dance for Parkinson's groups.	PD (no further details)	Unpublished questionnaire on subjective well-being and functioning as experienced by dancers
Kunte, 2024	India	Non-randomised controlled trial	34 (26 male, mean age 68). Convenience sample from local Parkinson's support groups.	PD diagnosis, UK Brain Bank criteria.	MDS-UPDRS-III, ACE, PDQ-39
Mehta, 2024	India	Randomised controlled trial	55 (33 male, mean age 59 intervention, 59 physiotherapy control, 62 standard pharmacotherapy control). Recruitment NR.	Idiopathic PD diagnosis (H&Y 1-2.5), aged 30-80, no known history of unstable cardiovascular status, respiratory illness, falls or head injury in past 3 months or significant cognitive impairment (MoCA <20)	MDS-UPDRS-III, FOG, Mini-BESTest, SCOPA-COG
Music therapy					
Wainwright, 2024	USA	Single-arm pilot trial (for PD)	5 (all male, mean age 74). Convenience sample from clinics and posters. There were also caregivers and people with Huntington's disease.	Idiopathic PD (MDS criteria), no significant injury or co-morbid diagnosis affecting upper extremities for instrument play, active psychosis or other neurological conditions	MDS-UPDRS-III, PDQ-39, Neuro-QoL
Singing					
Tamplin, 2024	Australia	Single-arm pilot study	28 (16 male, mean age 68). Recruited through local Parkinson's support groups and SLT clinics.	Diagnosis of idiopathic PD, no previous neurological, head and neck, or respiratory disorders, no visual or auditory impairment not remedied by aids, English speaking, computer with high-speed internet and web camera, MoCA score	Speech loudness, maximum phonation time, syllable repetition (diadochokinetic rate), and composite scores of intelligibility, naturalness, and disease severity, Dysarthria Impact Profile, MDS-UPDRS-III

				>=18 (or carer available if score between 10 and 17).	(modified for online administration), PDQ-39
Theatre					
[None]					

ACE = Addenbrooke's Cognitive Assessment, DBS = deep brain stimulation, FOG = freezing of gait, H&Y = Hoehn & Yahr, MDS = Movement Disorders Society, MI = myocardial infarction, Mini-BESTest = Mini-Balance Evaluation Systems Test MoCA = Montreal Cognitive Assessment, NR = not reported, PD = Parkinson's disease, PDQ = Parkinson's Disease Questionnaire, SCOPA-COG = SCales for Outcomes in PArkinson's disease-COGnition, SLT = Speech and language therapy, TUG = Timed up and Go, UK = United Kingdom, UPDRS = Unified Parkinson's Disease Rating Scale

Supplementary file 9. Intervention profile

Barnish & Barran (2020) search

First author, year	Content	Leader	Location	Duration
Dance				
Allen, 2017; McKay, 2016	Adapted tango.	A professional dance instructor.	A large multipurpose university room.	15 group sessions of 90 minutes over 3 weeks.
Batson, 2010	Modern dance.	A dance teacher experienced in teaching the elderly.	A large multipurpose room in a wellness centre.	3 group sessions of 85 minutes per week for 3 weeks.
Batson, 2014	Improvisational dance: seated, at the ballet Barre and ambulating.	Two dance instructors trained in improvisational dance.	An accessible dance studio.	3 group sessions of 1 hour per week for 7 weeks.
Bearss, 2017	Dance for Parkinson's Disease.	Two NBS faculty members trained in Dance for Parkinson's Disease.	NBS Canada.	1 group session of 75 minutes per week for 12 weeks.
Blandy, 2015	Argentine tango.	A professional dance instructor.	A dance studio.	2 group sessions of 1 hour per week for 4 weeks.
Clifford, 2017	Dance for Parkinson's programme, including improvisational and creative dance tasks.	A dance artist, who is an experienced Dance for Parkinson's practitioner.	A hospice.	1 group session of 90 minutes per fortnight for 12 weeks.
De Natale, 2017	Argentine tango.	A professional dance instructor.	NS	2 group sessions of 60 minutes per week for 10 weeks.
Duncan, 2014	Argentine tango.	Two volunteers who are experienced Argentine tango dancers.	A community-based location.	2 group sessions of 1 hour per week for 2 years.
Duncan, 2012; Foster, 2013	Argentine tango. Participants danced both lead and follow roles.	A tango instructor.	A community-based location.	2 group sessions of 1 hour per week for 1 year.

Hackney, 2007 a,b	Argentine tango. All participants danced both lead and follow roles.	A professional dance instructor.	NS.	2 group sessions of 1 hour per week for a total of 20 sessions over 13 weeks.
Hackney, 2009 a,b,c	Argentine tango. American ballroom: waltz/foxtrot. All participants danced both lead and follow roles.	An experienced professional ballroom dance instructor who was also a certified personal trainer.	NS.	2 group sessions of 1 hour per week for a total of 20 sessions over 13 weeks.
Hackney, 2010	Based on Argentine tango. Partner and Non-partner positions. All participants performed lead and follow roles.	An experienced professional ballroom instructor who was also a certified personal trainer.	NS.	2 group sessions of 1 hour per week for 10 weeks.
Hackney, 2018	Adapted tango. Participants assigned to lead or follow exclusively.	NS.	NS.	20 group sessions of 90 minutes over 13 weeks. Frequency NS.
Hashimoto, 2015	PD-specific dance: alone, in pairs and in groups.	NS.	NS.	1 group session of 60 minutes per week for 12 weeks.
Heiberger, 2011	Dance for Parkinson's disease.	A professional dancer.	A ballet studio.	1 group session of 75 minutes per week for 8 months.
Hulbert, 2017; Kunkel, 2017	Partnered dance based on basic ballroom and Latin steps. Dance steps differed by gender following tradition.	Two experienced ballroom and Latin dance teachers.	NS.	2 group sessions of 1 hour per week for 10 weeks.
Kalyani, 2019	Dance for Parkinson's Disease.	Dance for Parkinson's Disease trained instructors.	NS.	2 group sessions of 1 hour per week for 12 weeks.
Koch, 2016	Argentine tango.	Workshop 1: a dance movement therapist and	NS.	1 group session of 90 minutes in total. Three

		tango teacher from Argentina (session translated from English) Workshops 2 and 3: a dance movement therapy advanced student and tango teacher from Germany.		separate workshops were run attended by different participants.
Lee, 2018	Turo: a dance form based on the Qi meridian system.	A Turo instructor.	A Korean Medicine hospital.	2 group sessions of 60 minutes per week for 8 weeks.
McGill, 2019	Ballet.	Dance artists in the hosting ballet company's outreach department.	A ballet dance studio.	1 group session of between 75 and 90 minutes per week in term time (3 terms per year lasting 10-12 weeks) for 1 year.
McKee, 2013	Adapted tango.	Dance instructors without clinical experience.	Retirement communities.	20 group sessions of 90 minutes over 12 weeks.
McNeely, 2015	Dance for Parkinson's Disease. Tango. All participants danced both lead and follow roles.	Dance for Parkinson's Disease: an undergraduate student with pre- professional ballet and modern dance experience. Tango: two graduate students who were experienced tango dancers.	A community-based group setting on a university campus.	2 group sessions of 1 hour per week for 12 weeks.
McRae, 2018	Dance for Parkinson's disease.	NS – due to recruitment for assessment of participants from various established dance classes.	NS – due to recruitment for assessment of participants from various established dance classes.	Participants were in established dance classes and the pattern and frequency differed.

Marchant, 2010	Short duration, high dose contact improvisation dance workshop.	A professional improvisational dance instructor.	NS.	10 group sessions of 90 minutes over a 2 week period.
Michels, 2018 a,b	Dance therapy for Parkinson's disease. A customised session catered to the individual.	A certified dance therapist with experience teaching people with PD.	A movement studio in sports institute.	1 group session of 1 hour per week for 10 weeks.
Patel, 2018	Adapted tango.	NS.	NS.	30 hours of group sessions over 12 weeks.
Prewitt, 2017	Let's Dance!	Two academic physiotherapists (recreational dancers).	A university physiotherapy laboratory skills classroom.	2 group sessions of 1 hour per week for 8 weeks.
Rawson, 2019	Argentine tango.	Tango dance instructors.	University facilities.	2 group sessions of 1 hour per week for 12 weeks.
Rocha, 2018	Argentine tango. Mixed-genre: comprised tap dancing, creative dance and Irish dancing.	Two experienced dance teachers.	A dance venue with a wooden floor, barre and mirrors.	1 group session of 1 hour for 8 weeks with a concurrent home dance programme.
Romenets, 2015	Argentine tango.	Two professional tango instructors without expertise in PD.	A dance studio.	2 group sessions of 1 hour per week for 12 weeks.
Shanahan, 2017	Irish set dancing.	Irish set dancing teachers who were either also clinicians or experienced in teaching clinical populations.	A community venue.	1 group session of 90 minutes per week for 10 weeks. Parallel home programme.
Shanahan, 2015	Irish set dancing.	A set dancing teacher who was also a chartered physiotherapist.	A community hall.	1 group session of 90 minutes per week for 8 weeks. Parallel home programme.

Solla, 2019	Ballu Sardu (a Sardinian folk dance).	A Sardinian folk dance teacher.	NS.	2 group sessions of 90 minutes per week for 12 weeks.
Ventura, 2016	Dance for Parkinson's Disease.	Two trained Dance for Parkinson's Disease instructors.	NS.	1 group session of 75 minutes per week for 10 weeks – for some participants these were not consecutive.
Volpe, 2013	Irish set dancing.	Two set dancing teachers.	A dance studio.	1 group session of 90 minutes per week for 6 months. Supplementary home programme.
Westbrook, 1989	Dance/movement therapy: development of a movement theme facilitated by the therapists.	The authors – a search suggests they are psychologists.	The halls of two suburban churches.	Group sessions of 60 minutes for 6 weeks. It is not clearly stated whether it is one session per week.
Westheimer, 2015	Dance for Parkinson's Disease.	Dance teachers who developed the Dance for Parkinson's Disease method	Mark Morris Dance Center.	2 group sessions of 75 minutes per week for 8 weeks.
Zafar, 2017	Adapted tango.	Tango instructors.	Retirement communities.	20 group sessions of 90 minutes within 12 weeks. Classes were twice weekly.
Music therapy				
Pacchetti, 2000	Instrumental music improvisation: piano, organ, percussion instruments and a hi-fi system.	A music therapist.	NS.	1 group session of about 2 hours per week for 13 weeks.

Pantelyat, 2016	West African drum circle class.	Local African drumming instructors.	Dance studio at a university movement disorders centre.	2 group sessions of 45 minutes to 1 hour per week for 6 weeks.
Pohl, 2013	Ronnie Gardiner Rhythm and Music Method.	A certified Ronnie Gardiner Rhythm and Music Method practitioner.	NS.	2 group sessions of 1 hour per week for 6 weeks.
Spina, 2016	Music, singing and dancing.	NS.	NS.	1 group session of 90 minutes per week for 24 weeks.
Singing				
Azekawa, 2018	Well-known songs.	A trained graduate student supervised by music therapists.	NS.	1 group session of 50 minutes per week for 6 weeks.
Di Benedetto, 2009	Choral singing using modified popular and liturgical chants accompanied on the piano.	An SLT who is an expert choral singer.	A hospital chapel.	1 group session of 2 hours per week for 13 weeks. Prior to this, there was a series of vocal exercise sessions.
Elefant, 2012 a,b	Songs from the Beatles as well as Norwegian folk songs accompanied on the guitar.	A music therapist.	A familiar room in the hospital's rehabilitation centre.	1 group session of 1 hour per week for 20 weeks.
Evans, 2012	Call and response singing to well-known tunes then singing songs.	A professional singing teacher with a personal interest in PD.	NS.	1 group session of 2 hours per fortnight for 2 years.
Higgins, 2019	Singing.	A trained vocal performer with a master's degree in Music.	NS.	1 group session of 90 minutes per week for 11 weeks. Participation in 9 sessions was required for continuation.

Irons, 2020, 2019	Sing to Beat Parkinson's.	Trained facilitators.	NS.	1 group session of 1 hour per week for 6 months.
Matthews, 2018	Singing, voice and respiration exercise.	NS.	NS.	1 group session per week for 9 weeks – session duration not stated.
Shih, 2012	Singing popular songs.	An SLT who was also a singing instructor.	NS.	1 group session of 90 minutes per week for 12 weeks.
Stegemöller, 2017 a,b	Group singing of familiar songs.	Music therapists.	NS.	1 group session per week for 8 weeks – session duration NS. There was also a complementary home programme.
Tamplin, 2019, 2018	Singing popular and traditional songs and rounds.	Weekly: a music therapist. Monthly: community musicians and volunteers.	NS.	1 group session of 2 hours weekly or monthly for 3 months.
Tanner, 2016	Vocal exercises followed by melody and song singing, accompanied by a pianist.	An SLT who is also a classically trained singer.	NS.	2 group sessions of 90 minutes per week for 6 weeks
Yinger, 2016	Singing exercises using songs selected by the participant and accompanied on the guitar or piano.	A music therapist.	NS.	2 group sessions of 50 minutes per week for 6 weeks.
Theatre				
Mirabella, 2017	Movement, vocal and theatre training: the latter comprising vocal technique, improvisation and experimentation, and dramaturgy.	Professional performers (an actor and either a singer or a dancer).	NS.	1 group session of 3 hours per week for 15 months.

Modugno, 2010	Vocal warm-up, preparation of the scene and staging.	Professional actors.	NS.	2 or 4 (alternating monthly) group sessions of 6 hours per month for 3 years.

Adapted tango = steps from Argentine tango adapted to suit people with PD with all participants dancing both lead and follow roles regardless of gender unless stated, Argentine tango = danced in traditional gender roles unless stated, Dance for Parkinson's Disease = a model developed by Mark Morris Dance Center and Brooklyn Parkinson Group including modern dance choreography and partner dancing (Westheimer, 2008), Let's Dance! = a university-led PD-specific dance class with dances from a large repertoire of partner, group and line dances: the bachata, ballroom waltz, Texas two-step, polka, shim-sham, swing, Cajun waltz, foxtrot, samba, tango, square dance, electric slide, meringue, samba, and barangara, NBS = National Ballet School, NS = Not stated, PD = Parkinson's disease, Sadie Gardiner Rhythm and Music Method = musical exercises that challenge cognition and sensorimotor control, Sing to Beat Parkinson's = a programme developed by the investigators which after warm-ups featured singing participants' preferred songs, SLT = Speech and Language Therapy/ist.

February 2024 search

First author, year	Content	Leader	Location	Duration
Dance				
Bouquiaux, 2022	Dance training. Sit warm-up, dancing adding new steps each week with increasing difficulty, adaptions where needed, seated stretching to end.	Professional dancers.	NS.	16 group sessions of 60 minutes over 4 months, then a show.
Delabary, 2020	Samba and Forró Brazilian rhythmic dance.	Qualified dance teacher with an undergraduate degree in Dance.	Appropriate room for dance classes with mirrors, chairs and a barre.	24 group sessions of 60 minutes over 12 weeks.
Duarte, 2023	Physical activity based on dance movements, called the "Baila Parkinson" method.	NS.	Suitable rooms within Laboratory of Studies in Functional Rehabilitation.	2 group sessions of 50 minutes per week for six months.
Feenstra, 2022	Dance classes. Involved aspects of ballet, modern dance and jazz. Opportunity to socialise as well.	PD-skilled dance teachers.	Seven locations in the north of the Netherlands – details about venue type NS.	1 group session of 60 minutes per week for 22 weeks.
Fisher, 2020	Improvisational dance movement therapy.	Two trained dance movement therapists.	University chapel.	One group session of 90 minutes per week for 10 weeks.
Fontanesi, 2021	Dance for Parkinson's.	Certified dance instructor.	Mark Morris Dance Center, Brooklyn, NY.	Unclear.
Frisaldi, 2021	DArT method (combined dance-physiotherapy intervention).	Dance therapist with a strong neuroscience background and experience in PD conducted dance classes. Physiotherapist conducted conventional physiotherapy.	NS.	60 minutes of conventional physiotherapy followed by 60 minutes of group dance class, 3 times a week for 5 weeks.
Haas, 2024a	Brazilian dance	NS.	NS.	24 group sessions of an average of 60 minutes over 12 weeks.

Haputhanthirige, 2023	Dance for Parkinson's Disease	Dance for Parkinson's disease trained instructors.	Queensland Ballet.	Group sessions of 120 minutes twice a week for 3 months.
Harrison, 2020	Joywalk (walking dance), preceded by warm-up and centre practice	Professional contemporary dancer experienced in teaching people with PD.	NS.	Two group sessions of 60 60 minutes per week for 6 weeks.
Jola, 2022	Dance for Parkinson's disease	Dance instructors. Some had been trained in Dance for Parkinson's disease and one centre was a Dance for Parkinson's disease international affiliate centre.	Six established dance classes across the UK, details of venues not provided.	All participants took part in dance classes at least once a week with an average of at least 40 dance classes. All but three participants included in the quantitative analysis took part in dance classes for at least two months.
Lihala, 2021	Dance movement therapy	Dance movement therapists.	Institute of Neuroscience.	90-minute session. Frequency NS.
Moratelli, 2021, 2022	Dance classes (2 groups: binary rhythm and quaternary rhythm)	Trained researchers.	Santa Catarina Rehabilitation Center. It is stated that the environment in which the binary and quaternary classes were held differed, but details NS.	2 group sessions of 45 minutes per week for 45 minutes.
Moratelli, 2023	Forro Brasiliero and samba, samba only	NS.	NS.	1 group session of 60 minutes of samba and 1 group session of 60 minutes of Forro Brasiliero per week for 11 weeks or 2 group sessions of 60 minutes of samba per week for 11 weeks.
Park, 2023	Vocal-dance programme	Run by Oklahoma City Ballet outreach division. NS exactly who led classes.	Run by Oklahoma City Ballet outreach division. NS if held at the ballet.	2 group sessions of 60 minutes per week for 4 weeks.
Peter, 2020	Argentine tango	NS.	Independent living retirement facility with a wooden dance floor.	3 group sessions a week for 4 weeks. Duration NS.
Pinto, 2023	Online dance intervention based on Dance for Parkinson's.	An instructor who is a professional dancer and physiotherapist.	Online (taught via Zoom software).	Two group sessions of 60 minutes per week for 8 weeks.
Rabinovich, 2021	Argentine tango	Two experienced tango instructors.	Movement disorders section of a hospital – using a medical meeting or conference room.	Ten group sessions of 90 minutes over a 2-week period.
Tillmann, 2020	Brazilian samba	Dance teacher/ researcher with experience in ballroom dancing, assisted by 3 researchers.	A large room with a smooth floor and chairs.	2 group sessions of 60 minutes per week for 12 weeks.
Valverde-Guijarro, 2022	Contemporary dance programme	Professional dancer specialised in dance pedagogy.	A community rehabilitation setting.	1 group session of 60 minutes twice a week for 8 weeks.

Walton, 2022	Digital Dance for Parkinson's	Professional, experienced, dance instructor, certified in Dance for Parkinson's.	Online, taught via Zoom software.	1 online group session of 60 minutes per week for 10 weeks.
Music therapy				
Bastepe-Gray, 2022	Guitar lessons (using classical guitars).	Professional guitar teachers.	Community music school.	Two group guitar classes of 60 minutes per week for 6 weeks.
Pohl, 2020	Ronnie Gardiner Method.	Two physiotherapists	Neuro rehabilitation centre.	Two group sessions of 60 minutes per week for 12 weeks.
Shah-Zamora, 2024	Virtual group music therapy – instrument kits including a harmonica, drum, tambourine, drumsticks, wrist bells and more were provided.	Board-certified neurologic music therapist.	Online.	One group session of 60 minutes per week for 12 weeks.
Singing				
Brooks, 2021	Therapeutic group singing (vocal exercises then singing of familiar songs).	Board-certified music therapist.	NS.	1 group session of 60 minutes per week for 12 weeks.
Butala, 2022	Warm-up, vocal exercises, singing well-known songs (reinforced by home exercises).	Professional choir director.	Auditorium in a community-based church space.	1 group session of 90 minutes per week for 12 weeks.
Good, 2023	Community choir. Both groups were similar, emphasising community inclusion and vocal strengthening. Songs differed between sites.	Group A: professional choir director with a musical theatre background. There was also a trained piano accompanist. Group B: Music therapist who accompanied herself on the guitar.	At the community choir's normal venues – details NS.	1 group session of 50 minutes per week for 12 weeks (10 minutes' warm-up and 40 minutes' songs).
Lee, 2024	Therapeutic group singing. A second intervention group additionally received straw phonation.	Board-certified music therapist.	Same room where Treble Clefs, Arizona, usually meets.	Single session of 30 minutes.
Lewellen, 2020	Group singing therapy (following Therapeutic Singing Protocol by Yinger and LaPointe (2012).	Board-certified music therapist (first author).	NS.	1 group session of 50 minutes per week for 8 weeks (session duration NS).
Stegemöller, 2020	Group therapeutic singing, by telemedicine.	Board-certified music therapist.	Local church in each of the two communities, with a screen to access the recorded content.	8 group sessions over a period of 9 weeks.
Stegemöller, 2021, 2022, 2023	Group therapeutic singing (vocal exercises and singing familiar songs).	Board certified music therapist.	NS.	A single session of 60 minutes.
Tamplin, 2020	Singing popular and traditional songs and rounds.	Weekly: a music therapist. Monthly: community musicians and volunteers.	NS.	1 group session of 2 hours weekly or monthly for 3 months.

Theatre				
Bega, 2017*	Improvisational theatre (Second City improvisation). This is a comedy enterprise based out of Chicago.	Second City faculty members (same 2 instructors at each class).	NS.	1 group session of 1 hour per week for 12 weeks.

* Identified through citation chasing of February 2024 search results. Included to ensure the evidence base is as complete as possible. Argentine tango = danced in traditional gender roles unless stated, Dance for Parkinson's Disease = a model developed by Mark Morris Dance Center and Brooklyn Parkinson Group including modern dance, choreography and partner dancing (Westheimer, 2008), NBS = National Ballet School, NS = Not stated, PD = Parkinson's disease, Ronnie Gardiner Rhythm and Music Method = musical exercises that challenge cognition and sensorimotor control.

February 2025 search

First author, year	Content	Leader	Location	Duration
Dance				
Haas, 2024b	Dance class specifically designed for people with PD	Qualified dance instructor experienced in PD	Appropriate room with chairs and ballet barres	1 group session of 50 to 70 minutes per week for 3 months
Kristen, 2024	Dance for Parkinson's Disease	Dance for Parkinson's Disease instructor	NS	1 group session of 60 minutes per week for about 4 months
Kunte, 2024	Culturally informed dance-movement therapy	NS (sessions were designed by a trained psychologist and a certified dance movement therapist with intensive training in Indian classical dance forms	Community centre	1 group session of 90 minutes per week for 12 weeks
Mehta, 2024	Garba dance (form of Gujarati dance from India)	Professional Garba dancer	'At our centre' – does not specify if that is a medical centre or a dance centre	5 group sessions of 60 minutes per week for 12 weeks
Music therapy				
Wainwright, 2024	Drumming-based music therapy intervention	Board-certified music therapist	NS	2 group sessions of 60 minutes per week
Singing				
Tamplin, 2024	Therapeutic group singing	Co-delivered by a music therapist and a SLT	Online via Zoom	1 group session of 90 minutes per week for 12 weeks
Theatre				
[None]				

NS = not stated, PD = Parkinson's disease, SLT = Speech and language therapist

Supplementary file 10. Control profile

Barnish & Barran (2020) search

First author, year	Synopsis of control arm
Dance	
De Natale, 2017	Traditional rehabilitation: 2 group sessions of 1 hour per week for 10 weeks. Static and dynamic balance exercises, and gait training.
Duncan, 2014	Usual care.
Duncan, 2012; Foster, 2013	Usual care.
Hackney, 2007 a,b	Traditional exercise: 2 group sessions of 1 hour per week – completing 20 sessions within 13 weeks. Structured traditional strength/flexibility chair exercises.
Hackney, 2009 a,b,c	Usual care.
Hackney, 2018	Wellness education: 20 group sessions of 90 minutes over 13 weeks.
Hashimoto, 2015	PD exercise: 1 group session of 60 minutes for 12 weeks. Usual care.
Hulbert, 2017; Kunkel, 2017	Usual care.
Kalyani, 2019	Usual care.
Lee, 2018	Waiting list control.
McGill, 2019	Usual care – asked not to take dance classes during the study.
McKee, 2013	Education: 20 group sessions of 90 minutes over 12 weeks. Seminars on diverse health-related topics to encourage interaction and socialising.
Michels, 2018 a,b	Support group: 1 group session of 60 minutes per week for 10 weeks. Traditional talking therapy support group facilitated by a professional counsellor.
Patel, 2018	Education: 30 hours of group sessions over 12 weeks. Socially supportive classes addressing health and wellness topics relevant to older adults with PD.
Rawson, 2019	Treadmill: 2 group sessions of 60 minutes per week for 12 weeks. Stretching: 2 group sessions of 60 minutes per week for 12 weeks.

Romenets, 2015	Self-directed exercise: a wait list control group that was additionally given a booklet about exercise in PD produced by the Parkinson Society of Canada.
Shanahan, 2017	Usual care.
Solla, 2019	Usual care.
Ventura, 2016	Usual care.
Volpe, 2013	Routine physiotherapy: individual sessions of 80 minutes covering movement, stretching, strength training, balance training, postural re-education and gait training. Participants had an average of 21 sessions over 6 months.
Westbrook, 1989	Exercise group: Structured routine of exercises including rowing movements, windmill movements of the arms, and neck exercises. The exercise classes lasted for 6 weeks. The session duration and frequency are not stated.
Zafar, 2017	Usual care.
Music therapy	
Pacchetti, 2000	Physiotherapy: weekly group sessions of 90 minutes for 13 weeks.
Pantelyat, 2016	Usual care.
Pohl, 2013	Usual care.
Spina, 2016	Usual care.
Singing	
Matthews, 2018	Music appreciation: watching and discussing music videos in a group once a week for 9 weeks – session duration not stated.
Tamplin, 2019,2018	Weekly control: a weekly session of painting, dancing or tai chi. Monthly control: a monthly peer support group.
Theatre	
Mirabella, 2017	Physiotherapy: group sessions of 1.5 hours 2 days a week for 15 months.
Modugno, 2010	Physiotherapy: individual sessions of 2-3 hours 3 days a week for 3 years.

PD = Parkinson's disease.

February 2024 search

First author, year	Synopsis of control arm
Dance	

Bouquiaux, 2022	Usual care (no intervention).
Delabary, 2020	Walking programme. Matched for frequency and duration. Held outdoors on a 400-metre track. Taught by qualified teachers with an undergraduate degree in Physical Education.
Fontanesi, 2021	Matched-intensity exercise.
Frisaldi, 2021	Conventional physiotherapy.
Haas, 2024a	Deep-water exercise. Nordic walking. Both matched for frequency.
Haputhanthirige, 2023	Usual care.
Moratelli, 2023	Usual care (instructed to maintain their usual activities and lifestyle).
Peter, 2020	Usual care.
Tillmann, 2020	Usual care (guideline to adhere to current pattern of activities). Also invited to attend monthly lectures about maintenance of health, falls prevention and psychological care.
Valverde-Guijarro, 2022	The control formed the A in the A-B-A design. Physiotherapy programme comprising conventional physiotherapy (two sessions of 45 minutes per week), individual hydrotherapy (two sessions of 45 minutes per week) and manual techniques (two sessions of 30 minutes per month).
Music therapy	
Bastepe-Gray, 2022	The same guitar classes as the intervention group but after 6 weeks of usual care first.
Pohl, 2020	Usual care.
Singing	
Brooks, 2021	Usual care.
Butala, 2022	Discussion group, in a separate auditorium in the same building, matched for duration and frequency.
Lee, 2024	Speaking-only control group.
Stegemöller, 2021, 2022, 2023	1-hour quiet reading in a group environment.
Tamplin, 2020.	Weekly control: a weekly session of painting, dancing or tai chi. Monthly control: a monthly peer support group.
Theatre	
Bega, 2017*	No intervention (during control period of crossover trial)

* Identified through citation chasing of February 2024 search results. Included to ensure the evidence base is as complete as possible

February 2025 search

First author, year	Synopsis of control arm
Dance	
Haas, 2024b	Moderate physical activity (individual)
Kunte, 2024	Physical exercise group
Mehta, 2024	Physiotherapy (arm B); usual care (standard pharmacotherapy, arm C)
Music therapy	
Wainwright, 2024	Usual care
Singing	
[None]	
Theatre	
[None]	

Supplementary file 11. Narrative results

Rows for studies included in the Barnish & Barran (2020) review were originally published in the Barnish & Barran (2020) paper.[5] This paper is open access (Creative Commons Attribution 4.0 International License) and the copyright rests with the authors. The corresponding author – Dr Barnish – who is also the corresponding author of this manuscript – grants permission for the replication of these rows to aid clarity of reporting.

Barnish & Barran (2020)

First author, year	Results
Dance	
Allen, 2017; McKay, 2016	There was evidence that adapted tango significantly improved motor function, including through physiological assessment.
Batson, 2010	There was evidence that modern dance significantly improved balance, while the difference in TUG fell short of statistical significance.
Batson, 2014	There was evidence that improvisational dance significantly improved balance (although this fell slightly short of clinical significance), while the difference in TUG fell short of statistical significance.

Bearss, 2017	There was evidence that Dance for Parkinson's Disease significantly improved motor function, although this was not found for quality of life.
Blandy, 2015	There was evidence that Argentine tango improved quality of life, although statistical significance was not reached.
Clifford, 2017	There was evidence that a Dance for Parkinson's programme improved quality of life, although statistical significance was not reached.
De Natale, 2017	There was evidence that Argentine tango was significantly more effective for motor and cognitive functions than traditional rehabilitation exercises.
Duncan, 2014	There was evidence that Argentine tango was significantly more effective for motor function than usual care, and that these gains were sustained for two years while the usual control group deteriorated.
Duncan, 2012; Foster, 2013	There was evidence that Argentine tango was significantly more effective for motor function than usual care.
Hackney, 2007 a,b	There was evidence that Argentine tango was significantly more effective for motor function than traditional exercises.
Hackney, 2009 a,b,c	There was evidence that tango but not American Ballroom dancing significantly improved health-related quality of life. Both tango and
	American Ballroom dancing significantly improved motor function versus no intervention, but the effect was stronger for tango.
Hackney, 2010	There was evidence that tango significantly improved motor function (gait and balance) and that this did not differ significantly between partnered and non-partnered conditions.
Hackney, 2018	There was evidence that following rather than leading tango was significantly more beneficial overall for motor function, cognition and quality of life, although leading was more effective for motor fluctuations.
Hashimoto, 2015	There was evidence that PD-specific dance was significantly more effective than PD exercise or usual care in improving motor and cognitive symptoms.
Heiberger, 2011	There was evidence that Dance for Parkinson's Disease significantly improved motor function (with the strongest effect being on rigidity). A significant impact on quality of life was also found, particularly relating to recreation, socialising and social impact.

Hulbert, 2017; Kunkel, 2017	There was evidence that partnered dance significantly improved motor function (though not all on measures), though this effect was not found for quality of life.
Kalyani, 2019	There was evidence that Dance for Parkinson's disease significantly improved cognition and quality of life compared to usual care.
Koch, 2016	There was evidence that tango significantly improved quality of life, assessed by measures of well-being and body self-efficacy.
Lee, 2018	There was evidence that Turo dance significantly improved quality of life compared to a waiting list control. There was some evidence for a significant benefit on motor function, being found on UPDRS-motor but not a balance assessment.
McGill, 2019	There was no evidence that ballet significantly improved motor function, considering gait and balance confidence, compared to usual care.
McKee, 2013	There was evidence that adapted tango was significantly more effective than education in improving motor function and cognition.

McNeely, 2015	There was evidence that tango significantly improved motor function, while motor symptoms deteriorated in the Dance for Parkinson's Disease group. Gait analysis variables did not however change significantly in either group. Cognitive status was assessed but results post-intervention were not reported. There was no significant effect of either dance intervention on quality of life.
McRae, 2018	There was evidence that Dance for Parkinson's Disease improves quality of life, including self-efficacy. Mediation analysis showed that one way in which higher levels of functional mobility influence overall quality of life is through enhanced self-efficacy.
Marchant, 2010	There was evidence that contact improvisation dance improved motor function. Quality of life was measured but results were not reported.
Michels, 2018 a,b	There was evidence that a customised PD dance intervention improved motor function and quality of life, but this was not shown for cognition. The study was not designed to assess whether differences versus a support group control were significant.
Patel, 2018	There was evidence that adapted tango was significantly more effective than an educational intervention for motor function, cognitive function and quality of life.
Prewitt, 2017	There was evidence that a Let's Dance! programme significantly improved quality of life (self-efficacy and ADL measures) and some evidence of a significant benefit for cognitive function, although this was not found for all measures.
Rawson, 2019	There was no evidence that tango significantly improved motor function or quality of life.
Rocha, 2018	There was evidence that Argentine tango significantly improved mobility, balance and motor disability, while mixed-genre dance significantly improved freezing of gait. There was a trend to improved quality of life in Argentine tango participants (but not mixed-genre dance participants), although this did not reach statistical significance.

Romenets, 2015	There was some evidence that Argentine tango was significantly more effective than self-directed exercise for motor function, although this effect was not found for the primary outcome measure UPDRS- motor. There was no evidence of a significant effect on quality of life. Tango participants displayed greater improvement in cognition, although statistical significance was not reached.
Shanahan, 2017	There was no evidence that Irish set dancing significantly improved motor function. However, Irish set dancing improved quality of life more than usual care, although statistical significance was not reached.
Shanahan, 2015	There was evidence that Irish set dancing significantly improved quality of life. There was also an improvement in motor function, although statistical significance was not reached.
Solla, 2019	Ballu Sardu offered significantly greater benefits for motor and cognitive function than usual care.
Ventura, 2016	There was evidence that Dance for Parkinson's Disease was more than usual care for motor function and cognition, although effects were not consistent across measures. Large effect sizes were found for measures of cognitive switching, attention, gait speed and falls efficacy. Evidence of a significant benefit on quality of life was also found.
Volpe, 2013	There was evidence that Irish set dancing was significantly more effectively than physiotherapy exercise in improving motor function. For quality of life, both groups improved, but there was no significant difference.
Westbrook, 1989	There was evidence that dance/movement therapy was significantly more effective than exercise in improving movement initiation.
Westheimer, 2015	There was evidence that Dance for Parkinson's Disease significantly improved motor function, but this effect was not found for quality of life.
Zafar, 2017	There was evidence that adapted tango was significantly more effective than usual care in improving quality of life outcomes related

	to participation and autonomy, including social life, autonomy indoors and family role subscales.
Music therapy	
Pacchetti, 2000	There was evidence that instrument-based music therapy was significantly more effective than physiotherapy for motor function and quality of life.
Pantelyat, 2016	There was evidence that the drum circle intervention improved quality of life significantly more than usual care. There was some evidence that the drum circle intervention improved motor function significant more than usual care. There was no evidence for a significant beneficial effect of the drum circle intervention on cognition.
Pohl, 2013	There was evidence that the Ronnie Gardiner Rhythm and Music Method significantly improved motor function, cognition and quality of life, which did not improve significantly in the usual care control group.
Spina, 2016	There was evidence that active music therapy significantly improved cognition and quality of life significantly more than usual care, although this effect was not found for motor function.
Singing	
Azekawa, 2018	There was evidence that singing improved phonatory, intelligibility and fluency, although statistical significance was not consistently reached.
Di Benedetto, 2009	There was some evidence that singing significantly improved phonation, although this was not found for all phonatory measures.
Elefant, 2012a,b	There was some evidence that singing significantly improved functional communication (including facial expression), although this was not found for all measures. There was no evidence of a significant improvement in spoken fluency, intensity or phonatory measures.

Evans, 2012	There was evidence that singing significantly improved phonation and intensity, although this evidence was not found for intelligibility or quality of life.
Higgins, 2019	There was evidence that singing significantly improved intelligibility and articulation (vowel space area).
Irons, 2020,2019	There was evidence that singing improved quality of life, with statistical significance being reached for emotional well-being, cognition and communication quality of life subscales. An effect on the social support subscale was found, but it was moderated by country with the effect being found only in South Korean and not Australian or British participants.
Matthews, 2018	There was evidence that singing significantly improved phonatory, cognition and quality of life measures.
Shih, 2012	There was no evidence that singing significantly improved phonatory, intensity or functional communication measures.
Stegemöller, 2017a,b	There was evidence that singing significantly improved motor function, quality of life, and voice-related quality of life. There was some evidence that singing significantly improved phonatory measures, although this was not found for all measures. There was no evidence of a significant benefit on swallow-related quality of life.
Tamplin, 2019,2018	There was evidence that singing significantly improved speech intensity and voice-related quality of life, but not phonation. Weekly participants improved more than monthly participants.
Tanner, 2016	There was some evidence that singing significantly improved intensity and phonation, although this was not found for all measures. Clinically significant improvements were found for intensity range in read speech and fundamental frequency variation, while the improvement in fundamental frequency in read speech was possibly clinically significant.
Yinger, 2016	There was some evidence that singing significantly improved intensity, but this was not found for all measures. There was no evidence that singing significantly improved phonation.

Theatre	
Mirabella, 2017	There was evidence that theatre was significantly more effective than physiotherapy in improving quality of life (including emotional wellbeing). Neither the theatre nor the physiotherapy group improved significantly in terms of motor function or cognition.
Modugno, 2010	There was evidence that theatre significantly improved motor function and quality of life, whereas physiotherapy did not.

ADL = Activities of daily living, TUG = Timed Up and Go, UPDRS = Universal Parkinson's Disease Rating Scale.

February 2024 search

First author, year	Narrative results
Dance	
Bouquiaux, 2022	There was evidence that dance training improved one measure of motor function (10-metre test), but not cognition or other motor measures.
Delabary, 2020	There was evidence that Samba and Forró Brazilian rhythmic dance improved functional mobility, although the benefit was not greater than a group walking intervention.
Duarte, 2023	There was evidence that the Baila Parkinson method improved balance and gait, executive function, abstract reasoning and inhibitory control and quality of life.
Feenstra, 2022	There was evidence that dance classes improved quality of life (including self-esteem) and motor function. However, there was no significant change in balance confidence.
Fisher, 2020	There was some evidence that improvisational dance improved motor function and cognition, although this was not shown on all measures.
Fontanesi, 2021	There was evidence that Dance for Parkinson's improved body self-efficacy, gait symmetry and motor dual task performance.
Frisaldi, 2021	There was evidence that the DArT method improved motor performance (on the primary outcome, but not all secondary outcomes). However, there was no evidence of an improvement in cognition or quality of life over and above conventional therapy.
Haas, 2024a	There was some evidence that Brazilian dance improved motor function over and above deep-water exercise and Nordic walking, but not on all measures. There was no evidence of a significant difference in quality of life or cognition.
Haputhanthirige, 2023	There was evidence that Dance for Parkinson's improved dual task motor performance and most (but not all) gait analysis parameters.
Harrison, 2020	There was evidence that walking dance improved most (but not all) measures of gait. No evidence of a benefit on quality of life was shown.
Jola, 2022	There was evidence that Dance for Parkinson's improved motor function.
Lihala, 2021	There was evidence that dance movement therapy improved cognitive status and quality of life. Improvements in motor function did not reach statistical significance.
Moratelli, 2021, 2022	There was evidence that both binary and quaternary dance improved cognition, mental activity, activities of daily living and overall quality of life. Both rhythms improved motor function and balance, but only binary rhythm was shown to improve freezing of gait.
Moratelli, 2023	Evidence for a benefit of dance compared to control was stronger for samba at a higher frequency compared to the combined samba and fosso brasiliero intervention. Comparing samba and control, statistically significant benefit for samba was found for motor function and for the mobility subscale of PDQ-39. However, no overall significant benefit on quality of life was found.
Park, 2023	There was no evidence that vocal dance led to a statistically significant improvement in voice parameters, communication, voice-related or overall quality of life.
Peter, 2020	There was evidence that Argentine tango reduced falls risk. Improvements in overall motor function, freezing of gait and quality of life did not reach statistical significance.

Pinto, 2023	There was no evidence that online dance significantly improved motor function or quality of life in the PD group – however the study was primarily designed to assess feasibility not efficacy.
Rabinovich, 2021	There was evidence that high dose tango improved motor function as well as activities of daily living, sleep confidence and relatedness.
Tillmann, 2020	There was evidence that Brazilian samba improved motor function. There was some evidence of a benefit on quality of life – shown on the activities of daily living subscale of UPDRS and the mobility subscale of PDQ-39, but not on other subscales or the overall PDQ-39 score.
Valverde-Guijarro, 2022	There was evidence that the contemporary dance programme improved most (but not all) motor measures including functional mobility and balance. There was some evidence of a benefit on measures of aspects of cognitive functioning.
Walton, 2022	There was evidence that digital dance for Parkinson's improved physical functioning, memory and quality of life. It was noted however that some important elements of live dance were missing.
Music therapy	
Bastepe-Gray, 2022	There was evidence that the guitar intervention significantly improved motor function. There was a numerical improvement in quality of life, but statistical significance was not reached. There was no significant difference between early and late intervention groups and participants experienced benefits in motor function before the start of guitar lessons. Within the early intervention group alone, a clinically significant difference in quality of life was found (it was only statistically significant in unadjusted analysis).
Pohl, 2020	There was evidence that the Ronnie Gardiner method improved quality of life and confidence about falling in the short term, but these gains were not retained at three months. No significant improvements were shown in cognitive status, balance, dual-task motor performance and freezing of gait.
Shah-Zamora, 2024	There was no evidence that virtual music therapy significantly improved quality of life (including functional abilities) or cognition.
Singing	
Brooks, 2021	There was some evidence that therapeutic group singing improved voice, although it was not shown on all measures. Around half of participants improved their voice on singing. Improvements in cough and communication did not reach statistical significance.
Butala, 2022	There was evidence that group singing significantly improved motor function, some measures of voice and quality of life domains related to emotional wellbeing and body discomfort. There was however no evidence of an improvement on other voice measures as well as both voice-related and overall quality of life or cognitive status.
Good, 2023	There was evidence that community choir signing improved some but not all measures of vocal production.
Lee, 2024	There was evidence that therapeutic group singing improved acoustic and perceived voice quality. This effect was observed for the singing intervention both alone or in combination with straw phonation compared to control. Follow-up scores were not reported for communication or voice-related quality of life.
Lewellen, 2020	There was evidence that group singing therapy improved vocal function.
Stegemöller, 2020	Improvements in vocal measures following group therapeutic singing telehealth did not reach statistical significance.
Stegemöller, 2021, 2022, 2023	There was evidence that a single session of group therapeutic singing improved respiratory control and quality of life. There were some, but not consistent, evidence of a benefit on motor function. No evidence of a significant benefit on speech and facial expression was found.
Tamplin, 2020	There was evidence that both weekly and monthly singing improved standardised and conversational speech loudness, although the benefit was greater and took effect earlier for weekly singing. There were no statistically significant differences in respiratory measures relevant to speech, although weekly singers experienced a clinically significant improvement in maximum expiratory pressure. Between-group differences were found on one measure of speech intelligibility, although this appeared largely attributable to performance declines in the monthly control group. Voice-related quality of life improved significantly for weekly singers only. No statistically significant differences in overall quality of life were observed.
Theatre	
Bega, 2017*	Improvisational theatre was not associated with a statistically significant improvement in motor function or quality of life, although a trend ($p<0.1$) was shown on the PDQ-39 scale.

* Identified through citation chasing of February 2024 search results. Included to ensure the evidence base is as complete as possible

February 2025 search

First author, year	Narrative results
Dance	
Haas, 2024b	Dance improved turning at fast (but not comfortable) walking speed.
Kristen, 2024	Dance for Parkinson's was shown to improve balance and quality of life (wellbeing).
Kunte, 2024	Culturally informed dance movement therapy improved motor function and quality of life (although statistical significance was not met p=0.06) but did not improve most cognitive measures.
Mehta, 2024	There is evidence that Garba dance improved motor function, including balance and freezing of gait, while the minor improvement in cognitive function was not statistically significant.
Music therapy	
Wainwright, 2024	Drumming improved motor function but not quality of life (including social satisfaction, which declined), however due to small sample sizes, only descriptive statistics were presented, and no statistical tests were used.
Singing	
Tamplin, 2024	Singing did not improve speech (voice), quality of life or motor outcomes. This was a small pilot, focused on establishing feasibility and tolerability.
Theatre	
[None]	

Supplementary file 12. SURE assessment for experimental studies

Barnish & Barran (2020) search

a. Dance studies

SURE critical appraisal checklist questions	De Natale, 2017	Duncan, 2014	Duncan, 2012; Foster, 2013	Hackney, 2007a,b	Hackney, 2008a,b,c	Hackney, 2010
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	Yes, NS.	Yes, online.	Yes, NS.	Yes, hat.	Yes, hat.
Was allocation to intervention or comparator groups concealed?	No.	No.	No.	No	Yes – in so far as participants didn't know study purpose.	Yes – in so far as participants didn't know study purpose.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	NS, yes.	No, yes.	No, yes.	No, yes.	No, yes.	Participants, yes.
Were interventions (and comparisons) well described and appropriate?	Yes.	Unclear.	Yes.	Yes.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Unclear, was in line with policies.	Yes.	NS.	Yes.	Yes.

Was a trial protocol published?	NS.	NS.	Yes.	NS.	NS.	NS.
Were the groups similar at the start of the trial?	Yes.	Yes.	Yes.	Unclear.	Yes.	Yes.
Was the sample size sufficient?	Unclear.	Unclear.	Yes.	Unclear.	Unclear.	Yes.
Were participants properly accounted for?	Unclear.	Unclear.	Unclear.	Unclear.	Unclear.	Yes.
Are the statistical methods well described?	No.	Unclear.	Unclear.	No.	Unclear.	Unclear.
Results appropriate and clear?	Yes.	Yes.	Yes.	Unclear.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	Charity, no conflict.	Charity, no conflict.	Charity and academic, no conflict.	Charity, no conflict.	Charity and state, no conflict.	Charity and state, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	No.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	No, abstract stronger.	No, full text stronger.	No, full text stronger.	Unclear.	Unclear.	Unclear.

SURE critical appraisal checklist questions	Hashimoto, 2015	Hulbert, 2017; Kunkel, 2017	Kalyani, 2019	Lee, 2018	Mcgill, 2019	McKee, 2013
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	Yes, coin.	Yes, phone.	No.	Yes, online.	No.	No.
Was allocation to intervention or comparator groups concealed?	No.	No.	No.	No.	No.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No, yes.	No, no.	No, no.	No, yes.	No, no.	No, partly.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was a trial protocol published?	NS.	NS.	Yes.	NS.	NS.	NS.

Were the groups similar at the start of the trial?	Yes.	Yes.	Yes.	Yes.	Unclear.	Yes.
Was the sample size sufficient?	Yes.	Yes.	Yes.	Unclear.	Unclear.	No.
Were participants properly accounted for?	Unclear.	No.	Unclear.	Yes.	Unclear.	Unclear.
Are the statistical methods well described?	Unclear.	Unclear.	Unclear.	Unclear.	Unclear.	Yes.
Results appropriate and clear?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	No funding.	Academic, no conflict.	Academic, dance teaching conflicts declared.	State, no conflict.	Academic, state and commercial, no conflict declared.	State, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Unclear.	Yes.	Yes.	No, full text stronger.	Unclear.	Unclear.

SURE critical appraisal checklist questions	McNeely, 2015	Michels, 2018a,b	Rawson, 2019	Rocha, 2018	Roncaglio, 2015	Shanahan, 2017
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	Yes, online.	No.	Yes, online.	Yes, online.	Yes, envelopes.
Was allocation to intervention or comparator groups concealed?	No.	No.	No.	Yes, in so far as they were blind to aims.	Unclear.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	NS.	No, yes.	No, yes.	Dance teachers yes, yes.	Unclear, no.	No, yes.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.

Was ethical approval sought and received?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was a trial protocol published?	NS.	NS.	NS.	NS.	Yes.	Yes.
Were the groups similar at the start of the trial?	Yes.	No.	Yes.	Yes.	Yes.	Yes.
Was the sample size sufficient?	Unclear.	No.	Yes.	Unclear.	Unclear.	Yes.
Were participants properly accounted for?	Unclear.	Unclear.	Unclear.	Yes.	Yes.	No.
Are the statistical methods well described?	Yes.	Unclear.	Yes.	Yes.	Yes.	Unclear.
Results appropriate and clear?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	State, no conflict.	No funding. One author declares commercial conflicts.	Charity, state and academic, no conflict.	Academic and commercial, no conflict declared.	Charity and state, the authors declare no conflict of interest for the study.	NS.
Did the authors identify any limitations?	Yes.	Yes.	No.	Yes.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Unclear.	Unclear.	Unclear.	Yes.	No, abstract stronger.	Yes.

SURE critical appraisal checklist questions	Solla, 2019	Ventura, 2016	Volpe, 2017	Westbrook, 1989	Zafar, 2017
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.	Unclear.	Yes.
Was the population randomised? If yes, were appropriate methods used?	Yes, online.	No.	Yes, online.	No.	No.
Was allocation to intervention or comparator groups concealed?	No.	No.	No.	No – cross-over.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No, yes.	No, yes.	No, yes.	No – cross-over.	NS.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.	Yes.	NS.	Yes.
Was a trial protocol published?	NS.	NS.	Yes.	NS.	NS.

Were the groups similar at the start of the trial?	Yes.	Unclear.	Yes.	Yes.	Unclear.
Was the sample size sufficient?	Yes.	No.	Unclear.	Unclear.	Unclear.
Were participants properly accounted for?	Unclear.	Unclear.	Unclear.	Unclear.	Unclear.
Are the statistical methods well described?	Unclear.	Unclear.	No.	Unclear.	No.
Results appropriate and clear?	Yes.	No.	Yes.	Unclear.	Yes.
Is there any sponsorship/conflict of interest stated?	Charity, no conflict.	Charity, state and academic, no conflict.	Not stated, no conflict declared.	Charity, no conflict	Charity, state and academic, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Unclear.	Unclear.	No, abstract stronger.	Unclear.	No.

25 trials in total – quality assessment could not be undertaken for Hackney, 2018 and Patel, 2018 as they comprised only an abstract.

b. Music therapy studies

SURE critical appraisal checklist questions	Pacchetti, 2000	Pantelyat, 2016	Pohl, 2013	Spina, 2016
Does the study address a clearly focused question/hypothesis?	Unclear.	Unclear.	Yes.	Unclear.
Was the population randomised? If yes, were appropriate methods used?	Yes, online.	No.	Yes, online.	Yes, NS.
Was allocation to intervention or comparator groups concealed?	No.	No.	No.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No, yes.	No, yes.	No, yes.	No, yes.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.	No.
Was ethical approval sought and received?	NS.	Yes.	Yes.	NS.
Was a trial protocol published?	NS.	NS.	NS.	NS.

Were the groups similar at the start of the trial?	Unclear.	Yes.	Yes.	Yes.
Was the sample size sufficient?	Unclear.	Unclear.	Yes.	Unclear.
Were participants properly accounted for?	Unclear.	Unclear.	Unclear.	Unclear.
Are the statistical methods well described?	Yes.	No.	No.	No.
Results appropriate and clear?	Yes.	Yes.	No.	No.
Is there any sponsorship/conflict of interest stated?	State, no conflict.	Charity, academic and state, no conflict.	Academic and state, no conflict.	NS, no conflict declared.
Did the authors identify any limitations?	No.	Yes.	Yes.	No.
Are the conclusions the same in the abstract and full text?	Unclear.	No, abstract stronger.	No, abstract stronger.	No abstract.

4 trials in total.

c. Singing studies

SURE critical appraisal checklist questions	Tamplin, 2019
Does the study address a clearly focused question/hypothesis?	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.
Was allocation to intervention or comparator groups concealed?	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No, partly.
Were interventions (and comparisons) well described and appropriate?	No – weekly and monthly controls were different activities. Weekly and monthly interventions had leaders with different backgrounds.
Was ethical approval sought and received?	Yes.
Was a trial protocol published?	Yes.

Were the groups similar at the start of the trial?	Unclear.
Was the sample size sufficient?	Yes.
Were participants properly accounted for?	Unclear.
Are the statistical methods well described?	No.
Results appropriate and clear?	Yes.
Is there any sponsorship/conflict of interest stated?	Charity and academic, no conflict
Did the authors identify any limitations?	Yes.
Are the conclusions the same in the abstract and full text?	Yes.

2 trials in total – quality assessment could not be undertaken for Matthews, 2018 as it comprised only an abstract.

d. Theatre studies

SURE critical appraisal checklist questions	Mirabella, 2017	Mongugno, 2010
Does the study address a clearly focused question/hypothesis?	Unclear.	Unclear.
Was the population randomised? If yes, were appropriate methods used?	No.	No, online.
Was allocation to intervention or comparator groups concealed?	Yes, in so far as participants were not told that the other group involved.	Yes, in so far as participants were not told that the other group involved.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No, yes.	No, yes.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.
Was a trial protocol published?	NS.	NS.

Were the groups similar at the start of the trial?	Yes.	Yes.
Was the sample size sufficient?	Unclear.	Unclear.
Were participants properly accounted for?	Unclear.	Unclear.
Are the statistical methods well described?	Yes.	Unclear.
Results appropriate and clear?	Yes.	Unclear.
Is there any sponsorship/conflict of interest stated?	Charity, no conflict.	Stated, no conflict.
Did the authors identify any limitations?	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Unclear.	Unclear.

2 trials in total. NS = not stated. 'Online' randomisation refers to randomisation techniques using computerised algorithms.

February 2024 search

Assessment could not be conducted for any studies that comprise solely a conference abstract.

a. Dance studies

SURE critical appraisal checklist questions	Bouquiaux, 2022	Delabary, 2020	Frisaldi, 2021	Haas, 2024a	Moratelli, 2021/2022	Moratelli, 2023
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	No.	Yes, computer-generated random numbers.	Yes, online randomisation tool.	Yes, using Excel software.	No.
Was allocation to intervention or comparator groups concealed?	No.	No.	No.	No.	Unclear.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No.	No.	Assessors only.	Assessors and statisticians.	Unclear.	No.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Was a trial protocol published?	NS.	Yes.	NS.	Yes.	Yes.	Yes.
Were the groups similar at the start of the trial?	Yes.	Unclear.	Yes.	Yes.	Yes.	Yes.

Was the sample size sufficient?	NS.	Yes.	Unclear.	Unclear.	Unclear.	Yes.
Were participants properly accounted for?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Are the statistical methods well described?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Results appropriate and clear?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	NS, no conflict.	'Funded by the authors'. Motivation for this NS. However, does say no conflicts.	Academic, no conflict.	Academic, no conflict.	Academic, no conflict.	Academic, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Yes.	Yes.	Unclear, no separate conclusion section.	Yes.	Yes.	Yes.

SURE critical appraisal checklist questions	Peter, 2020	Pinto, 2023	Tillmann, 2020
Does the study address a clearly focused question/hypothesis?	No.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	No.	No.

Was allocation to intervention or comparator groups concealed?	No.	No.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No.	No.	No.
Were interventions (and comparisons) well described and appropriate?	Not well described.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.	Yes.
Was a trial protocol published?	Unclear.	Yes.	Yes.
Were the groups similar at the start of the trial?	Unclear.	Unclear.	Yes.
Was the sample size sufficient?	Unclear.	Unclear.	Yes.
Were participants properly accounted for?	Unclear.	Yes.	Yes.
Are the statistical methods well described?	No.	Yes.	Yes.
Results appropriate and clear?	No – unclear presentation.	Yes.	Yes.

Is there any sponsorship/conflict of interest stated?	Academic, no conflict.	Academic, one author declared being the director of a national Dance for Parkinson's programme	NS, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Unclear, no separate conclusions section.	No, full text stronger.	No, full text stronger.

b. Music therapy studies

SURE critical appraisal checklist questions	Bastepe-Grey, 2023	Pohl, 2020
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	Yes, stepped wedge.	Yes, random number website.

Was allocation to intervention or comparator groups concealed?	No.	No.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	Assessors only.	Assessors only.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.
Was a trial protocol published?	NS.	Yes.
Were the groups similar at the start of the trial?	Yes.	Yes.
Was the sample size sufficient?	Unclear.	Yes.
Were participants properly accounted for?	Yes.	Yes.
Are the statistical methods well described?	Yes.	Yes.
Results appropriate and clear?	Yes.	Yes.

Is there any sponsorship/conflict of interest stated?	Academic, no conflicts.	Academic and charity, one conflict declared regarding being a non-practising certified practitioner of Ronnie Gardiner method (the person was blind to outcome assessments).
Did the authors identify any limitations?	Yes.	Yes.
Are the conclusions the same in the abstract and full text?	Yes.	Unclear, no separate conclusion.

c. Singing studies

SURE critical appraisal checklist questions	Brooks, 2021	Butala, 2022	Lee, 2024	Stegemoller, 2021/2022/2023
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	Yes, Excel random number generator.	Yes, NS.	No.
Was allocation to intervention or comparator groups concealed?	No.	No.	NS.	No.

Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	No.	Assessors only.	NS.	No.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.	Yes.	Yes.
Was a trial protocol published?	NS.	Yes.	NS.	NS.
Were the groups similar at the start of the trial?	Yes.	Yes.	Yes.	Yes.
Was the sample size sufficient?	Unclear.	Unclear.	Unclear.	No.
Were participants properly accounted for?	Yes.	Yes.	Yes.	Yes.
Are the statistical methods well described?	No.	Yes.	Yes.	Yes.
Results appropriate and clear?	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	NS.	NS, no conflicts.	NS.	Museum, no conflict.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.

Are the conclusions the same in the abstract and full text?	No, full text stronger.	Yes.	Yes.	No, abstract stronger.

d. Theatre studies

SURE critical appraisal checklist questions	Bega, 2017*
Does the study address a clearly focused question/hypothesis?	Yes.
Was the population randomised? If yes, were appropriate methods used?	Yes, unclear.
Was allocation to intervention or comparator groups concealed?	Unclear.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	Yes (single blind)
Were interventions (and comparisons) well described and appropriate?	Yes.
Was ethical approval sought and received?	Yes.

Was a trial protocol published?	Unclear.
Were the groups similar at the start of the trial?	Yes.
Was the sample size sufficient?	Unclear.
Were participants properly accounted for?	Yes.
Are the statistical methods well described?	Yes.
Results appropriate and clear?	Yes.
Is there any sponsorship/conflict of interest stated?	Some authors are employees of the improvisational dance company.
Did the authors identify any limitations?	Yes
Are the conclusions the same in the abstract and full text?	No, abstract stronger

* Identified through citation chasing of February 2024 search results. Included to ensure the evidence base is as complete as possible

February 2025 search

a. Dance studies

SURE critical appraisal checklist questions	Haas, 2024b	Kunte, 2024	Mehta, 2024
Does the study address a clearly focused question/hypothesis?	Yes.	Yes.	Yes.
Was the population randomised? If yes, were appropriate methods used?	No.	No.	Yes, unclear.
Was allocation to intervention or comparator groups concealed?	No.	No.	Unclear.
Were participants/ investigators blinded to group allocation? If no, was assessment of outcomes blinded?	Assessors blinded.	Unclear.	No.
Were interventions (and comparisons) well described and appropriate?	Yes.	Yes.	Yes.
Was ethical approval sought and received?	Yes.	Yes.	Yes.
Was a trial protocol published?	Unclear.	Unclear.	Unclear.
Were the groups similar at the start of the trial?	Yes, mainly, though a statistically significant difference in age.	Yes.	Yes.

Was the sample size sufficient?	Yes.	Unclear.	Unclear.
Were participants properly accounted for?	Yes.	Unclear.	Unclear.
Are the statistical methods well described?	Yes.	Yes.	Yes.
Results appropriate and clear?	Yes.	Yes.	Yes.
Is there any sponsorship/conflict of interest stated?	No conflict.	No conflict.	No conflict.
Did the authors identify any limitations?	Yes.	No.	Yes.
Are the conclusions the same in the abstract and full text?	Yes.	Yes.	Yes.

b. Music therapy studies
[None]

c. Singing studies
[None]

d. Theatre studies
[None]

Supplementary file 13. SURE assessment for observational studies

Rows for studies included in the Barnish & Barran (2020) review in the characteristics, intervention, control, results and risk of bias tables, as well as in the included studies list, were originally published in the Barnish & Barran (2020) paper.[5] This paper is open access (Creative Commons Attribution 4.0 International License) and the copyright rests with the authors. The corresponding author – Dr Barnish – who is also the corresponding author of this manuscript – grants permission for the replication of these rows to aid clarity of reporting.

Barnish & Barran (2020) search

a. Dance studies

SURE critical appraisal checklist questions	Allen, 2017; McKay, 2016	Batson, 2010	Batson, 2014	Bearss, 2017	Blandy, 2015
Is the study design clearly stated?	Yes.	Yes.	Yes.	Unclear.	Yes.
Does the study address a clearly focused question?	Yes.	Unclear.	Yes.	Unclear.	Yes.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.	Partly.	Partly.
Were participants fairly selected?	No.	No.	Unclear.	Unclear.	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.
Was bias considered?	Yes.	Unclear.	Unclear.	Unclear.	Yes.
Is there a description of how the study size was arrived at?	Yes.	No.	No.	No.	Unclear.

Are the statistical methods well described?	Yes.	No.	No.	No.	No.
Is information provided on participant flow?	Yes.	Partly.	No.	Partly.	Yes.
Are the results well described?	Yes.	No.	No.	Partly.	Yes.
Is there any sponsorship/ conflict of interest reported?	Charity, state and academic, no conflict.	Academic, no conflict.	NS, no conflict declared.	Charity and academic, no conflict.	No funding.
Did the authors identify any limitations?	Yes.	No.	Yes.	No.	Yes.

SURE critical appraisal checklist questions	Clifford, 2017	Heiberger, 2011	Koch, 2016	McRae, 2018	Marchant, 2010
Is the study design clearly stated?	No.	Unclear.	Yes.	Unclear.	Yes.
Does the study address a clearly focused question?	No.	Unclear.	Yes.	Unclear.	Yes.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Yes.	Partly.	Partly.
Were participants fairly selected?	Unclear.	Unclear.	Unclear.	Unclear.	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Unclear – dance classes attended by some participants were translated.	Yes.	Yes.
Was bias considered?	Unclear.	Unclear.	Yes.	Yes.	Unclear.
Is there a description of how the study size was arrived at?	No.	No.	Partly.	No.	No.
Are the statistical methods well described?	No.	No.	No.	Yes.	Yes.

Is information provided on participant flow?	Partly.	No.	No.	No.	No.
Are the results well described?	Partly.	Partly.	Yes.	Partly.	Partly.
Is there any sponsorship/ conflict of interest reported?	'External funding', no conflict declared.	NS, no conflict declared.	No funding.	NS, no conflict declared.	Charity and academic, no conflict.
Did the authors identify any limitations?	Partly.	Partly.	Yes.	Yes.	Yes.

SURE critical appraisal checklist questions	Prewitt, 2017	Shanahan, 2015	Westheimer, 2015
Is the study design clearly stated?	Unclear.	No.	Yes.
Does the study address a clearly focused question?	Yes.	Yes.	Unclear.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.
Were participants fairly selected?	Unclear.	Unclear.	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.
Was bias considered?	Unclear.	Unclear.	Unclear.
Is there a description of how the study size was arrived at?	No.	No.	Partly.

Are the statistical methods well described?	Yes.	No.	Unclear.
Is information provided on participant flow?	No.	No.	
Are the results well described?	Yes.	Partly.	Partly.
Is there any sponsorship/ conflict of interest reported?	NS, no conflict declared.	NS, no conflict declared.	NS, no conflict declared.
Did the authors identify any limitations?	Yes.	Yes.	Yes.

13 studies in total.

b. Music therapy studies

No cohort studies.

c. Singing studies

SURE critical appraisal checklist questions	Azekawa, 2018	Di Benedetto, 2009	Elefant, 2012a,b	Evans, 2012	Higgins, 2019
Is the study design clearly stated?	Yes.	Yes.	Yes.	Yes.	Partly.
Does the study address a clearly focused question?	Partly.	Yes.	Yes.	Yes.	Yes.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.	Yes, except the exact venue.	Partly.
Were participants fairly selected?	Unclear.	Yes, probably.	Unclear.	Unclear.	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.
Was bias considered?	Yes.	Unclear.	Unclear.	Unclear.	Unclear.
Is there a description of how the study size was arrived at?	No.	No.	No.	No.	No.

Are the statistical methods well described?	No.	No.	No.	No.	No.
Is information provided on participant flow?	Partly.	No.	No.	No.	No.
Are the results well described?	Yes.	No.	Partly.	Partly.	Partly.
Is there any sponsorship/ conflict of interest reported?	NS.	Charity, no conflict.	NS.	NS.	No funding.
Did the authors identify any limitations?	Yes.	Partly.	Yes.	Yes.	Yes.

SURE critical appraisal checklist questions	Irons 2019, 2020	Shih, 2012	Stegemöller, 2017a,b	Tanner, 2016	Yinger, 2016
Is the study design clearly stated?	Yes.	Yes.	Yes.	Partly.	Yes.
Does the study address a clearly focused question?	Yes.	Unclear.	Yes.	Yes.	Yes.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.	Partly.	Partly.
Were participants fairly selected?	No.	Unclear.	Unclear.	Unclear.	No.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.
Was bias considered?	Yes.	No.	Unclear.	Yes.	Unclear.
Is there a description of how the study size was arrived at?	No.	Yes, although design was changed.	No.	Partly.	No.
Are the statistical methods well described?	Unclear.	No.	Unclear.	Unclear.	No.

Is information provided on participant flow?	Partly.	Partly.	No.	No.	No.
Are the results well described?	Yes.	Yes.	Partly.	Partly.	Partly.
Is there any sponsorship/ conflict of interest reported?	Charity and academic, no conflict.	Charity, state, academic and commercial, no comment on conflict.	Charity, no conflict.	Charity, no conflict.	NS.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.

10 studies in total.

d. Theatre studies

No cohort studies. NS = Not stated. Note: In Evans et al (2012), the acknowledgements provide the name of the partner of the participants and say that this partner provided 'organizational support' to the study. No further information on this was available.

February 2024 search

a. Dance studies

SURE critical appraisal checklist questions	Duarte, 2023	Feenstra, 2022	Fisher, 2020	Fontaine, 2021	Haputhanthirige, 2023
Is the study design clearly stated?	Yes.	Yes.	No.	Yes.	Yes.
Does the study address a clearly focused question?	Yes.	Yes.	Yes.	Yes.	Yes.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.	Partly.	Partly.
Were participants fairly selected?	Unclear.	Unclear.	Unclear.	Unclear.	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.

Was bias considered?	Yes.	Unclear.	Unclear.	Yes.	Unclear.
Is there a description of how the study size was arrived at?	No.	No.	No.	No.	Yes.
Are the statistical methods well described?	No.	No.	Partly.	Yes.	Yes.
Is information provided on participant flow?	Yes.	Yes.	No.	No.	Yes.
Are the results well described?	Yes.	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/ conflict of interest reported?	Academic, no conflict.	Academic, one author developed the dance classes.	Academic, no conflict.	Academic, no conflict.	Academic, one author declares being national director of Dance for Parkinson's.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.

SURE critical appraisal checklist questions	Harrison, 2020	Jola, 2022	Lihala, 2021	Rabinovich, 2021	Valverde-Guijarro, 2022

Is the study design clearly stated?	Yes.	Yes.	Yes.	Yes.	Yes.
Does the study address a clearly focused question?	Yes.	Yes.	Yes.	Yes.	Yes.
Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.	Partly.	Partly.
Were participants fairly selected?	Unclear.	No.	No.	Unclear.	Yes (consecutive).
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.	Yes.	Yes.
Was bias considered?	Yes.	Unclear.	Unclear.	Yes.	Yes.
Is there a description of how the study size was arrived at?	No.	No – says 'not practical' to define a sample size.	No.	No.	No.
Are the statistical methods well described?	No.	Yes.	No.	No.	Yes.
Is information provided on participant flow?	Partly.	No.	Yes.	Partly.	Partly.

Are the results well described?	Yes.	Yes.	Yes.	Yes.	Yes.
Is there any sponsorship/ conflict of interest reported?	No funding declared, no conflicts.	Academic, no conflicts.	Institutional, no conflicts.	Academic, no conflicts.	NS, no conflicts.
Did the authors identify any limitations?	Yes.	Yes.	Yes.	Yes.	Yes.

SURE critical appraisal checklist questions	Walton, 2022
Is the study design clearly stated?	Yes.
Does the study address a clearly focused question?	Yes.
Are the setting, locations and relevant dates provided?	Partly.
Were participants fairly selected?	Unclear.

Are the measures of exposures and outcomes appropriate?	Yes.
Was bias considered?	Unclear.
Is there a description of how the study size was arrived at?	No.
Are the statistical methods well described?	Yes.
Is information provided on participant flow?	Yes.
Are the results well described?	Yes.
Is there any sponsorship/ conflict of interest reported?	Academic, no conflict.
Did the authors identify any limitations?	Yes.

b. Music therapy studies

SURE critical appraisal checklist questions	Shah-Zamora, 2024
Is the study design clearly stated?	Yes.
Does the study address a clearly focused question?	Yes.
Are the setting, locations and relevant dates provided?	Yes.
Were participants fairly selected?	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.
Was bias considered?	Yes.
Is there a description of how the study size was arrived at?	Yes.
Are the statistical methods well described?	Yes.

Is information provided on participant flow?	Yes.
Are the results well described?	Yes.
Is there any sponsorship/ conflict of interest reported?	Academic, no conflict.
Did the authors identify any limitations?	Yes.

c. ***Singing studies***

SURE critical appraisal checklist questions	Good, 2023	Lewellen, 2020	Stegemoller, 2020
Is the study design clearly stated?	No.	Yes.	No.
Does the study address a clearly focused question?	Yes.	Yes.	Yes.

Are the setting, locations and relevant dates provided?	Partly.	Partly.	Partly.
Were participants fairly selected?	Unclear.	No.	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.	Yes.	Yes.
Was bias considered?	Unclear.	Unclear.	Unclear.
Is there a description of how the study size was arrived at?	No.	No.	No.
Are the statistical methods well described?	Yes.	No.	No.
Is information provided on participant flow?	Partly.	No.	Partly.
Are the results well described?	Yes.	Yes.	Yes.
Is there any sponsorship/ conflict of interest reported?	Academic, conflicts NS.	NS.	NS, no conflict.

Did the authors identify any limitations?	Yes.	NS.	Yes, but not clearly stated.

d. Theatre studies

[None]

February 2025 search

a. Dance studies

SURE critical appraisal checklist questions	Kristen, 2024
Is the study design clearly stated?	Yes.
Does the study address a clearly focused question?	Yes.
Are the setting, locations and relevant dates provided?	Partly.
Were participants fairly selected?	Unclear.

Are the measures of exposures and outcomes appropriate?	Yes.
Was bias considered?	Unclear.
Is there a description of how the study size was arrived at?	Unclear.
Are the statistical methods well described?	No.
Is information provided on participant flow?	No.
Are the results well described?	Yes.
Is there any sponsorship/ conflict of interest reported?	No conflict.
Did the authors identify any limitations?	Yes.

b. Music therapy studies

SURE critical appraisal checklist questions	Wainwright, 2024
Is the study design clearly stated?	Yes.
Does the study address a clearly focused question?	Yes.
Are the setting, locations and relevant dates provided?	Partly.
Were participants fairly selected?	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.
Was bias considered?	Unclear.
Is there a description of how the study size was arrived at?	No.
Are the statistical methods well described?	Partly.

Is information provided on participant flow?	No.
Are the results well described?	Yes.
Is there any sponsorship/ conflict of interest reported?	No conflict.
Did the authors identify any limitations?	Yes

c. Singing studies

SURE critical appraisal checklist questions	Tamplin, 2024
Is the study design clearly stated?	Yes.
Does the study address a clearly focused question?	Yes.

Are the setting, locations and relevant dates provided?	Partly.
Were participants fairly selected?	Unclear.
Are the measures of exposures and outcomes appropriate?	Yes.
Was bias considered?	Unclear.
Is there a description of how the study size was arrived at?	Unclear.
Are the statistical methods well described?	Yes.
Is information provided on participant flow?	Yes.
Are the results well described?	Yes.
Is there any sponsorship/ conflict of interest reported?	Conflict.

Did the authors identify any limitations?	Yes.

d. Theatre studies
[None]

Supplementary file 14. CRD assessment for RCTs included in meta-analysis

	Duncan, 2012/ Foster, 2013	Hackney, 2007a,b	Hackney, 2009a,b,c	Hashimoto, 2015	Modugno, 2010	Romenets, 2015
Was the method used to generate random allocations adequate?	Yes.	Unclear.	Yes.	Yes.	Yes.	Yes.
Was the allocation adequately concealed?	No.	No.	Yes.	No.	Yes.	Unclear.
Were the groups similar at the outset of the study in terms of prognostic factors, e.g. severity of disease?	Yes.	Unclear.	Yes.	Yes.	Yes.	Unclear.
Were the care providers, participants and outcome assessors blind to treatment allocation? If any of these people were not blinded, what might be the likely impact on the risk of bias (for each outcome)?	Only outcome assessors were blinded. Interven tions look different, so difficult to blind. May result in performance bias.	Only outcome assessors were blinded. Interven tions look different, so difficult to blind. May result in performance bias.	Only outcome assessors were blinded. Interven tions look different, so difficult to blind. May result in performance bias.	Only outcome assessors were blinded. Interven tions look different, so difficult to blind. May result in performance bias.	Only outcome assessors were blinded. Interven tions look different, so difficult to blind. May result in performance bias.	Only outcome assessors were blinded. Interven tions look different, so difficult to blind. May result in performance bias.
Were there any unexpected imbalances in drop-outs between groups? If so, were they explained or adjusted for?	Unclear.	Unclear.	Unclear.	Unclear.	Unclear	Unclear.

Is there any evidence to suggest that the authors measured more outcomes than they reported?	No.	No.	No.	No.	No.	No.
Did the analysis include an intention to treat analysis? If so, was this appropriate and were appropriate methods used to account for missing data?	Yes, yes, no (last observation carried forward).	Unclear.	Unclear.	Unclear.	Unclear.	Yes, yes, no (last observation carried forward).

CRD = University of York Centre for Reviews and Dissemination; RCT = randomised controlled trial

Supplementary file 15. NOS assessment for non-randomised trials and observational studies included in the meta-analysis

Note: A study can be awarded a maximum of one star (*) for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability.

	De Natale, 2017	Fontanesi, 2021	Kalyani, 2019	Mirabella, 2017	Moratelli, 2021	Tillmann, 2020	Ventura, 2016
Selection							
Representativeness of exposed cohort	No description	Somewhat representative*	Somewhat representative*	Somewhat representative*	Somewhat representative*	Somewhat representative*	Somewhat representative*
Selection of non-exposed cohort	Same community*	Same community*	Same community*	Same community*	Same community*	Same community*	Same community*
Ascertainment of exposure	Secure record*	Secure record*	Secure record*	Secure record*	Secure record*	Secure record*	Secure record*
Demonstration that outcome of interest was not present at start of study	No	No	No	No	No	No	No
Comparability							
Comparability of cohorts on the basis of the design or analysis	Groups similar at baseline* (comparability on basis of design) but no specific control factors in the statistical analysis (comparability on basis of analysis)	Single-group cross-over design precludes effect of any group differences at baseline* (comparability on basis of design) and means it is not necessary to have control factors in	Groups similar at baseline* (comparability on basis of design) and says the statistical analysis was demographically adjusted* (comparability on basis of analysis)	Groups similar at baseline* (comparability on basis of design) but no specific control factors in the statistical analysis (comparability on basis of analysis)	Groups similar at baseline* (comparability on basis of design) but no specific control factors in the statistical analysis (comparability on basis of analysis)	Groups similar at baseline* (comparability on basis of design) but no specific control factors in the statistical analysis (comparability on basis of analysis)	Unclear whether groups similar at baseline (comparability on basis of design) and no specific control factors in the statistical analysis (comparability on basis of design)

		the statistical analysis* (comparability on basis of analysis)					
Outcome							
Assessment of outcome	Independent assessment*, self-report	Independent assessment*, self-report	Independent assessment*, self-report	Independent assessment*, self-report	Independent assessment*, self-report	Independent assessment*, self-report	Independent assessment*, self-report
Was follow-up long enough for outcomes to occur	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*
Adequacy of follow up of cohorts	No statement	No statement	No statement	No statement	No statement	No statement	No statement
Total score (out of 9)[a]	5 – Moderate quality	7 – High quality	7 – High quality	6 – Moderate quality	6 – Moderate quality	6 – Moderate quality	5 – Moderate quality

NOS = Newcastle-Ottawa Scale – the cohort studies version was the most appropriate for non-randomised trials. a 7-9* = high quality, 4-6* = moderate quality, 0-3* = low quality.

Supplementary file 16. Meta-analysis and GRADE assessment

Part A. Assessment of feasibility

Following the narrative assessment of available evidence, the following standardised scales were considered for use in meta-analysis:

- Quality of life: PDQ-39 total, VRQoL
- Functional communication: VHI, CES
- Speech: Intelligibility, jitter, shimmer
- Motor function: UPDRS-III, TUG.
- Cognitive function: MMSE, FAB and MoCA

Meta-analysis was considered feasible where there were at least two studies assessing the same outcome measure comparing the same intervention-comparator pair. 6MWT was considered as another possible outcome measure for motor function, but was not selected, to maintain consistency with the approach taken by Barnish & Barran (2020) and as there were already two standardised motor measures under consideration.

Singing and music therapy were considered unitary interventions due to limited available evidence to consider sub-types. Based on the available evidence, dance was sub-divided into:

- Brazilian/Samba-based dance
- PD-specific dance forms
- Tango-based dance

We are updating the meta-analysis from Barnish & Barran (2020), so are focusing our assessment of feasibility on studies published after the Barnish & Barran search date (February 2020) that can be added to the existing meta-analyses or allow the creation of new meta-analysis sets.

The following new studies were available to inform potential meta-analyses:

Dance (only list Dance for PD; Tango; Brazilian)

- Delabary, 2020 – Brazilian dance vs walking; TUG
- Fontanesi, 2021 – Dance for Parkinson's vs exercise; TUG
- Haas, 2024a – Brazilian vs deep water exercise; Nordic walking; UPDRS-III, TUG, PDQ-39, MoCA
- Haas, 2024b – PD-specific dance vs moderate individual physical activity; TUG
- Haputhanthirige, 2023 – Dance for PD vs usual care; TUG
- Moratelli, 2023 – Brazilian vs usual care; UPDRS-III, PDQ-39
- Peter, 2020 – Tango vs usual care; UPDRS-III, PDQ-39 – following investigation, reporting was insufficient to include in meta-analyses
- Tillmann, 2020 – Brazilian vs usual care; UPDRS-III, PDQ-39

Music therapy

- Bastepe-Gray, 2022 – waitlist (then intervention before assess); UPDRS-III, PDQ-39
- Pohl, 2020 – usual care; PDQ-39, MoCA.

Singing

- Brooks, 2021 – usual care; voice measures, VHI, CES
- Butala, 2022 – discussion group (no other studies with this comparator)
- Lee, 2024 – speaking (no other studies with this comparator)
- Stegemoller, 2021, 2022, 2023 – reading (no other studies with this comparator)

Theatre

- Bega 2017* – no intervention; UPDS-III, PDQ-39

* identified through citation chasing of Feb 2024 search.

While 'no intervention' may be considered comparable enough with 'usual care' to pool in a meta-analysis, there were no other theatre studies using a usual care comparator.

The following analysis sets were feasible:

1. Brazilian/Samba dance vs usual care UPDRS-III (Moratelli et al, 2023; Tillmann et al, 2020)
2. Brazilian/Samba dance vs usual care PDQ-39 (Moratelli et al, 2023; Tillmann et al, 2020)
3. PD-specific dance vs exercise TUG (Hashimoto et al, 2015; Fontanesi et al, 2021)
4. PD-specific dance vs usual care TUG. (Ventura et al, 2016; Hashimoto et al, 2015)
5. PD-specific dance vs usual care PDQ-39. (Ventura et al, 2016; Kalyani et al, 2019)
6. Tango-based dance vs exercise UPDRS-III. (De Natale et al, 2017; Romenets et al, 2015; Hackney et al, 2007 a,b).
7. Tango-based dance vs usual care UPDRS-III. (Hackney and Earhart, 2009 a,b,c; Duncan and Earhart, 2012/Foster et al, 2013)
8. Tango-based dance vs exercise TUG. (Romenets et al, 2015; Hackney et al, 2007 a,b)
9. UPDRS motor for theatre vs physiotherapy (Mirabella et al, 2017]; Modugno et al, 2010)

There were no two singing studies using a sufficiently similar comparator to conduct meta-analysis.

All analyses that were conducted on follow-up scores in the Barnish & Barran (2020) review, as there were not two studies for this particular combination of intervention, comparator and outcome that reported change scores plus a measure of variability, were reproduced using follow-up scores for comparability. These results were entered into the comparison table in Part D below. Where data permitted, analyses were also run using change scores, to protect against confounding due to baseline imbalances. However, the ability to do this was very limited.

This was because while a change score was provided or could be calculated, for very few studies was a standard deviation provided for the change score, or anything that could be converted into a standard deviation. Most obviously, this could be a standard error, a variance or 95% confidence intervals, however variance itself could be calculated as variance of difference equals the sum of the variances less twice the covariance. However, studies did not report the covariance. Incompatibility in results presentation, such as between Pohl et al (2020) and Pantelyat et al (2016) for MoCA further restricted the meta-analysis sets that could be conducted. Furthermore, for some studies, potentially valuable measures, such as UPDRS motor in Pohl et al (2020) were only reported for baseline and not follow-up time points. Evidence in usable form for meta-analysis was too sparse to consider a network meta-analysis.

Analyses were not repeated where analysis sets remained unchanged from the 2020 review, therefore forest plots are only provided for analysis sets that are either new or have changed since 2020 (no analysis sets changed, as there were no additional studies with the required data for the specific intervention-comparator-outcome configurations.

In the 2020 review, only 10 out of 56 included studies (18%) could be used in the meta-analysis. Three out of the 38 new included studies (8%) identified through the present systematic review could be used in the meta-analysis. In total, out of the 94 studies available across the two reviews to address the present research question, only 13 (14%) could be used in the meta-analysis.

Therefore, there is a disjoint where on the one hand the evidence available for the narrative synthesis is rich and has developed considerable since 2020, although not all evidence gaps have been fully resolved; whereas on the other hand evidence for the secondary analysis method of meta-analysis remains very limited, due to methodological differences limiting the number of studies that can be used in the meta-analysis. While the meta-analysis in itself is limited, it is presented for comparability with the 2020 review and to highlight the challenges still facing meta-analysis in this area.

Looking forward, considerable development in terms of standardisation of comparator arms, outcome measures and ways in which statistical results are presented (in particular an increased focus on change scores with a measure of variability around them) would be necessary to facilitate future more extensive meta-analyses, and potentially network meta-analyses in the area of the performing arts as therapy for PD.

Part B. Tabulation of data

Analysis set 1: Brazilian/Samba dance vs usual care UPDRS-III (Moratelli et al, 2023; Tillmann et al, 2020) – new for 2025

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Moratelli et al, 2023	23	14.04	9.4	23	20.04	13.1
Tillmann et al, 2020	10	12.0	2.8	10	25.1	2.8

Comparison conducted on follow-up scores. For Moratelli et al (2023), Samba group scores were used as the intervention rather than the forro and Samba group.

Analysis set 2: Brazilian/Samba dance vs usual care PDQ-39 (Moratelli et al, 2023; Tillmann et al, 2020) – new for 2025

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Moratelli et al, 2023	23	49.73	26.1	23	65.21	32.1
Tillmann et al, 2020	10	49.0	27.9	10	66.4	9.3

Comparison conducted on follow-up scores. For Moratelli et al (2023), Samba group scores were used as the intervention rather than the forro and Samba group.

Analysis set 3: PD-specific dance vs exercise TUG (Hashimoto et al, 2015; Fontanesi et al, 2021) – new for 2025

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Hashimoto et al, 2015	15	9.7	2.1	14	9.1	1.9
Fontanesi et al, 2021	7	13.04	1.89	7	12.30	0.66

Comparison conducted on follow-up scores. Time score used for TUG (simple TUG).

Analysis set 4: PD-specific dance vs usual care TUG. (Ventura et al, 2016; Hashimoto et al, 2015) – was conducted in 2020 review

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Hashimoto et al (2015)	15	9.7	2.1	14	10.2	2.4
Ventura et al (2016)	8	11.3	1.9	7	16.3	6.5

Comparison conducted on follow-up scores. Time data used for TUG. This analysis set remains unchanged from the 2020 review. This is because Haputhanthirige et al, 2023 only presents data for TUG sub-components (not TUG total score) as a change score, while Hashimoto et al (2015) presents only raw scores, and Ventura et al (2016) offers both raw and change scores, but only for TUG total score.

Analysis set 5: PD-specific dance vs usual care PDQ-39. (Ventura et al, 2016; Kalyani et al, 2019) – was conducted – was conducted in 2020 review

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Kalyani et al (2019)	17	-4.74	6.76a	16	2.07	5.95a
Ventura et al (2016)	8	-8.1b	7.4	7	4.0c	10.4

Comparison conducted on change scores. a = converted from 95% confidence interval for input into meta-analysis. b = presented by authors as a positive value as represents an improvement, but is numerically a reduction in score, and needs to be entered as a negative value in meta-analysis. c = presented by authors as a negative value as represents a deterioration, but it is numerically an increased in score, and needs to be entered as a positive value in meta-analysis.

There were no new studies assessing PDQ-39 for the comparison of PD-specific dance and usual care, so this analysis set remains unchanged from the 2020 review.

Analysis set 6: Tango-based dance vs exercise UPDRS-III. (De Natale et al, 2017; Romenets et al, 2015; Hackney et al, 2007 a,b) – was conducted in 2020 review

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
De Natale et al (2017)	9[a]	16.12	7.55	7[a]	14	9.9
Hackney et al (2007a,b)	9	22.6	1.3	10	20.6	1.2
Romenets et al (2015)	18[b]	19.1	10.2	15[b]	26.3	13.5

Comparison conducted on follow-up scores. a = using headline N – 2 participants dropped out, but it is not stated from which arm(s). b = the primary analysis was intention to treat, though there were 9 protocol violations, of which 7 occurred in the intervention arm. N = number, SD = standard deviation.

There were no new studies comparing tango-based dance and exercise, so this analysis set remains unchanged from the 2020 review. A comparison based on change scores could not be conducted, because there were not two studies for which change scores (with SD, or something that can be converted to SD) were reported.

Analysis set 7: Tango-based dance vs usual care UPDRS-III. (Hackney and Earhart, 2009 a,b,c; Duncan and Earhart, 2012/Foster et al, 2013) – was conducted in 2020 review

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Duncan and Earhart (2012)/Foster et al (2013)	26	31.7	2.4	26	45.0	1.9
Hackney and Earhart (2009a,b,c)	14	26.0	2.5	17	32.4	2.6

Comparison conducted on follow-up scores.

This analysis set remains unchanged from the 2020 review, as the only available additional study (Peter et al, 2020) for this combination of intervention, comparator and outcome did not present numerical results for the UPDRS-III outcome.

Analysis set 8: Tango-based dance vs exercise TUG. (Romenets et al, 2015; Hackney et al, 2007 a,b) – was conducted in 2020 review

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Hackney et al (2007a,b)	9	9.8	0.4	10	11.8	0.4
Romenets et al (2015)	18[a]	6.1	1.5	15[a]	8.0	2.2

Comparison conducted on follow-up scores. Time data used for TUG. a = the primary analysis was intention to treat, though there were 9 protocol violations, of which 7 occurred in the intervention arm.

There were no new studies comparing tango-based dance and exercise, so this analysis set remains unchanged from the 2020 review. A comparison based on change scores could not be conducted, because there were not two studies for which change scores (with SD, or something that can be converted to SD) were reported.

Analysis set 9: Theatre vs physiotherapy UPDRS-III (Mirabella et al, 2017; Modugno et al, 2010)

There were no new studies comparing theatre and physiotherapy, so this analysis set remains unchanged from the 2020 review.

Study	Intervention			Control		
	N	Mean	SD	N	Mean	SD
Mirabella et al (2017)	12	24.2	9.9	12	22	4.9
Modugno et al (2010)	10	19.5	10.53[a]	10	21.7	12.74[a]

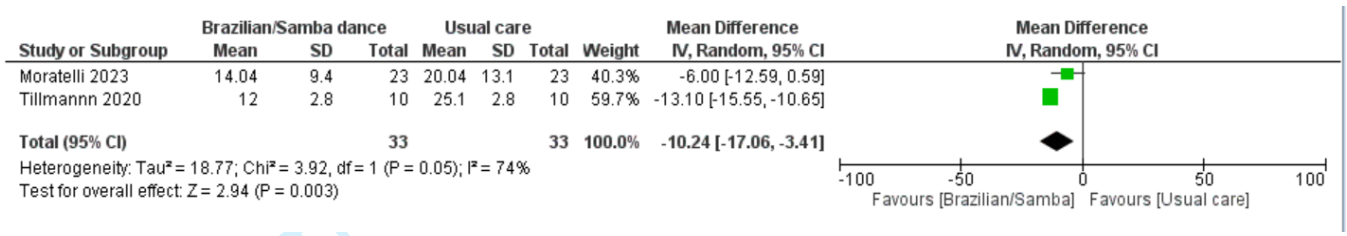
Comparison conducted on follow-up scores. [a] = converted from standard error.

In total, there were 9 meta-analysis sets, 6 of which came from Barnish & Barran (2020) and were unchanged, while 3 analysis sets (analysis sets 1, 2 and 3) were new for the present review.

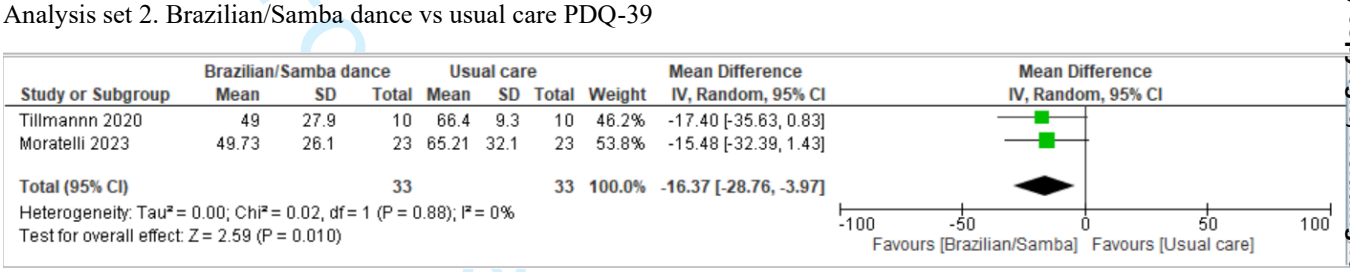
Part C. Meta-analysis forest plots

These are presented for the three new analysis sets. The six existing analysis sets were unchanged, so are not repeated here.

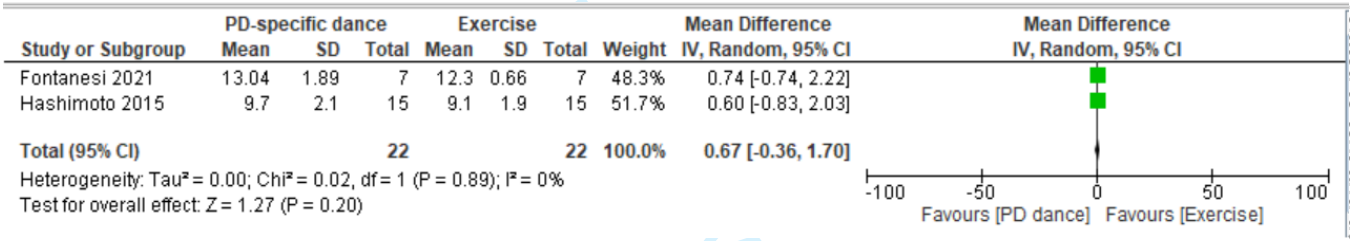
Analysis set 1. Brazilian/Samba dance vs usual care UPDRS-III



Analysis set 2. Brazilian/Samba dance vs usual care PDQ-39



Analysis set 3. PD-specific dance vs exercise TUG



Part D. Comparison of meta-analysis results with those from the 2020 review

Only for the analysis sets that were conducted both in 2020 and 2024.

Comparison	2020 MD (95% CI)	2024 MD (95% CI)
UPDRS motor for tango-based dance vs exercise	-0.13 (-5.41, 5.14)	Unchanged, no new studies
UPDRS motor for tango-based dance vs usual care	-9.89 (-16.65, -3.13)	Unchanged, no new studies
TUG for PD-specific dance vs usual care	-2.11 (-6.33, 2.12)	Unchanged, no new studies
TUG for tango-based dance vs exercise	-1.99 (-2.34, -1.65)	Unchanged, no new studies
PDQ-39 for PD-specific dance vs usual care	-7.81 (-11.87, -3.75)	Unchanged, no new studies
UPDRS motor for theatre vs physiotherapy	-2.11 (-6.33, 2.12)	Unchanged, no new studies

CI = Confidence interval, MD = Mean difference.

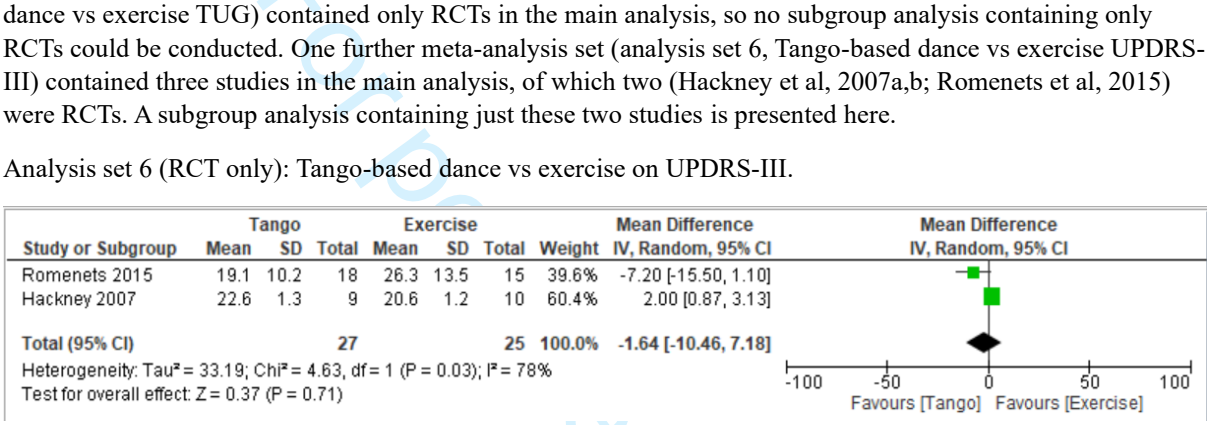
Part E. Analytical code

Analysis was conducted in Reviewer Manager (RevMan 5.4.1) from the Cochrane Collaboration. RevMan is menu-drive rather than code-driven. For guidance as to how to use RevMan, please consult the Cochrane training manual. In summary, we selected new review and from the launch screen select interventional review and label it 'Performing arts for Parkinson's disease'. Then in the 'Studies and references' section we added the relevant studies for the meta-analysis as included studies. Then, for each meta-analysis in turn, we went to 'Data and analyses', specified which studies will be used, defined the outcome, intervention and control arms, specified that the data were continuous, confirmed that we were using random effects, specified that the outcome was mean difference, specified that we wanted the forest plots ordered by weight, then entered the data and ran the analyses. For each analysis, once it was run, we clicked on forest plot and then saved this as a Figure within RevMan for convenient export to our Supplementary material.

Part F. Subgroup analysis including only RCTs

Two meta-analysis sets (analysis set 7, Tango-based dance vs usual care UPDRS-III; analysis set 8, Tango-based dance vs exercise TUG) contained only RCTs in the main analysis, so no subgroup analysis containing only RCTs could be conducted. One further meta-analysis set (analysis set 6, Tango-based dance vs exercise UPDRS-III) contained three studies in the main analysis, of which two (Hackney et al, 2007a,b; Romenets et al, 2015) were RCTs. A subgroup analysis containing just these two studies is presented here.

Analysis set 6 (RCT only): Tango-based dance vs exercise on UPDRS-III.

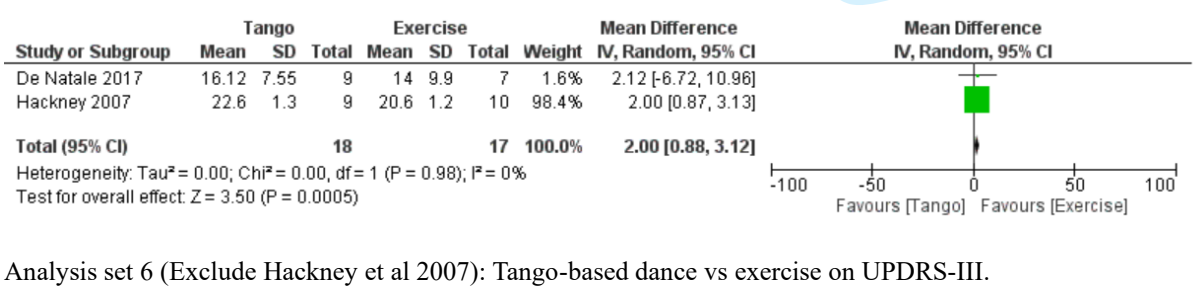


The subgroup analysis including only RCTs reaches the same conclusion as the main analysis – that there is no evidence of a statistically or clinically significant benefit for tango-based dance vs exercise on UPDRS-III using studies that can be pooled in a meta-analysis. It does not resolve the heterogeneity, which remains high, and indeed increases when only RCTs are considered.

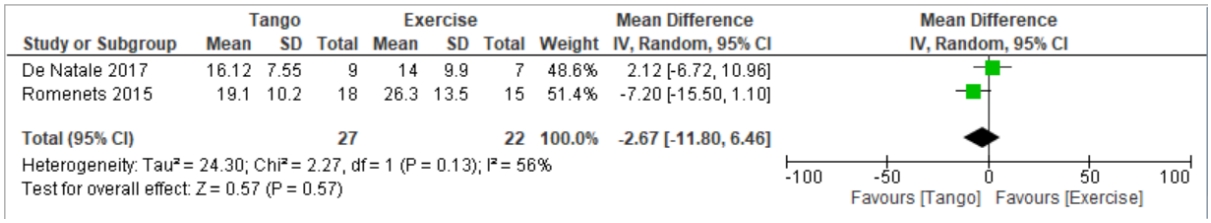
Part G. Leave-one-out sensitivity analysis

Only one meta-analysis set (analysis set 6, Tango-based dance vs exercise UPDRS-III) contained three studies and can therefore be used for a leave-one-out sensitivity analysis. The analysis leaving out the one non-RCT study (De Natale et al, 2017) was presented above in Part F. Therefore, sensitivity analyses i) excluding Hackney et al (2007a,b) and ii) excluding Romenets et al (2015) are presented here.

Analysis set 6 (Exclude Romenets et al, 2015): Tango-based dance vs exercise on UPDRS-III.



Analysis set 6 (Exclude Hackney et al 2007): Tango-based dance vs exercise on UPDRS-III.



The analysis excluding Romenets et al (2015) showed a statistically but not clinically significant difference in favour of exercise. This led to a further check on data extraction but did not identify any issues. Few studies compared tango-based dance vs exercise for UPDRS-III and could be pooled in the meta-analysis. We could not identify any particular characteristics of the Romenets et al (2015) study that could explain this difference. We considered that due to high heterogeneity and observed differences between studies, it is appropriate that the result of the main meta-analysis that there is no statistically significant difference between groups.

Part H. GRADE assessment on meta-analysis sets

Set starting value at High if at least half of included studies in the meta-analysis set are RCTs.

Analysis set 1: Brazilian/Samba dance vs usual care on UPDRS-III, statistically significant, not clinically significant. Start at Low GRADE as neither included study is randomised. Cannot upgrade for large effect as not clinically significant. Dose-response gradient has not been assessed. There is no evidence that the direction of plausible bias indicates an underestimate of treatment effect. Downgrade to Very low GRADE due to heterogeneity.

Analysis set 2: Brazilian/Samba dance vs usual care on PDQ-39, statistically significant, clinically significant. Start at Low GRADE as neither included study is randomised. Upgrade to Moderate GRADE for large effect as clinically significant. Dose-response gradient has not been assessed. There is no evidence that the direction of plausible bias indicates an underestimate of treatment effect.

Analysis set 3: PD-specific dance vs exercise on TUG, not statistically significant, not clinically significant. Start at High GRADE because 50% of the evidence is RCT. Downgrade to Moderate GRADE because of potential risk of bias in the Fontanesi et al (2021) non-randomised study.

Analysis set 4: PD-specific dance vs usual care on TUG, not statistically significant, not clinically significant. Start at High GRADE because 50% of the evidence is RCT. Downgrade because of potential risk of bias in the Ventura et al (2016) non-randomised study. Downgrade because confidence interval is wider than MCID. Downgrade to Very low GRADE because of heterogeneity.

Analysis set 5: PD-specific dance vs usual care on PDQ-39, statistically significant, clinically significant. Start at Low grade because the analysis set includes solely non-randomised studies. Downgrade to Very low GRADE because confidence interval wider than MCID.

Analysis set 6: Tango-based dance vs exercise on UPDRS-III, not statistically significant, not clinically significant. Start at High grade because two thirds of the studies are RCTs. Downgrade because of heterogeneity. Downgrade to Low GRADE because confidence intervals wider than MCID.

Analysis set 7: Tango-based dance vs usual care on UPDRS-III, statistically significant, clinically significant. Start at High GRADE because all studies in this meta-analysis set are RCTs. Downgrade because of heterogeneity. Downgrade to Low GRADE because confidence intervals wider than MCID.

Analysis set 8: Tango-based dance vs exercise on TUG, statistically significant, not clinically significant. Start at High GRADE because all studies in this meta-analysis set are RCTs. Downgrade to Moderate GRADE because confidence intervals wider than MCID.

Analysis set 9: Theatre vs physiotherapy on UPDRS-III, not statistically significant, not clinically significant. Start at High GRADE because 50% of the studies were randomised. Downgrade because of potential risk of bias in the non-randomised Mirabella et al (2017) study. Downgrade to Low GRADE because confidence intervals wider than MCID.

Part I. GRADE assessment on narrative synthesis

Assessment performed on the nine combinations of performing arts modality and outcome that were overall supported by the evidence base. When conducting GRADE on narrative synthesis, instead of only setting the starting GRADE as High if the majority of studies were RCTs, we set it as High if there were multiple RCTs to support the conclusion and the findings stand based on RCT evidence alone.

Combination 1: Dance on quality of life. Start at High GRADE because the conclusion is supported by multiple RCTs and the findings stand based on RCT evidence alone. No factors identified to downgrade the finding.

Combination 2: Music therapy on quality of life. Start at High GRADE because the conclusion is supported by multiple RCTs and the findings stand based on RCT evidence alone. No factors identified to downgrade the finding.

Combination 3: Singing on quality of life. Start at High GRADE because the conclusion is supported by multiple RCTs and the findings stand based on RCT evidence alone. Downgrade to Moderate GRADE because of inconsistency with a benefit not being supported on all outcome measures.

Combination 4: Theatre on quality of life. Start at High GRADE because the conclusion is supported by multiple RCTs and the findings stand based on RCT evidence alone. Downgrade to Moderate GRADE because of inconsistency with a benefit not being supported by the Bega et al (2017) crossover RCT.

Combination 5: Singing on speech. Start at High GRADE because the conclusion is supported by multiple RCTs and the findings stand based on RCT evidence alone. Downgrade to Moderate GRADE because of inconsistency across multiple speech outcome measures.

Combination 6: Dance on motor function. Start at High GRADE because the conclusion is supported by multiple RCTs and the findings stand based on RCT evidence alone. No factors identified to downgrade the finding.

Combination 7: Music therapy on motor function. Start at High GRADE because the conclusion is supported by multiple RCTs and the findings stand based on RCT evidence alone. No factors identified to downgrade the finding.

Combination 8: Singing on motor function. Start at Low GRADE because the finding is not supported by multiple RCTs. No factors identified to upgrade.

Combination 9: Dance on cognitive status. Start at High GRADE because the conclusion is supported by multiple RCTs and the findings stand based on RCT evidence alone. Downgrade to Moderate because of some inconsistency across studies.

Supplementary file 17. Supplementary results and discussion

RESULTS

Search results

The February 2020 Barnish & Barran search identified a total of 5,660 database records (AMED 52, PsycINFO 244, CINAHL 341, EMBASE 1567, and MEDLINE 456), plus nine from supplementary searches. Following title and abstract screening, 441 records proceeded to initial full-text screening. De-duplication was applied at this stage and reduced the number of records to 260. A total of 129 records proceeded to detailed full-text screening (this is the stage that we will class as 'full-text screening' when combining results from the different search dates), and 67 records (56 unique studies) were included in the systematic review. Sixty-two records were excluded at the full-text review stage (32 records were excluded because the intervention was not eligible, 17 were excluded for methodology, eight for outcomes, three for being abstracts more than two years before the search, one for population, and one for being a duplicate.

The February 2024 update search identified a total of 1,677 database records (AMED 97, APA PsycINFO 111, CINAHL 128, EMBASE 1077, MEDLINE 264), plus six from supplementary searches, of which 1,286 remained following automatic and manual deduplication. A total of 74 records were assessed at full text screening, and 36 records (33 unique studies) were included in the systematic review. Thirty-eight records were excluded at the full-text stage: 13 for intervention, 11 for outcomes, 11 for study design/article type, and three for being duplicates,

The February 2025 search identified a total of 366 database records (AMED 3, APA PsycINFO 21, CINAHL 30, EMBASE 236, MEDLINE 76), plus none from supplementary searches, of which 238 remained following automatic and manual deduplication. A total of seven records were assessed at full-text screening, and six records (six unique studies) were included in the systematic review. One record was excluded at the full-text stage: this was for intervention).

Across the three search stages, a total of 7,703 database records (AMED 152, PsycINFO/APA PsycINFO 376 (database rebranded between 2020 and 2024 search), CINAHL 499, EMBASE 2,880, and MEDLINE 796 were identified, plus 15 from supplementary searches. A total of 7,199 records preceded to title and abstract screening. It should be noted that in the Barnish & Barran (2020) review, de-deduplication was applied after title and abstract screening prior to full-text screening. A total of 210 records proceeded to full-

text screening (this is taken to be the detailed full-text review stage in the case of the Barnish & Barran 2020 search), and 109 records (94 unique studies) were included in the systematic review. The total number of included studies sums to one less than the sum of the included studies across the three searches because an additional publication was identified in the 2024 search for one of the studies already included in the Barnish & Barran 2020 review. A total of 101 records were excluded at the full-text review stage: 46 for intervention, 31 for methodology (including article type, study design, and abstracts more than two years before the search), 19 for outcomes, four for being duplicates, and one for population). The low number of records excluded for population was because the population criterion (Parkinson's disease) was typically easily assessed using the title and abstract. The number of studies included in the meta-analysis, along with feasibility assessment, data tabulation, and forest plots, is provided in Supplementary file 16. The principal reason why only a small proportion of studies from the systematic review could be included in the meta-analysis was a lack of consistency between studies in the outcomes assessed (both conceptual differences in outcomes as well as using different assessment tools) and differences in the comparator arms used.

Study profile

The 94 studies identified across the three search stages came from a total of total of 18 countries across five continents: Asia: India; Japan, South Korea; Europe: Belgium, Germany, Netherlands, Ireland, Italy, Norway, Spain, Sweden, UK; North America: Canada, USA; Oceania: Australia; New Zealand; South America: Argentina, Brazil. The only continent permanently inhabited by humans that was not covered by the included studies is Africa. There were considerable cultural, political and health system differences between the countries studied. This could be of relevance given, for example, i) differences in cultural attitudes to Parkinson's disease, ii) differences in access to lifestyle-based interventions such as the performing arts through the health system as opposed to privately sourced memberships of organisations, iii) differences in how the arts are valued within the cultural system, iv) differences in how gender norms may influence arts participation, and v) differences in which art forms are socially preferred. Studies were published between 1989 and 2024. No eligible studies published in 2025 were identified.

Assessing dance as a therapeutic modality, there were 63 studies, including a total of 1,723 people with PD (median sample size 22, range 6 to 83, mean age 68, 54% male, range 13% to 97%), of which 21 (33%) were randomised trials. Age and gender were based on the studies for which this information was available. Four studies did not report age, and seven studies did not report gender. Where studies did not report total

age or total gender, these were calculated from intervention- and control-arm specific values where available, using reasonable assumptions where necessary. Eighteen studies used tango-based dance as the main intervention, 18 used PD-specific dance forms (including Dance for Parkinson's Disease), three used samba-based dance and 24 used other dance forms, reflecting the heterogeneity of dance forms that were assessed in studies.

Assessing music therapy, there were eight studies, including a total of 184 people with PD (median sample size 21, range 5 to 46, mean age 68, 67% male, range 39% to 100%), of which five (63%) were randomised trials. One study did not report gender. Assessing singing, there were 20 studies, including a total of 480 people with PD (median sample size 20, range 5 to 95, mean age 69, 56% male, range 37% to 88%), of which three (15%) were randomised trials. One study did not report age or gender. Assessing theatre, there were three studies, including a total of 66 people with PD (median sample size 22, range 20 to 28, mean age 64, 52% male, range 42% to 64%, of which two (67%) were randomised trials. All three studies reported age and gender.

There were no studies comparing artistic modalities, i.e. two or more of dance, music therapy, singing and theatre with each other. Also, there were no eligible studies assessing other performing arts modalities besides dance, singing, music therapy, and theatre. Following discussion with fellow experts at conferences (Society for Social Medicine and Population Health Annual Scientific Meeting, Exeter, UK, 2022 and 1st International Meeting of Arts Prescribing in HealthCare, Thessaloniki, Greece, 2024), it was decided not to class tai chi as a performing arts intervention, as it was considered more a form of exercise. This decision was consistent with the decision taken by the Barnish & Barran (2020) review.

In total, across all artistic modalities, there were 94 studies included in the systematic review, including a total of 2,453 people with PD (median sample size 22, range 5 to 95, mean age 68, 55% male, range 13% to 100%), of which 31 (33%) were randomised trials. Five studies did not report age. Nine studies did not report gender.

Two separate forms of tango were used – traditional Argentine tango and adapted tango, the latter adapting steps for people with PD (see Supplementary file 9 for details of which was used in which included studies). Traditionally, in tango, the lead role is danced by the male. In adapted tango, typically all participants danced both lead and follow roles, while some studies of Argentine tango also adopted this practice.

Across studies, there was a wide range of disciplinary backgrounds and levels of experience among session leaders. In dance studies, where information was available, the session leaders typically included professional dance instructors or professional dancers with varying levels of experience with PD. However, in some studies, dance sessions were led by physiotherapists (Prewett et al, 2017), dance movement therapists (Fisher et al, 2020), psychologists (Westbrook et al, 1989), experienced amateur dancers (Duncan & Earhart, 2014) and trained researchers (Moratelli et al, 2012, 2022). In music therapy studies, sessions were all led by music therapists or music instructors, except for one study (Pohl et al, 2020) where sessions were led by physiotherapists. In singing studies, sessions were led by speech-and-language therapists, trained singers, singing instructors/choir directors, or music therapists (in on case supervising graduate students), except for one study (Irons et al, 2019, 2020), where 'trained facilitators' led the sessions. In theatre studies, sessions were always led by professional stage performers or instructors.

There were a few particularities about the delivery of the intervention in a few studies that should be noted. In Koch et al (2016) (single-arm study, Germany, n=34) on Argentine tango, the group was divided into three and there were three workshops, each participant attending one. The first workshop was taught in English (by an Argentine instructor) and translated into German, whereas the other two workshops had a different leader and were taught directly in German. In Tamplin et al (2019, 2018) (non-randomised controlled trial, Australia, n=75) on singing, both intervention and control groups also received social interaction and conversation practice (in the form of morning or afternoon tea). Furthermore, the intervention was offered in weekly and monthly versions. However, these differed in important ways besides the frequency of intervention. The weekly version was led by a professional music therapist, whereas the monthly version was led by amateur community musicians and volunteers. The weekly version was compared to a painting, dancing or tai chi control, whereas the monthly version was compared to a peer support group control. In Good et al (2023) (cohort study, n=22) on singing, one choir group was led by a professional choir director along with a pianist, while the other choir group was led by a music therapist who played the guitar. The perception of cues from the leader may differ depending on whether or not the leader is playing an instrument or is free to conduct with their hands.

Definitions of performing arts modalities in this review were identical to that used in Barnish & Barran (2020), which focused on the content of the intervention rather than the disciplinary background of the leader. Music therapy was conceptualised as "active interventions of a musical nature that did not solely involve singing" (Barnish & Barran, 2020, p.5). This approach differs from others who define performing

arts modalities principally by the disciplinary background of the leader, e.g. dance movement therapist, music therapist, drama therapist. There are advantages to both approaches, and it should be recognised that definitions of disciplines and accreditation processes differ greatly between countries. Our approach benefits from the strength of appreciating the wide variety of disciplinary backgrounds that can contribute to research into the performing arts in PD and is not tied to the professional definitions used by any one country, increasing international relevance. However, the downside of this approach is reduced direct generalisability to clinical practice settings in specific countries, e.g. UK, USA or Germany.

Narrative synthesis

Across the 94 studies included in the systematic review, 63 studies assessed dance, eight studies assessed music therapy, 20 studies assessed singing, and three studies assessed theatre. For consistency, the interventions were classified in the same way as in Barnish & Barran (2020).

Quality of life

Dance

Thirty-seven dance studies assessed quality of life. In cases like this, where there are a large number of studies for a combination of outcome and performing arts modality, we focus on the totality of evidence rather than profiling every separate study, so as to provide the most useful synthesis. Among these 37 studies, nearly two thirds (24/37, 65%) provided evidence of a benefit of dance on quality of life. A wide range of dance interventions were studied and were generally supported by available evidence. It is difficult to separate which dance forms are the most effective from which dance forms have been studied most. Only one study (Hackney & Earhart, 2009a,b,c) assessed American ballroom and did not find evidence of benefit. Earlier evidence (up to February 2020) on the benefit of dance on quality of life focused primarily on PD-specific dance forms (including Dance for Parkinson's Disease) (n=9) and tango (either Argentine or adapted), between them covering 18 out of the 22 studies on this outcome up to that point (82%), while more recent studies have shown greater diversity of dance forms. Three studies assessed Brazilian dance forms, often based on samba (Haas et al, 2024a; Moratelli et al, 2023; Tillmann et al, 2020), although did not find conclusive evidence of benefit. Two studies (Pinto et al, 2023, non-randomised feasibility trial, Brazil, n=23, online dance intervention based on Dance for Parkinson's; Walton et al, 2022, single group within-participants design, Sweden, n=23, Digital Dance for Parkinson's) assessed whether the benefit of Dance for Parkinson's Disease translates to online delivery, where the group dynamics are different, as a

result of not being in the same physical room as each other. The Walton et al (2022) study, but not Pinto et al (2023) provided evidence that the quality of life benefits do transfer to an online setting, but this should be interpreted in the context of the limitations of small non-randomised studies, while Walton et al (2022) note that some important elements of live dance were missing as they cannot be replicated online. One study, in a tango context (Hackney et al, 2018) specifically compared following and leading (the dancing roles were not related to gender) and found that following offered greater quality of life benefit to people with PD. This may be worthy of further exploration. Studies typically used PDQ-39 (Jenkinson et al, 1997) to assess quality of life. The overall volume of evidence for a benefit of dance on quality of life is greatest for PD-specific dance forms and tango. There were 12 RCTs of dance for quality of life. Hackney et al (2009a,b,c) (USA, n=61, Argentine tango with all participants dancing lead and follow roles vs usual care), Hackney et al (2018, USA, n=83, adapted tango with participants assigned (not by gender) to lead or follow vs wellness education) and Patel et al (2018) (USA, n=36, adapted tango vs education) all found evidence of a statistically significant difference on quality of life, while Rocha et al (2018) (n=21, Argentine tango vs mixed-genre dance) found numerical evidence of a benefit but statistical significance was not reached. It should be noted that this was the smallest of the four trials mentioned here, so statistical power may be an issue. It should be noted that Hackney et al (2009a,b,c) did not find a benefit for American Ballroom dancing and Rocha et al (2018) did not find evidence of a benefit for mixed-genre dance. One RCT (Romenets et al, 2015, Canada, n=33, Argentine tango vs self-directed exercise) did not find evidence of a benefit of dance on quality on life, while one further study (Hulbert et al, 2017; Kunkel et al, 2017) did not find evidence for a benefit of partnered dance overall on quality of life. Considering which types of dance rhythm may be most beneficial in PD, Moratelli et al (2021, 2022) found that dancing using both binary and quaternary dance rhythms benefitted quality of life. Tango is the only dance form with positive evidence from more than one RCT supporting its use to benefit quality of life. Single RCTs (Lee et al, 2018; Michels et al, 2018a,b) offer evidence for a benefit of Turo (a dance form based on the Qi meridian system) and a customised PD dance intervention respectively. Irish set dancing may offer a benefit on quality of life – one RCT (Shanahan et al, 2017) found a numerical benefit over usual care but statistical significance was not reached, while Volpe et al (2013) found that both Irish set dancing and physiotherapy improved quality of life, but there was no significant difference in outcome between them. While Frisaldi et al (2021) did not find evidence of a significant benefit of the DArT method (combined dance-physiotherapy intervention, Haas et al (2024a) found that Brazilian dance, Nordic walking and deep-water exercise all benefitted quality

of life, but there was no significant difference in outcome between them. The overall body of evidence supports a benefit of dance for quality of life. Across all studies, the evidence is greatest for tango and PD-specific dance forms, though RCT evidence is greatest for tango.

Music therapy

Eight music therapy studies assessed quality of life. There was evidence from five RCTs (Pacchetti et al, 2000, Italy, n=32, instrumental music improvisation vs physiotherapy; Spina et al, 2016, Italy, n=25, music, singing and dancing music therapy intervention vs usual care; Pohl et al, 2013, Sweden, n=18, Ronnie Gardiner Rhythm and Music Method vs usual care; Pohl et al, 2020, Sweden, n=46, Ronnie Gardiner Rhythm and Music Method vs usual care; Bastepe-Grey et al, 2022, USA, n=24, guitar lessons vs usual care followed by guitar lessons) that music therapy offers a benefit for quality of life, as measured by PDQ-39, although in Bastepe-Grey et al (2022) the effect was numerical and fell short of statistical significance., although reached clinical significance. Furthermore, a non-randomised trial by Pantelyat et al (Pantelyat et al, 2016, USA, n=18, West African drum circle class vs usual care) also found a statistically significant benefit on PDQ-39. Two studies did not show a benefit on quality of life (Shah-Zamora et al, 2024; Wainwright et al, 2024), but both were small single-arm studies. There is evidence from multiple RCTs to support a benefit for music therapy on quality of life.

Singing

Eight singing studies assessed quality of life. An RCT by Matthews et al (2018, New Zealand, sample size NR, singing, voice and respiration exercise vs music appreciation) found a benefit of singing on PDQ-39. A cross-over RCT by Butala et al (2022, USA, n=26, singing vs discussion group) reported a benefit of singing on quality-of-life sub-scales related to emotional wellbeing and body discomfort, but not the overall quality of life score. It was considered to have shown some evidence of a benefit on quality of life. The only other RCT (Lee et al, 2024) did not report quality of life at follow-up, only in the baseline profile, so cannot be considered here. Further support for a benefit of singing on quality of life was provided by a single-arm study by Irons et al (2019, 2020), a two-group repeated measures study by Stegemoller et al (2017a,b) – which in addition to finding an effect on WHOQOL (WHOQOL Group, 1995) found an effect on voice-related quality of life, but not swallowing quality of life, a non-randomised trial on a single session of singing by Stegemoller et al (2021, 2022, 2023, USA, n=25, group therapeutic singing vs quiet reading in a group environment), and a non-randomised trial by Tamplin et al (2018, 2019, 2020, Australia, n=75,

singing vs painting, dancing or tai chi (weekly group) or peer support group (monthly group) on voice-related quality of life. It should be noted that Tamplin et al (2020) only found a statistically significant effect for the weekly singing group not the monthly singing group. Two studies found no effect on quality of life (Evans et al, 2012; Tamplin et al, 2024), but both were limited using a single-arm design. The majority of the available evidence supports a benefit for singing on quality of life.

Theatre

Three theatre studies assessed quality of life. One RCT by Modugno et al (2010) (Italy, n=20) compared to physiotherapy and one non-randomised trial by Mirabella et al (2017) (Italy, n=24) compared to physiotherapy both found evidence of a benefit of theatre on quality of life, assessed by PDQ-39. However, a cross-over RCT (Bega et al (2017, USA, n=22, control period is no intervention) did not find evidence of a benefit on PDQ-39. Most available evidence supports a benefit for theatre on quality of life, however the number of studies remains limited.

Functional communication

Dance

One dance study assessed functional communication outcomes. This was the Park et al (2023) study. Conducted in the USA, this assessed the potential benefit of vocal dance on Voice Handicap Index (VHI, Jacobson et al, 1997) scores. No evidence of a statistically significant benefit on this outcome was observed. However, using a single group repeated measures design (n=6), the study was likely too small and limited to assess this relationship. Despite a plausible rationale for an expressive art such as dance offering a benefit on communication, no other studies assessed this relationship. There is currently no evidence for a benefit of dance on functional communication.

Music therapy

No music therapy studies assessed functional communication outcomes. There is currently no evidence for a benefit of music therapy on functional communication.

Singing

Five singing studies assessed functional communication outcomes. The earliest two studies both used a single group repeated measures design. Elefant et al (2012a,b) (Norway, n=10) found that a group singing

intervention of one 60-minute session per week for 20 weeks significantly improved communicative facial expression and physical communication, although improvements in overall communication, plus functional and emotional subscales of the VHI did not reach statistical significance. Shi et al (2012) (USA, n=13) found no statistically significant change in functional communication (VHI) after a group singing intervention of one 90-min session per week for 12 weeks. These studies were limited by the single group design and small sample sizes. One RCT (Lee et al, 2024) (USA, n=27) comparing therapeutic group singing with a speaking-only control group used VHI as a baseline profiling measure, but no follow-up scores were reported. A non-randomised trial (Brooks et al, 2021) (USA, n=17) comparing therapeutic group singing with usual care assessed VHI and the Communicative Effectiveness Survey (CES, Donovan et al, 2007) and did not find evidence of a statistically significant benefit of singing. A further single-arm pilot study by Tamplin et al (2024) (Australia, n=28) did not find evidence of a benefit on Dysarthria Impact Profile (Walshe et al, 2009) scores, although this was a pilot study aimed at establishing feasibility and tolerability. Currently, evidence for any benefit of singing on functional communication outcomes remains limited – coming only from one single group study (Elefant et al, 2012a,b) where a benefit of singing was shown on some, but not all communication measures.

Theatre

No theatre studies assessed functional communication outcomes. There is currently no evidence for a benefit of theatre on functional communication.

Speech

Dance

No dance studies assessed speech outcomes. There is currently no evidence for a benefit of dance on speech.

Music therapy

No music therapy studies assessed speech outcomes. There is currently no evidence for a benefit of music therapy on speech.

Singing

Twenty singing studies assessed speech outcomes. Of these, seventeen (85%) support a benefit for singing on this outcome. The three studies that did not show an effect were all single-arm studies (Shih et al, 2012; Stegemoller et al, 2020; Tamplin et al, 2024). Studies assessing speech often used a wide range of acoustic and perceptual outcome measures. Frequently assessed acoustic parameters included vowel duration, intensity, minimum and maximum fundamental frequency (pitch), jitter, shimmer and harmonic-to-noise ratio. When interpreting speech outcomes, it is important to take a broad perspective across all reported outcomes, as no one acoustic parameter is widely considered to be the most pivotal for speech quality. In addition to the studies using traditional acoustic parameters, a randomised controlled trial by Lee et al (2024) used the Acoustic Voice Quality Index (AVQI, Maryn et al, 2020) an innovative measure of acoustic voice quality based on a weighted combination of six acoustic measures. AVQI has been shown to be valid as a measure of voice quality, although there are contradictory findings about the effect of age on the validity of the tool (Jayakumar & Benoy, 2024). While AVQI has been used in people with PD (Convey et al, 2024; Moya-Gale et al, 2024), no disease-specific validation study could be identified. Lee et al (2024) found evidence of a statistically significant benefit of singing (both alone and in combination with straw phonation) on AVQI compared to a speaking-only control group. Only Tanner et al. [91] reported clinical significance, and clinically significant improvements were found for intensity range in read speech and fundamental frequency variation, while the improvement in fundamental frequency in read speech was possibly clinically significant. Studies assessing perceptual speech and voice ratings (Brooks et al, 2021; Lee et al, 2024; Tamplin et al, 2020) offered evidence of a benefit on perceived speech or voice quality. Among the seventeen studies supporting the benefit of signing on speech, there were two RCTs (Matthews et al, 2018, New Zealand, sample size NR, singing, voice and respiration exercise vs music appreciation; Lee et al, 2024, USA, n=27, therapeutic group singing vs a speaking-only control group) and one crossover RCT (Butala et al, 2022, USA, n=26, control is discussion group). Overall, the majority of available evidence, including multiple RCTs, support a benefit for singing on speech outcomes.

Theatre

No theatre studies assessed speech outcomes. There is currently no evidence for a benefit of theatre on speech.

Motor function

Dance

A total of fifty-four dance studies assessed motor function outcomes. The most commonly assessed outcome was MDS-UPDRS-III as well as the original UPDRS-III scale (Fahn et al, 1987). This is an overall assessment of motor function as part of a wider multi-domain PD rating scale. Some studies also assessed more specific aspects of motor function, including balance, freezing of gait and falls. Another frequently used assessment of motor function was the Timed Up and Go (TUG) test (Podsiadlo & Richardson, 1991), which is an assessment of basic functional mobility involving standing up from a seated position in a chair, walking 3 metres away, turning round and coming back to sit in the chair again. This test also encapsulates balance and risk of falling. One study, in a tango context (Hackney et al, 2018) specifically compared following and leading (the dancing roles were not related to gender) and found that following offered greater motor function benefit to people with PD. As noted under quality of life, this finding may be worthy of further exploration. Evidence for a statistically significant benefit of dance on motor function was very consistent across a large number of studies, although only one study assessed clinical significance (Batson et al, 2014) and the observed effect fell slightly short of the minimally clinically important difference. Out of 54 studies on dance in relation to motor function, fifty (93%) showed evidence of a benefit. This is the combination of performing arts modality and outcome domain for which there is the greatest volume and consistency of supportive evidence. Nine RCTs (Duncan & Earhart, 2012; Foster et al, 2013, USA, n=52, Argentine tango with participants dancing both lead and follow roles vs usual care; Duncan & Earhart, 2014, USA, n=10, Argentine tango vs usual care; Hackney et al, 2007a,b, USA, n=19, Argentine tango with participants dancing both lead and follow roles vs traditional exercise; Hackney et al, 2009a,b,c, USA, n=61, Argentine tango with participants dancing both lead and follow roles vs usual care; Hackney et al, 2010, USA, n=39, dance based on Argentine tango with participants dancing both lead and follow roles – partnered vs non-partnered; Hackney et al, 2018, USA, n=83, adapted tango with participants assigned (not by gender) to lead or follow vs wellness education, Patel et al, 2018, USA, n=36, adapted tango vs education; Rocha et al, 2018, n=21, Argentine tango vs mixed-genre dance; Romenets et al, 2015, Canada, n=33, Argentine tango vs self-directed exercise) assessed the potential benefit of dance for motor function. All found evidence of a benefit, although in one RCT (Romenets et al, 2015), a statistically significant effect was found for balance and functional mobility, but not on the MDS-UPDRS-III. No specific explanation for this difference could be identified. Hackney et al (2009a,b,c,) also found benefit for American Ballroom dancing, but the effect was stronger for tango. Interestingly, Hackney et al (2010) found no difference in the benefit for partnered and non-partnered tango conditions. One RCT

(Hulbert et al (2017), Kunkel et al (2017) found overall evidence of partnered dance on motor function, though not on all outcome measures. Moratelli et al (2021, 2022) found that both binary and quaternary dance rhythms were beneficial for motor function, although only binary rhythms improved freezing of gait. There was evidence from a single RCT for a benefit on motor function of each of Turo dance (Lee et al, 2018), Irish set dancing (Volpe et al, 2013), Ballu Sardu (Sardinian folk dance) (Solla et al, 2019), DaRT method (Frisaldi et al, 2021), Brazilian dance (Haas et al, 2024a), and Garba dance (Gujarati dance form) (Mehta et al, 2024). In some cases, the effect was not found on all motor outcome measures. In addition, a further RCT (Shanahan et al, 2017) did not support a benefit of Irish set dancing. Two RCTs assessed PD-specific dance forms (Hashimoto et al, 2015, Japan, n=46, PD-specific dance vs PD exercise or usual care; Michels et al, 2018a,b, USA, n=13, Dance for Parkinson's Disease vs support group) and both found evidence of a significant benefit of dance over the control interventions. The benefit of dance for motor function is well supported by a large body of evidence, including multiple RCTs, and the evidence is overall greatest for tango-based dance forms.

Music therapy

Seven music therapy studies assessed motor function. Three RCTs (Pacchetti et al, 2000, Italy, n=32, instrumental music improvisation vs physiotherapy; Pohl et al, 2013, Sweden, n=18, Ronnie Gardiner Rhythm and Music Method vs usual care; Bastepe-Grey et al, 2022, USA, n=24, guitar lessons vs usual care followed by guitar lessons) found a benefit of music therapy interventions on motor function. A further RCT (Pohl et al, 2020, Sweden, n=46, Ronnie Gardiner Rhythm and Music Method vs usual care) was classified as a positive finding, as it demonstrated improved short-term confidence about falling, however improvement was not shown on some other motor measures. A single-arm study (Wainwright et al, 2024, USA, n=5, drumming-based music therapy intervention) provides further supporting evidence. However, a non-randomised trial by Spina et al (2016, Italy, n=25, music, singing and dancing music therapy intervention vs usual care) showed no evidence of benefit and a non-randomised trial (Pantelyat et al, 2016, USA, n=18, West African drum circle class vs usual care) was inconclusive. Overall, most of the available evidence, including several RCTs, supports a benefit of music therapy on motor function.

Singing

Four singing studies assessed motor function. A cross-over RCT by Butala et al (2022) (USA, n=26, control is discussion group) found a significant benefit of singing on motor function as measured by MDS-UPDRS-

III (Goetz et al, 2008). This was corroborated by evidence from a two group repeated measures study – where the cohort was divided in a non-randomised manner by 'high dosage' and 'low dosage' of the singing intervention (Stegemoller et al, 2017a,b) (USA, n=27) as well as a non-randomised controlled trial (Stegemoller et al, 2021, 2022, 2023) (USA, n=25), though not for all measures of motor function. However, this benefit was not found in a single-arm study by Tamplin et al (2024) (Australia, n=28). A benefit of singing on motor function was supported by most available evidence, including the only RCT.

Theatre

Three theatre studies assessed motor function. One RCT by Modugno et al (2010) (Italy, n=20) compared to physiotherapy found a statistically significant benefit of theatre on UPDRS-III (it is not stated whether it is the original version or the MDS revision). However, one cross-over RCT by Bega et al (2017) (USA, n=22, control period is no intervention) and one non-randomised trial by Mirabella et al (2017) (Italy, n=24) compared to physiotherapy did not find evidence of a benefit of theatre on motor function. Evidence to support a benefit of theatre for motor function remains limited.

Cognition

Dance

Twenty dance studies assessed cognitive status. Three quarters of the studies (15/20, 75%) showed evidence of a benefit of dance on cognition. One challenge in interpreting the cognitive status findings, particularly for dance where the volume of studies is greatest, is variety in outcome measures. Therefore, the cognitive outcome measure used is noted when describing the available RCTs below. One study, in a tango context (Hackney et al, 2018) specifically compared following and leading (the dancing roles were not related to gender) and found that following offered greater cognitive benefit to people with PD. As per quality of life, and motor function, this may be worthy of further exploration. There was a total of ten RCTs assessing dance in relation to cognitive outcomes. Two RCTs assessed PD-specific dance forms. Hashimoto et al (2015) (Japan, n=46) found that PD-specific dance was significantly more effective than either PD exercise or usual care in improving cognitive symptoms as assessed by the Frontal Assessment Battery (FAB, Dubois et al, 2000), which is a short screening tool for cognitive function. However, Michels et al (2018a,b) (USA, n=13) did not find evidence than a customised PD dance intervention was any more effective than a support group in improving cognitive function as assessed by Montreal Cognitive Assessment (MoCA) (Nasreddine et al, 2005), which is another short screening tool. In a different neurological condition,

amyotrophic lateral sclerosis, there is evidence (Osborne et al, 2014) that FAB may be more feasible than MoCA. It is unknown whether this may explain the result, as MoCA is frequently used in PD cognitive research. Considering the benefit of different dance rhythms, Moratelli et al (2021, 2022) (Brazil, n=31) found that both binary and quaternary dance improved cognition as measured by MoCA. There was no evidence of improved performance in cognitive status compared to control for the DArT method (Frisaldi et al, 2021, Italy, n=38, vs conventional physiotherapy, cognition assessed by MoCA), Brazilian dance (Haas et al, 2024a, Brazil, n=83, vs deep-water exercise and Nordic walking, cognition assessed by MoCA), or Garba (Gujarati dance) (Mehta et al, 2024, India, n=55, vs physiotherapy and usual care, cognition assessed by SCOPA-COG). SCales for Outcomes in PArkinson's disease-COGnition (SCOPA-COG) (Marinus et al, 2003) is a short cognitive assessment tool designed specifically for PD. It is important to note that where RCTs contain an active control arm, the absence of a benefit vs control does not mean that there is no benefit in the dance intervention, solely that it does not offer a greater benefit than the other activity. One RCT (Solla et al, 2019) (Italy, n=20) found that the Sardinian folk dance Ballu Sardu offered significantly greater benefit for cognitive status as measured by MoCA compared to usual care. Three RCTs assessed tango-based dance for cognitive status. Hackney et al (2018) (USA, n=83) found that tango (especially when following) was significantly more beneficial for cognitive status as assessed by Corsi blocks (short-term working memory) and Tower of London test (executive functioning, Shallice, 1982) than wellness education. Patel et al (2018) (USA, n=36) found that adapted tango was significantly more effective than an educational intervention for cognitive function, although the cognitive tool used was not stated. Romenets et al (2015) (Canada, n=33) found a numerical benefit of Argentine tango compared to self-directed exercise on cognitive status as assessed by MoCA. Statistical significance was not reached. The potential impact of using English and French versions of assessment tools in the study was not sufficiently discussed by the authors. Overall, the majority of evidence supports a benefit of dance on cognitive status. Tango-based dance is the dance form for which there is the most RCT evidence for a benefit on cognition.

Music therapy

Five music therapy studies assessed cognitive status. RCTs by Pohl et al (2013) (Sweden, n=18, Ronnie Gardiner Rhythm and Music Method) and Spina et al (2016) (Italy, n=25, music, singing and dancing) both found a statistically significant benefit on standardised cognitive assessments compared to usual care. However, a further RCT by Pohl et al (2020) (Sweden, n=46, Ronnie Gardiner Rhythm and Music Method) compared to usual care, as well as a non-randomised trial by Pantelyat et al (2016) (USA, n=18, West

African drum circle class) and a single-arm cohort study by Shah-Zamora et al (USA, n=16, virtual group music therapy – instrument kits including a harmonica, drum, tambourine, drumsticks, wrist bells and more were provided) did not find a statistically significant benefit of music therapy on cognitive status. There is some evidence for a benefit of music therapy on cognitive status, but it is not conclusive. While less than half (40%) of the total available evidence supports a benefit of music therapy on cognitive status, two out of the three RCTs (67%) support this benefit.

Singing

One singing study assessed cognitive status. An RCT by Butala et al (2022) (USA, n=26), comparing group singing with a discussion group, did not find any statistically significant improvement in MoCA scores in the overall cohort or significant differences between the signing and discussion groups. No other studies directly assessed cognitive status, although a single group repeated measures study by Irons et al (2019, 2020) (Australia, UK and South Korea, n=95) considered a cognitive quality of life subscale, which was considered a quality-of-life measure, and found a statistically significant benefit of singing. There is currently no direct evidence for a benefit of singing on cognition.

Theatre

One theatre study assessed cognitive status. A non-randomised trial by Mirabella et al (2017) (Italy, n=24) compared to physiotherapy found no statistically significant evidence of benefit in either arm. There is currently no evidence for a benefit of theatre on cognitive status.

Risk of bias

This risk of bias profile is based on SURE, which is the primary risk of bias tool in this systematic review, following Barnish & Barran (2020) and Clare & Camic (2020). SURE focuses on domain-level profiles to give an overall picture of risk of bias within and across studies. It does not offer a summary score to categorise studies as 'low', 'medium' and 'high' risk of bias. This is consistent with recommendations from Katikireddi et al (2015) to focus on profiling risk of bias domains and to approach summary scores with caution, as they do not indicate limitations specific to that study. Assessment using CRD (RCTs) and NOS (non-randomised trials and observational studies) is available in Supplementary files 14 and 15. It was noted in particular that CRD asks very similar questions to the SURE Experimental studies checklist and the answers were highly consistent between the checklists. NOS asks some different questions, in particular

as it was used for all non-randomised and observational studies, whereas SURE uses the Experimental studies checklist for all trials (randomised and non-randomised). However, the NOS assessment was consistent with the SURE assessment where questions overlapped. Analysis of risk of bias assessment was conducted at the individual study level

There were several specific methodological issues in the included studies that are not captured by standard risk of bias tools. These are: i) the absence of control groups in some studies, ii) variation in intervention duration and frequency, iii) variation in professional backgrounds and levels of experience of session leaders, iv) variation in outcome measures, v) focus on statistical rather than clinical significance in almost all studies, and vi) cultural factors including underrepresentation of male participants. These are discussed in the study profile earlier in this Supplementary file 17 as well as in the main manuscript, as appropriate.

All dance experimental studies (RCTs and non-randomised trials) addressed a clearly focused research question, except Westbrook et al (1989), which provided a general introduction but then went into the methods section without first setting out clear aims and rationale. Where the population was randomised, the method of randomisation was appropriate where stated (e.g. online randomisation or random draw from a hat), however some studies did not report their randomisation method. Allocation concealment was rarely mentioned and while outcome assessors were often blinded, it was seldom possible to blind participants or those delivering interventions. This is due to the nature of the performing arts and other complex interventions which may be used as comparators, which look fundamentally different from each other. There were no significant issues with reporting of interventions and no studies were found to lack ethical approval, although Westbrook et al (1989) did not mention ethical approval. Publication of trial protocols was mixed across studies, although studies were typically well balanced for baseline characteristics. Where studies are randomised, this should ensure that any between-group baseline differences are non-systematic. Sample size insufficiency was a concern, as was lack of detailed information about participant flow. While results were typically clear and well-presented, limited detail on some of the statistical methods was a common issue. Conflict of interest was not typically considered an issue and study authors typically identified at least some of the key limitations in their work, although in some cases the strength of conclusions was not equal between the abstract and the full text. The pattern of risk of bias domains is generally highly consistent across performing arts modalities, so it is not necessary to repeat this profile for each of music therapy, singing and theatre.

Most dance observational studies had a clearly stated study design and addressed a clearly focused research question. Partial information about study setting and issues with fair selection of participants were common. For example, convenience sampling poses an increased risk of selection bias. Measurement of exposures and outcomes tended to be appropriate, using validated outcome measures wherever possible. In terms of speech outcomes (used for singing interventions), the value of acoustic parameters has typically not been validated, at least not until the recent development of measures such as AVQI, although the use of certain fairly standard acoustic parameters such as fundamental frequency, loudness, jitter and shimmer is well supported by long-standing custom in the field of phonetics. Some studies did not discuss addressing potential sources of bias, there were concerns about potentially insufficient sample sizes, statistical methods were not always well-described, and there was often limited information on participant flow. However, results were typically well described, conflict of interest was not an issue, and study authors typically identified some of the key limitations in their work.

It is appropriate to focus this text on mainly dance, as it is the modality for which there is the greatest number of studies, and the pattern of bias domain findings is very similar across performing arts modalities. Therefore, it would be repetitive to duplicate this profile for each of music therapy, singing and theatre. However, it should also be noted that generally study quality was more variable for observational studies and there were more limitations. Furthermore, there were limitations that could not be captured by the SURE risk of bias tool (or any other appropriate risk of bias tool), such as single arm studies where there is no comparator to control the potential effect of treatment for factors such as attentional biases, where participants may improve due to feeling that they have received attention from others, rather than any direct effect of treatment.

Overall, while summary bias scores are not something that SURE offers, our impression was that especially the experimental studies were fairly well designed and conducted, acknowledging some of the particular challenges of arts research as well as the arts and health still being an emerging field of research, where many of the RCTs were fairly small and exploratory, regardless of whether they were formally designated as pilot trials. Allocation concealment may be an issue, although this may in some cases be a reporting issue in the papers rather than an issue in how the studies were conducted. Blinding is frequently a challenge in complex interventions and participants' knowledge of their allocation may influence their performance. Where outcome assessors were blinded, this would protect against analysis bias based on expected results. Greater information on participant flow would help reassure against the risk of selection and attrition bias.

We consider that the most robust approach to considering how the results of the narrative synthesis would change if we only consider the best available evidence is to look solely at the results of randomised studies. The arts and health is an emerging area of research and methodological limitations are not uncommon, as some RCTs were designed as pilot trials. In particular, the nature of arts interventions makes it very difficult to blind participants or those delivering the treatment to the participant's group allocation. Frequently, it was only possible for trials to blind outcome assessors.

Assessment of evidence if we only consider RCTs

In the narrative synthesis above, for each combination of performing arts modality and outcome domain, we have initially presented the totality of the evidence and then presented the results if we only consider RCTs. Using all available evidence, the narrative synthesis supports a benefit for: i) dance on quality of life, ii) music therapy on quality of life, iii) singing on quality of life, iv) theatre on quality of life, v) singing on speech, vi) dance on motor function, vii) music therapy on motor function, viii) singing on motor function, and ix) dance on cognitive status. Considering only RCTs does not remove any of these findings but adds a benefit for music therapy on cognitive status, where less than half of the total evidence supports this benefit, but it is supported by two out of the three available RCTs.

Assessment of evidence if we only consider RCTs with a sample size of at least 40

One of the greater concerns across studies is adequacy of sample size. However, this is not unusual in an emerging field. Inadequate sample size would tend to bias studies towards a null result, so is unlikely to explain away positive findings observed. Any threshold for sample size across studies is arbitrary. However, if we only consider RCTs with a total sample size of at least 40, we retain evidence from eight dance RCTs (Duncan & Earhart, 2012/Foster et al, 2013; Hackney & Earhart 2009a,b,c; Hackney et al, 2018, Hashimoto et al, 2015; Hulbert et al, 2017/Kunkel et al, 2017; Shanahan et al, 2017; Haas et al, 2024a; Mehta et al, 2024) and one music therapy RCT (Pohl et al, 2020), the characteristics and results of which are profiled above. This more restricted set of studies provides overall evidence for a benefit for i) dance on quality of life; ii) dance on motor function; and iii) music therapy on quality of life. Evidence for a benefit of dance on cognitive status was less clear cut if we only consider RCTs with a sample size of at least 40.

DISCUSSION

A review by Cerri et al (2019) shows that PD is twice as common in men than women. A meta-analysis by Moisan et al (2016) showed that the male: female ratio was 1.48 for prevalence and 1.49 for incidence. However, this study also showed that male: female ratios in PD increase by 0.05 for prevalence and 0.14 for incidence for every 10 years of age. While the male: female ratio for incidence was <1.2 (not statistically significant) at age 50, it rose to 1.6 ($p<0.001$) by age 80. Therefore, given that the mean age in studies included in our review was 68, a male percentage of 55% likely substantially underestimates the proportion of men in the PD population for that age.

Sex may have a biological role in influencing PD progression and symptomatology through sex-related risk and protective factors (Moisan et al, 2016). PD may be milder among women at earlier disease stages (Haaxma et al, 2007) and sex-related differences have been observed in the expression of early non-motor symptoms (Liu et al, 2015). Sex differences in PD most likely involve a combination of genetic, lifestyle, hormonal and reproductive factors, as well as differences in the structure and functioning of the dopaminergic pathway (Gillies et al, 2014; Smith & Dahodwala, 2014).

Sex and gender may also play an important role in people's engagement with the arts, as the arts are inextricably linked with culture, which is a gendered space (Myrdahl, 2019), whose manifestations differ between different cultures across the world. For example, in dance, while men typically perform the lead role in traditional partnered dance forms, there is a persisting cultural view in some cultures that dance is not a masculine pursuit (Holdsworth, 2013). While playing instruments is more likely to be a comfortable cultural space for men, in many settings choirs may be seen as more of a female-dominated space and there can be multiple barriers to male involvement (Register, 2019).

Experiences of health may also be gendered (World Health Organization, 2021) and differ between cultural settings. For example, the perception of ageing and cognitive impairment in Africa may be very different than in a Western context (Faure-Delage et al, 2012). Culture and gender may also play important roles in psychological factors and stigma (Simpson et al, 2013; Tickle-Degnen et al, 2011) that can be a barrier to societal participation in PD.

Therefore, the underrepresentation of male participants in studies on the arts and health in PD is likely an important issue that future studies should aim to address. Across health conditions, male under-recruitment in longitudinal research studies (observational studies or trials) is a longstanding problem (Borg et al,

2024). These authors (Borg et al, 2024), using a systematic review design to identify all available relevant literature on barriers and facilitators to male recruitment, found that men on average appear disinterested towards participation in health research compared to women, but this lack of enthusiasm can be overcome by clear, non-directive communication, and studies that support the participants' interests. Free medical screening, reminders for appointments, and enrolment of wives or family members were seen as potentially valuable strategies to improve male recruitment and retention.

It is important that recruitment strategies recognise the role that gender plays in society (Barr et al, 2024) and recognise cultural perceptions related to masculinity and health-seeking behaviour in the relevant culture context where the study will take place (Pirkis et al, 2017). Studies have shown that taking health studies to men and settings where men habitually socialise and feel at ease can be a valuable way to encourage men to engage with health research and health-facilitating activities (Gray et al, 2013; Wyke et al, 2015).

No studies were identified that specifically looked at strategies to improve male recruitment in PD research. However, Vaswani et al (2020) set out useful strategies for improving uptake in PD research in general. These included: i) in trial design, broadening inclusion criteria, attending to participant burden, and focusing on trial efficiency and ii) at the recruitment stage, increasing awareness, with traditional outreach or digital approaches; improving engagement, particularly with community physicians; and developing targeted recruitment efforts. We considered that the evidence and suggestions about increasing male recruitment in general are likely to generalise to the PD context.

No studies were identified that specifically looked at strategies to improve male recruitment in arts research or arts activities. However, the evidence and points explored above are likely to be relevant. In particular, i) identifying and understanding the gendered cultural context, ii) identifying arts activities and locations that are more likely to appeal to men (noting that of course men will have different preferences), and iii) finding ways to communicate with men in an encouraging and appropriate way to facilitate involvement.

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Citations to all included studies are shown in Supplementary file 6. Other articles cited within Supplementary file 17 are listed below.

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