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Full Report

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Contents

Aims

The request from the DHSC was to examine the following:

1. Are dance-based interventions effective in preventing falls, reducing risk of falls, or preventing fear of falls in older adults?
2. What is the evidence for cost-effectiveness of dance-based interventions for falls prevention amongst older people?
3. Should the NHS be advised to invest in dance-based interventions rather than traditional strength and balance interventions (e.g. FaME or Otago interventions)?

This report presents the findings of a rapid review conducted at the end of 2022 and early 2023. It aims to highlight the types of dance interventions and whether they are effective in reducing falls, risk of falls, and fear of falling[1]. We also explore what evidence exists in terms of the cost-effectiveness of dance-based interventions for falls prevention. This evidence will permit rational policy decisions on the appropriateness of dance-based initiatives as a cost-effective alternative to traditional balance and strength-focused exercise programmes aimed at reducing falls amongst older adults.

Exercise for falls prevention resumé

By way of initial introduction it is worth noting that the most recent Cochrane review of exercises to prevent falls [1] reports that exercise reduces risk by 23% (Rate Ratio=0.77[0.71,0.83]). When delivered by health professional an even more impressive result is observed (RR=0.69[0.61,0.79]). The Cochrane review, however, only included one randomised controlled trial (RCT) of dance and that study revealed an increase in falls for dance (3D exercise) [2] [2] (RR 1.34[0.98,1.83]) which compares poorly to those studies focussing on balance and functional strength exercises (RR=0.76[0.7,0.81]), while Tai Chi (3D) reduces risk (RR=0.81[0.67,0.99]). Cochrane reviews are sometimes criticised because they are very exacting as to the inclusion of studies and the rating of evidence. Sometimes there is concern that the very rigorous Cochrane process excludes evidence that may help guide policy and practice. The current review will therefore take a more inclusive approach and include non-randomised studies, but provides clear assessment as to the quality of the evidence arising from these different designs, and the way the studies are conducted.

Background

A fall is defined as “an event which results in a person coming to rest inadvertently on the ground or floor or other lower level” [3]. Some 30% of older adults aged 65 years and over fall each year, accounting for the second leading cause of unintentional injury death each year [4]. Falls prevention is recognised as a global public health priority [5]. Whilst most falls do not result in death, 5-10% result in injuries (e.g., fractures, head injuries). Unless there

[1] The nomenclature has changed recently and fear-of-falling is now referred to as concerns-about-falling to more properly represent the nature of the emotional state [12]. For the purposes of this review and searches undertaken we have stayed with the former language as this is what is used in the papers reviewed.

[2] The Prevention of Falls Network Europe (ProFaNE) taxonomy [2] defines 3D (dance) training uses dynamic movement qualities, patterns and speeds whilst engaged in constant movement in a fluid, repetitive, controlled manner through three spatial planes. Exercise programmes included in this analysis had 3D (dance) training as the single primary exercise category; these exercise programmes may also include secondary categories of exercise.

are effective interventions, the number of injuries is likely to further increase with population ageing [6–9]. In the UK, approximately 10.5% of ambulance service calls are to people over 65 who have fallen [10] and some 60% of these cases are taken to hospital. The recent *NHS England 'Going further for winter: community-based falls response*' highlights the importance of falls prevention to improving system efficiency, focussing ambulance capacity and the need for community falls prevention [11].

As well as injuries, falls can result in a loss of confidence and a reduction in participation in physical activities [12,13]. Given this, there has been a lot of research interest on investigating what causes older adults to fall and how to prevent the fall from occurring. Studies have looked at identifying the risk factors of falls to identify the most effective interventions that will prevent not only the fall from happening, but also to address the underlying risk factors. Falls risk factors can be intrinsic (e.g., biological; use of multiple medications; history of falls; psychological status such as fear of falls; impaired mobility and gait; visual impairments; and sedentary behaviour) or extrinsic (e.g., environmental hazards such as poor building design, slippery floor, uneven surfaces; footwear and clothing; and inappropriate walking aids or assistive devices) [7,9,14]. Apart from biological factors such as age, gender, race, and ethnicity, most risk factors are modifiable through tailored interventions.

Overall multifactorial[3] interventions may reduce the rate of falls compared with usual care or attention control. However, there may be little or no effect on other fall-related outcomes. Multiple component interventions, usually including exercise, may reduce the rate of falls and risk of falling compared with usual care or controls [14]. Amongst people with high risk of falling, home interventions [14] on safety appear to be effective, especially when carried out by occupational therapists. Targeting behavioural change to ensure a healthy lifestyle is also a recommended strategy [5].

There is a strong evidence base indicating that group and community or home-based exercise programmes are very effective in reducing the risk of falls and that interventions should focus on balance and strength training [1,6]. Meta-analysis shows that a well-designed exercise programme has the biggest effect on falls rates if undertaken at moderate intensity to challenge balance and conducted at a sufficient dose of around 2 hours a week for a period of 6 months. Cochrane reviews [1,14] also recommended group exercises focusing on high challenge balance and progressive strength training can reduce the rate of falls. Single exercise programmes like Falls Management Exercise (FaME) [15,16] and Otago [17,18] have strong established evidence on falls prevention. In the UK, PHE recommend FaME and Otago as programmes with positive return on investment [19].

There is evidence that Tai Chi, as a 3D form of exercise, prevents falls [1] but other forms of 3D activity, such as Qi Gong and dance have been less studied and therefore less is known as to their effectiveness. Dance has been put forward as an alternative approach to falls

[3] What is the difference between "multifactorial interventions" and "multiple component interventions"? Hopewell et al [14] make this distinction clear: "A multifactorial intervention is one in which the selection of falls prevention interventions (such as exercise, home-hazard modification or medication review) prescribed or provided to each individual is matched to their risk-of-falls profile, which is assessed beforehand. This individually-tailored intervention means that after receiving an assessment of known risk factors for falling, individuals are likely to received different combinations of interventions: i.e. one person may receive supervised exercise and home-hazard modification whereas another may receive home-hazard modification and medication review. Multiple component interventions are those where people receive a fixed combination of two or more fall prevention interventions selected from different categories of intervention (e.g. exercises, medication review, environment/assistive technology)" (pp7-10).

prevention. It is argued that since dance is oftentimes conducted either as a group or with a partner [20], it can be an enjoyable and sociable form of exercises in comparison to more formal exercises, thus enhancing both uptake and adherence. However, it should be noted that strength and balance programmes, such as FaME and Otago, are often delivered in groups and organised so as to use the group sessions to provide sociable and enjoyable activities which engage the older people participating [21,22].

A number of reviews have reported physical and mental health benefits of different forms of dance [23–28], but such dance programmes do not usually focus on the types of exercises known to prevent falls, namely, progressively challenging balance exercise and functional strength exercises. A recent systematic review [25] of dance and falls risk reports improvements in Timed Up and Go (TUG), Berg Balance Scale and one-leg stand tests in dance groups compared to controls. It should be noted however that a reduction in falls risk does not necessarily mean a reduction in falls. It is clear that proxy markers of falls risk (TUG, balance, etc) improve in many studies without actual falls rate or number of fallers being reduced [1]. Nonetheless a systematic review [28] of 29 RCTs of mind-motor dance activities[4] for healthy older people reports improvements in risk of falling (37%) (five of eight RCTs in sub-analysis are of Tai Chi) and rate of falls (31%) (five of seven RCTs in sub-analysis are of Tai Chi), suggesting much of the observed effects is a function of Tai Chi exercise rather than dancing per se. A more recent review [23] highlighted that dance-related combination exercises (e.g., aerobics with creative dance) have significant effect on lower-body strength and functional balance. Similarly, a review [27] on the physical benefits of dance for healthy older adults suggested that dance can improve lower-body strength and endurance, especially for female older adults.

Whilst some reviews find in favour of dance as providing health benefits, this is by no means unanimous. For example, there appears to be no evidence in support of the hypothesis that dance interventions provide psychosocial benefit when delivered using technology, as meta-analysis revealed low quality evidence that there was little or no difference from controls for fear-of-falling or depression [29]. Another review [26] on therapeutic effects of dancing as a physical exercise modality on balance showed that dance has positive effects on balance and mobility for healthy older adults. However, there are aspects of the studies that do not enable the reviewers to confirm that dance has significant benefits. These include poor methodological quality, small sample size, and variation in scale of improvements in assessment tools. A review [24] on dance-based therapy suggested no effect on falls but that there may be improvements in fear of falling. Whilst dance appeared to be a safe alternative, there is a lack of strong evidence on the effect of dance in preventing falls. Whilst dance interventions may improve overall physical health, cognitive abilities, and physical activity [23,27] of older adults, benefits in terms of falls prevention are still uncertain [1].

Falls are a large burden for health care costs [30] with costs per person varying considerably across countries and programmes. There is some evidence on the cost effectiveness of single factor interventions, such as Otago, FaME, and Tai Chi, that are balance and strengths-focused [31]. However, there is still sparse information on whether dance offers the same value for money. Therefore, more robust economic evaluations of the effectiveness of dance-based interventions still need to be widely examined.

[4] Defined as coordinated upright mind-motor movements that emphasise dynamic balance, structured through music or an inner rhythm (e.g. breathing) and distinctive instructions or choreography, and involve social interaction. Mind-motor activities are activities that combine cognitive and physical tasks (dual tasking or multitasking activities) that involve working memory and deliberate motor control [28]

There are various policy recommendations on how successfully to address falls prevention. For instance, world guidelines for falls prevention and management have recently been published [6]. These guidelines highlight that successful implementation requires a supportive organisational context and policies that focus on behaviour change for older adults and health care professionals.

In the UK, with the predicted increase in falls over the coming years as a result of the COVID-19 pandemic, falls prevention has become even more of a priority [32]. Resources are being committed to address this issue and despite the resources being developed [33], it may be unclear on how best to commission falls prevention programmes, especially given concerns that evidence may have changed over the last few years. We thus conducted a rapid review of the literature around falls prevention and dance interventions.

Methods

Due to the time sensitivity of this request, a rapid review was conducted. The focus of our search is to look at existing evidence on dance interventions and their effectiveness in falls prevention. The main aim is to look at studies examining falls outcomes (falls rate and number of falls). We also want to look at those studies with proxy markers for falls risk, even though there is evidence from structured exercise programmes that it is possible to reduce risk factors for falls (improve strength and balance) without seeing a reduction in falls.

We are interested in studies that investigate the causal relationships between dance-based programmes and falls in older adults. To address the first aim of this review, we included studies that are experimental, quasi-experimental, or non-experimental in nature with an element of dance within the intervention. Our definition of dance is guided by the ProFANE Falls Taxonomy [2], which is “constant movement in a controlled, fluid, repetitive way through all 3 spatial planes or dimensions (forward and back, side to side, and up and down) in a wide range of dynamic movement qualities, speed, and patterns” (p.21). Examples of dance may include dance exercises, dance therapy, contemporary dance, etc.

To address the second aim of this review, we also included cost effectiveness analyses of dance interventions within our searches.

We also only wanted to look at studies with adults aged 50 years and over, who are either healthy, at risk of falls, or have co-morbidities. Given the scope of this review, we excluded studies that do not test any dance interventions and/or are purely qualitative in nature.

The detailed search strategy is presented in Appendix A.

Findings

We identified 397 papers after a systematic search. Following removal of duplicates, 256 titles were screened. 96 studies remained for abstract screening and 54 studies were included for full text screening. At full text a further six studies were excluded. In total, there are 48 studies included in this rapid review.

A PRISMA [34] diagram of paper identification, and exclusion is presented in Appendix B (Figure 1).

Study characteristics

In this review, there are 23 RCTs, 22 quasi-experimental studies, two mixed methods studies, and one cost-effective analysis. Population included in the studies are as follows: older adults who are either sedentary or healthy and active; those who are living in the community, nursing homes, or senior care facilities; and those with clinical conditions such as Parkinson's disease, visual impairment, and stroke. Seven studies [35–41] looked at only women. The duration of each dance session included in the review ranges from 30 minutes to 2 hours per week, with frequency of 1-5 times a week. Intervention periods ranged from 3 weeks to 14 months.

In terms of outcomes, we are interested in studies that looked at the impact on falls. We found eight studies [39,42–48] that recorded number of falls or fallers before and after intervention. In addition, we also wanted to look at risk factors for falls, such as balance impairment and fear of falling. In this review, there were seven studies that looked at quality of life [47,49–54], eight on concern of falling [39,43,51,54–58], 43 on balance [36–43,45–50,52,54–56,58–82], five on strength [35,41,59,60,77], and three on risk of falls [47,76,77]. We also included studies that looked at cost-effectiveness of dance interventions and found one study [44] that addresses this.

Assessment tools that are commonly used in the assessment include the following: balance – Timed Up and Go (TUG) test, Berg Balance Scale (BBS), Short Physical Performance Battery (SPPB), and the Functional Reach Test (FRT); strength – lower body strength such as hip and knee flexors, hip and knee extensors; fear-of-falling – Falls Efficacy Scale–International (FES-I); quality of life – EUROQoL; risk of falls – Physiological Profile Assessment (PPA); and falls – number of falls, number of recurrent falls, fall rates, number of fallers etc [3].

A summary of all studies included in this review is presented in Appendix B (Table 1).

Types of dance interventions

The studies reported a variety of dance-based interventions. We categorised the different types of dances as follows:

Ballroom and Latin dances. [42,46–48,50,52,62,67,68,72–75,78,79] N=15

Social dances, such as Ballroom and Latin American dance, are amongst the most popular forms of dance-based interventions for older adults particularly for those with neurological diseases or chronic illnesses, such as Parkinson’s disease, diabetes, stroke and/or dementia [20,83]. As opposed to regular aerobic and strengthening exercises, social dances have

specific choreographies and synchronised routines depending on the type of dance. Since Ballroom and Latin dances are traditionally danced with a partner, it has the potential to assist older adults in improving their gait, balance, and coordination. In addition, it is possible that the intensity of the steps brings recreational and rehabilitative value to the participants, thus, increasing their motivation and willingness to continue [20,84].

Cultural dances. [36,37,45,59,61,66,69,76] N=8

Folk dances are traditional forms of social dancing that are associated with a particular population and its culture, customs, and rituals [85]. They incorporate movements that have distinct postures that are usually unique to the community and are oftentimes used for ceremonial or spiritual purposes [86]. As a form of exercise, folk dances are usually low-cost [86] since they are based in local communities or can be conducted at home and can be easily performed by people of all ages [61].

The success of cultural dances as an effective mode of exercise for older adults is attributed to the fact that participants can dance it without a partner [85], unlike Ballroom and Latin dances [20].

Dance-based exercises. [38,40,70,41,44,49,53,54,63–65] N=11

The essential difference between dance-based exercises and the Ballroom, Latin and cultural dances identified above is that exercise is the aim and dance is a way of achieving that aim, whereas the Ballroom, Latin and cultural dances exist for their own sake. Dance-based exercises focus on cardiovascular exercises and incorporate low to moderate strength, endurance, balance, or coordination training. As opposed to social dance dance-based exercises found in this review feature multiple dance styles in combination with general conditioning activities such as aerobics, balance and strength training, light stretching, and breathing exercises [38,40,41,49,54,63–65,70]. In this review, the most common form is group aerobics accompanied by music [38,40,41,54,70].

Dance-based therapy. [71,77] N=2

Dance-based therapy is also referred to as Dance/Movement therapy (DMT) or Dance Movement Psychotherapy (DMP) in the literature. It is defined as “the therapeutic use of movement to further the emotional, cognitive, physical, spiritual and social integration of the individual” by the European Association Dance Movement Therapy [87]. DMT features the use of low-impact physiotherapy movements through dance and has been attributed to a wide-range of health benefits, which include reducing pain and healing injuries [88,89].

Dance-based exergames. [35,39,43,56–58,80] N=7

Exergames are technology-based exercises through video or virtual reality games. With features such as fast-paced music and dancing through video games or devices, it has become an emerging form of exercise that encourages older adults to improve their physical health and to enjoy themselves at the same time [29,90]. In general, there is some evidence that exergames improve global cognition [91] and that exergaming approaches can prevent falls, albeit not specifically as a result of dance components of the games [91].

Low impact dances. [51,55,60,81,82] N=5

There are five studies that we could not classify with the rest of the dance styles. However, the movements are often described as low impact so in this review, we grouped them together under the same category.

Two studies [51,55] were contemporary dances focusing on interpretative movements. It has elements of low-impact aerobics and resistance. As a form of exercise, it may yield improvements in balance and increased physical levels for older adults [27]. One of the studies [81] explored tap dance, where movements are focused on the ankles and feet. Another [60] looked at Line Dance and the last one [82] Ballet.

Features and effectiveness of dance interventions

Due to the time constraint of this rapid review, we are unable to conduct a meta-analysis. We therefore conducted a narrative synthesis of the dance interventions by highlighting their key features and the outcomes reported. Summary of outcomes can be found in Appendix B (Table 2). We have also looked quite carefully at the quality of the evidence and present risk of bias and quality assessments evidence to help interpretation (Appendix B: Figures 2 and 3).

Ballroom and Latin dances.

The mode of delivery varies from single to multi-modal training. Four studies investigated Ballroom Tango [46,50,62,67], another three Argentine Tango [48,75,78], one on Cha-Cha [73], and one study Brazilian Samba [52]. Six studies were mixed dance programme, with dances varying from Foxtrot, Waltz, Rumba, Jive, Swing, Line dance, Jazz, Rock and Roll, and Salsa [42,47,68,72,74,79]. Dance partners of the participants were spouses, caregivers, and/or volunteers. Six of the studies [46,48,52,62,72,78], primarily Tango and Brazilian Samba dances, were designed for older adults with Parkinson's disease. Movements were modified to adapt to motor impairments.

Multi-modal programmes have various intervention elements in addition to the Ballroom and Latin dances. One study used mind-motor activities [68], where the focus of the dancing programme is for participants to learn and remember the choreography of five dances. In the last 2 weeks of the dancing programme, participants are asked to recall the dance movements. Two studies conducted interviews on participant experiences [72,75] to explore perceptions of the appropriateness of the dance programme. Diaries and multimedia training via workshops, guidebook and DVD [47] were used by one study. Dance instructors delivered the training through these resources. Lastly, one study incorporated socialisation after dancing [48].

Sessions are delivered by dance instructors, who either have professional experience or have been specifically trained for the intervention [46–48,50,52,67,72–75]. Some are also supervised by a qualified physical therapist [78]. Intensity of the programme also depends on the type of dance. Each session can last from 50 minutes to 1.5 hours, with frequency of 1-3 times per week.

All fourteen studies looked at balance as a key outcome, of which ten showed positive associations between participation in Ballroom [42,50,67,74] and Latin dances

[48,52,68,73,75,79] and balance. For instance, the adapted Tango programme [50,67] for visually impaired older adults resulted in improved balance reactions and lower body strength. It was compared with a multimodal exercise programme called FallProof, where tasks and challenges were performed in increasing progression alongside additional sensory stimuli. Both FallProof and adapted Tango were reportedly equally effective and good exercise options for older adults with visual impairment.

There are also several social dance programmes for older adults with Parkinson's disease such as adapted Argentine Tango [46,48,72,78] and Brazilian Samba [52]. However, in the two studies measuring falls, the number of fallers and falls did not significantly improve [46,48]. There was inconsistency in balance improvements, whilst overall quality of life of the participants (PDQ-39) did not significantly improve [52]. In terms of falls outcomes, only four studies looked at the number of fallers before and after the intervention [42,46–48]. Only three studies [42,47,48] are RCTs. They compared the experimental group with usual care, which is to carry on with their daily activities. Only one study [42] showed positive significant results, where there were fewer falls in the dance group after engaging with the ballroom intervention. Thus, results are inconclusive since only one RCT showed positive changes and it is not possible to estimate the effect size from the data presented.

Dance-based exercises.

Tempo and dance movements are often tailored to the age and capacity of the participants. For example, the Dance for Parkinson’s Disease® (DfPD®) programme [54,70] has smaller movements that isolate the different parts of the body. Participants participate in warm-up sessions, which include balanced poses and weight shifting, before proceeding to choreographed dance movements. The coordinated sequences of the upper and lower limbs in DfPD is particularly tailored to participants with Parkinson's disease and offers more benefits and variety than traditional rehabilitation methods [70]. Another study's exercise intensity was set at the individual participant's heart rate and rating of perceived exertion [41]. The tempo of the music and choreography of the dance are modified for the participants.

Progressive development in the activities is also a feature. One study [63], for instance, offers light exercises for the first two weeks followed by balance exercises combined with dance for the remainder of the programme. Another study [65] began with a low-intensity warm-up to prepare the participants for gradual progression to a more strenuous exercise. In contrast, one study [38] has specifically designed its functional and fitness elements to naturally deteriorate with the ageing process, with the intensity of the dance movements slowing down as the programme progresses.

Some dance-based exercise programmes also have a social component, where participants are free to socialise with each other after the dance. In the DfPD programme, participants can bring a family member, a friend, or a caregiver to join them in the dance. Each class is followed by socialisation with tea and coffee [70]. Another programme called Dance to Health [44,53] has embedded the FaME and Otago exercises into creative and social dancing. The dance session is followed by half an hour of socialising time to encourage friendships within the group. It should be noted that falls prevention exercise such as FaME and Otago sessions very often include optional social elements [92,93] and thus the extra socialisation is not unique to dance based intervention.

Nine [38,40,41,44,53,63–65,70] of the eleven studies reported positive outcomes on balance, strength, and quality of life. Only four of these are RCTs [38,40,41,63]. Only one

study [54] reported on fear-of-falling. The quasi-experimental pilot programme on Dance for Parkinson's curriculum showed reduced fear-of-falling in people with Parkinson's disease, and this was attributed to the modified strategies for changing dance positions in class. Dance instructors provided reminder cues to the participants to stabilise their feet when transitioning from being seated in chairs to the standing position. Also, only one study [38] compared the intervention with an active control group. The structured dance programme with multiple dance styles targeting balance, flexibility, and aerobic conditioning was found to be as effective as walking on a treadmill. The rest of the studies compared with usual care or made no comparison at all.

One study [44], with no control or comparison group, reported number of falls, and concluded there was a 58% reduction after participation in the Dance to Health programme. However, this study was a service evaluation and data were not presented on an intention to treat basis, only on a 'completers' basis. Some 1194 people started the intervention and data are only presented on 246 people. This is very likely to introduce bias into results. It was not clear how falls were recorded or reported to show the reported reduction. This paper also reports a cost-effectiveness analysis, (see below). Normally such an analysis would be based on robust effectiveness data derived from a randomised trial design, and thus we may need to query the robustness of this analysis.

Cultural dances.

There are two types of cultural dances found in this review: folk dances and martial arts dance.

The folk dances studied originated from Thailand [36,37,45,61], Indonesia [76], Brazil [66], and the Faroe Islands [69]. Five of these studies are RCTs [36,37,66,69,76]. The dances researched had different forms. For example, the Thai folk dances have slow movements and rhythmic patterns with music very similar to Tai Chi. However, unlike Tai Chi, Thai folk dances have more complex postures [36] and focus more on coordination and muscle strength of the upper and lower limbs [37]. The Indonesian folk dance [76], Molong Kopi, also has gentle movements with a melodious classical music. It is originally danced by farmers as a way to show gratitude for their agricultural harvest. Similarly, the dance from the Faroe Islands [69] is a simple ancient chain dance accompanied by a ballad and is normally performed in celebratory events. Folk dance can also be in a form of aerobic-based exercise with traditional dance music as an accompaniment. The Senior Dance programme [66] is an alternative to structured exercises and consists of different choreographies following rhythmic folk songs.

Implementing folk dance interventions vary from setting to setting. Senior Dance [66], for instance, was conducted in older adults living in retirement villages who are more likely to be physically inactive than those that reside in community settings. It was led by instructors, who were also physical therapists. Two of the studies [36,76] used training videos and manuals so participants can follow the dance movements.

Another form of cultural dance is martial arts. We found one study [59] in this review that used Thai boxing as a form of aerobic exercise. Movements are usually low impact, where punches, kicks, elbow, and knee strikes are conducted while music is being played.

In this review, all seven studies [36,37,45,61,66,69,76] on folk dances showed positive significant outcomes on balance, whilst the Thai boxing programme [59] found significant improvements both in balance and strength. Only one study [76] examined the effect on risk

of falls. Older adults that engaged in Molong Kopi dance had reduced risk of falls (measured by Morse Fall Scale), as opposed to those that just continued their usual activities. None of the studies examined number of falls as a primary outcome.

Dance-based therapy.

Dance-based therapy sessions are delivered by trained instructors, who are also in most cases qualified physiotherapists. The duration of each class was 45 to 60 minutes, with frequency varying between 2-3 times per week. Two studies used the Lebel Method (TLM) dance therapy [71,77], which was originally developed for those with lymphoedema and physical limitations. The exercises focus on particular sequences that are slow, smooth, and with very slight resistance that are carried out on each arm one at a time. The movements focus on balance and mobility, and do not include a specific strength component [77].

Both studies [71,77] are quasi-experimental. Dance-based therapy was found to improve leg strength of older adults when compared with those participating in a structured exercise programme [77]. However, only one study [77] looked at how DTM can reduce falls risk. In fact, when compared with a multifactorial exercise programme called Stay Active and Independent for Life (SAIL), the participants in DTM had poorer outcomes. This showed that whilst DTM offers positive benefits in balance and social interaction, exercise interventions are still more effective in reducing risk of falls in older adults. Thus, in summary, general dance has many benefits to risk factors for falls but it seems that, in the evidence base so far, exercise interventions are more effective in terms of falls outcomes.

Dance-based exergames.

There are various forms of exergames found in this review. StepMania, for example, is a game software where participants follow a series of stepping sequences following arrows on a display screen. As a modification for older adults, it is used in conjunction with pressure-sensitive step pads, like impact dance platforms [43,56] or metal dance pads [57]. As such, this type of exergame requires the simultaneous use of cognitive attention and motor coordination [43,56]. Participants were required to stand and hold on to ropes for safety purposes. Music is played according to the participants' preference. The Dance Central software, an XBox 360 game, is also commonly used [35,39,58,80]. It is usually played with a Kinect motion device and songs are chosen in advance for the participants.

The intensity of the sessions varies per study. Two studies chose movements based on the guidelines published by the American College of Sports Medicine [39,57]. In StepMania, the level of difficulty is adapted to each individual’s coordination ability [43,56]. For the Dance Central game, dance movements are rhythmical, single and double steps, step-in-place, and sidekick motions. Song duration varies from two to four minutes, where participants get an average of 30-second breaks in between the alternating slow- and fast-paced songs. The sequence of songs tends to increase progressively in difficulty. For other studies [57,58,80], the progression is controlled through the beats per minute. Some studies modify the programme to further add variety and more intensity to the game. One study [39] added colourful flashing lights to increment the sensory input difficulty, whilst another study [57] added distracting visual cues to increase the cognitive load so participants can try to keep their attention on the sequence of arrows.

All studies, except for one [35], examined fear-of-falling as a primary outcome in their interventions. Only two [43,58] of these studies showed a positive effect. For instance,

playing the Dance Central software games [58] led to gains in falls efficacy for older adults with stroke. In terms of number of falls, an aerobic endurance with dance game through Virtual Reality (VR) [43] reduced fall rate by 77% in healthy, community-dwelling older adults. This speculates that engaging with cognitive tasks whilst walking can focus older adults' attention, thus reducing the risk of falling. Another Dance Central study [39] reported a more detailed record on the falls, by including where the falls have occurred, the causes of the fall, and the types of falls that occur after the intervention. Perhaps worryingly, results from this study suggest a slight increase in falls in the dance group, although no significance testing of the data is presented and the small sample size is unlikely to be sufficient to reveal any difference between groups.

Low impact dances.

The contemporary dances [51,55] included in this review are fluid and organic in form, whereby creative expression is encouraged. In one of the studies [55], the structure of the programme is very dynamic. The exercise is low impact aerobics followed by improvisation. The session ends with the participants sharing their dance with friends and family. Similarly, the other study [51] incorporates jazz and classical music into contemporary dance routines. The dances are conducted in pairs and small groups, and improvisation of movements is also encouraged.

Tap dance [81] was modified to take into consideration the fitness of the older adults participating in the programme. Line dance [60] used a simple, low impact aerobic exercise modified for those with mobility limitations. Ballet is also used in one of the studies [82] using modified simple static and dynamic movements. The intervention is consistent with professional ballet training and the participants are given enough time to learn each step whilst receiving feedback throughout the session.

Only two studies [60,81] were RCTs, and none of the low-impact dance studies recorded number of falls as primary outcome. However, two looked at fear-of-falling and whilst there was positive improvement, one [51] of the studies showed no significant differences following the completion of a contemporary dance programme. Both tap [81] and line [60] dancing improved balance of the participants.

Cost-effectiveness of the interventions

We only found one study reporting cost-effectiveness, and this related to the Dance to Health programme [44]. Dance to Health is a UK-based dance intervention that is being pioneered as a nationwide falls prevention dance programme for older adults. Incorporating the exercise elements of Otago and FaME, Dance to Health aims to engage older adults into creative dancing whilst improving their strength, balance, and flexibility. The programme comprises sessions of two hours per week, with 90 minutes of dance activities and 30 minutes of socialising. The programme is delivered over six months.

The study used an adjusted model of the Public Health England Return on Investment tool [19], and pre- and post-intervention data from implementation of the Dance to Health programme, rather than robust RCT data. Based on their analysis the authors claim a potential cost saving of more than £196m over a 2-year period, with a 58% reduction in the number of falls. A key problem for the paper is that they only use data from a subset of the sample (246 from 1194) thus introducing bias and extrapolate from "completers" to the whole population. The economic methods are not well described and assumptions made are open

to question. The analysis is based on a service evaluation with inherent bias, rather than a RCT, therefore, any claims of effectiveness should be treated with caution. This is particularly important given assessment of quality of evidence reported below for this study [44].

Quality of the evidence

To check the quality of the evidence, we conducted an assessment of risk bias for the studies included in this review. Details on the assessment of risk of bias for RCTs and non-randomised studies can be found in Appendix B (Figures 2 and 3).

Randomised studies

We examined 23 randomised studies using the Cochrane Risk of Bias Tool (RoB-I) [94] (Appendix B, Figure 2). Rob-1 covers the following domains: selection bias, performance bias, detection bias, attrition bias, and reporting bias and provides an overall assessment of bias for the study.

Only four randomised studies [36,38,47,81] showed low risk of bias consistently across all five domains. Eleven studies [35,48,60,63,66,68,69,72,74,75,78] were at high risk of bias, whilst the rest of the studies [37,40,43,56,57,59,73,76] have unclear risk of bias with all but one [40] having high risk of bias in at least one key domain.

Most of the studies showed low risk of bias on the random sequence generation. However, there was a high risk of selection bias in two studies [48,78] where concealment of allocation was difficult to conduct successfully. Both studies used serial or sequential enrolment to accommodate the limited availability of instructors or excessive waiting time for intervention. Therefore, there was a chance that the participants may have realized the type of intervention they received or the group they may have been assigned to. In some studies [40,68,73], it was unclear as to how the researchers have blinded participants and personnel. This raises concern in terms of performance biases, especially when there is little or no information on the blinding process of participant assignment to intervention and control groups. In most studies [37,42,43,48,56,57,59,60,63,66,69,72,74–76,78], however, blinding of researchers was unlikely to have been successfully achieved due to the nature of the intervention. There was also high risk of detection bias in four studies [35,43,56,60], where blinding of outcome assessors was not possible. In terms of attrition bias, six studies [37,66,68,74–76] provide insufficient information on incomplete outcome data. Finally, there is high concern of bias on outcome reporting [42,59,63,68,75], particularly on the under-reporting of data (i.e. reported only as “not significant” or “P>0.05” with no effect sizes) making it difficult to extract information for meta-analysis

Overall, the studies have shown various levels of risk of bias in different domains. Whilst RCTs are normally considered to provide a high standard of evidence, biases can still occur for reasons highlighted above, undermining the confidence we can have in that evidence. If we focus on the four RCTs, which scored consistently well with low risk of bias across all domains [36,38,47,81], it is noteworthy that none of the studies demonstrate any effect on falls rates. However, only one [47] actually reports falls data, and the other three RCTS all report significant improvements in proxies or fall risk factors (Timed-Up-and-Go [36], Sit-to-Stand [81], muscle power and balance [38]). In a proposed future piece of work we will undertake more robust RoB assessment, using the revised tool (RoB-2) [95] where biases arising on each stage of the trial is assessed against each outcome. We then propose to

use these data as part of a meta-analysis of balance and proxy outcomes, something which is beyond the remit of this report.

Non-randomised studies

For the 25 non-randomised studies, we used the ROBINS-I tool [96] to assess risk of bias (Appendix B, Figure 3). All studies by definition are likely to have overall moderate to critical risk of bias due to the lack of random allocation to groups, and/or because they are dependent on before/after designs. ROBINS-I assesses bias due to: confounding, participant selection, intervention classification, deviation from intended intervention, missing data, outcome measurement, and reporting selection [96].

There were seven studies [35,44,49,53–55,82] that scored as at critical risk of bias in almost all key domains (Figure 3). Several studies [35,44,49,52–55,82] have serious to critical risk of bias on pre-intervention domains. Some studies recruited participants who already have prior knowledge of the intervention [52–54] whilst others let the participants choose which intervention group they want to participate in [35,82], causing an inherent risk of selection bias. This also led to moderate [41,46,49,50,58,65,70,77,80] to serious [39,44,45,51–53,67,71] risk of bias at intervention, where classification of intervention status has been affected by the knowledge of outcomes by the participants. In fact, most studies did not perform blinded allocation of the intervention that the participants receive. Only one study [70] performed a pseudo-random allocation where two-thirds of participants were randomly allocated between intervention and control groups. Blinding of assessors of outcomes was also not possible in most studies, leading to serious [44,46,52,54,67,70,71] to critical [39,49,53,55,82] risk of bias post-intervention.

In overview, none of these non-randomised studies was assessed as being at low risk of bias, and in only 10 cases [41,46,50,58,61,64,65,70,77,80] was the risk of bias overall assessed as moderate. Thus the majority of studies were assessed to be at critical [35,44,49,53–55,82], or serious [39,45,51,52,62,67,71,79] risk of bias. Considerable caution must therefore be taken when drawing conclusions on the basis of any of these studies, and especially so when considering the poorer quality studies with critical levels of risk of bias.

Cost-effectiveness is only assessed in one study [44]. Considerable caution must be used in interpreting the cost-effectiveness of the Dance to Health intervention since the study is rated as being at critical or serious risk of bias across all risk domains except for two where no conclusion could be drawn because of the lack of information in the paper.

Conclusions

Echoing the results of previous reviews [1,23–28], this study finds that there is inconclusive evidence on the effectiveness of dance interventions in falls prevention. Effectiveness of falls prevention programmes is best assessed when a RCT design is used, numbers of falls are assessed before and after the intervention and in comparison to a control, and outcome is based on number of falls or fallers, or rate of falls rather than the use of risk of falls proxy indicators [6,84]. Out of the 48 studies examined in this review, only eight studies examined the number of falls after participation in dance. Only four [42–45] of them claimed positive effect of dance on the number of fallers or falls after the intervention. Most importantly the one RCT that measured falls as an outcome and that was assessed as being of high quality (i.e. low risk of bias) reported no effect on falls outcomes.

Existing evidence [23,27] shows that dance-based interventions may reduce the risk of falling through modification of risk factors and improvements in physical activity as well as

psychological health. In this review, however, there are inconsistent results. Reduced fear of falling, for example, was only statistically significant in three studies [43,55,58], two of which are dance-based exergames. Most of the studies that recorded balance and strength have shown positive significant associations with low impact dance [55,60,81], cultural dance [36,37,45,59,61,66,69,76], and Ballroom [42,50,67,74] and Latin dance [48,52,68,73,75,79]. However, we must be cautious in interpreting that these dances are effective at actually reducing falls rates or number of fallers. Given that the types of dances found in this review vary, it is difficult to pinpoint which type of dance is likely to be the most effective. Each intervention has different assessments and scales for improvement; therefore, a more robust analysis is required (i.e., meta-analysis) to evaluate this effectively.

The other aim of this review was to find out whether dance-based initiatives are cost effective or not. We know from previous studies [97] that traditional balance and strength-based exercises, e.g., Otago, FaME, Tai Chi, have strong evidence on cost effectiveness. In this rapid review, we found no robust evidence that dance interventions are cost-effective. We know that effectiveness is best formally evaluated through a clinical trial, with robust and triangulated (self-report and checking of medical records) reporting methods of outcomes; therefore, the service-evaluated Dance to Health intervention cost-effectiveness analysis should be considered exploratory and needs confirmation in a robust, intention to treat analysed RCT. Because of the flaws in the research design, and the critical risk of bias identified for this study, it can at best be accepted as indicative of an intervention worth exploring further.

Implications for policy and practice

Dance may provide benefits to older people who take part, but at present there is insufficient evidence to recommend any form of dance as an alternative to strength and balance training, if the aim is to prevent falls. There is no robust evidence on the cost-effectiveness of dance interventions for the prevention of falls.

The World Guidelines for Falls Prevention and Management [6] recommend risk stratification of older adults. Older adults at low falls risk should be offered education about falls prevention and exercise for general health and/or fall prevention if interested; those at intermediate risk, should, in addition, be offered targeted exercise or a physiotherapist referral in order to improve balance and muscle strength, and reduce fall risk; older adults at high risk for falls should be offered a multifactorial falls risk assessment to inform individualised tailored interventions. The World Guidelines conclude that the evidence for effectiveness of dance for falls prevention is of very low certainty using GRADE [98]. There is therefore no evidence upon which to prioritise dance over exercise programmes with known effectiveness for falls prevention for any of the three risk groups. Nonetheless, it may be that older people at low falls risk could potentially benefit from dance as part of a general health regimen, in which case it should be part of a structured progressive programme delivered by appropriately qualified professionals.

Further research is nonetheless warranted in this area, especially in terms of RCTs putting dance interventions head to head with interventions known to be effective such as FaME or Otago exercises. A potential first step would be to undertake meta-analysis of the data presented in this report more fully to understand the effect that different dance approaches may have on proxy outcomes (e.g. balance) and risk of falls in robust RCT studies. Such analysis should also take into account the quality of the evidence using RoB-2 [95] and GRADE [98] assessments.

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Appendix A: Search strategy

All searches carried out 02 December 2022

Epistemonikos

(title:((title:(((elder* OR eldest OR "old* age*" OR senior* OR aged OR geriatri*) OR (older AND (person* OR people OR woman OR women OR female* OR man OR men OR male* OR adult* OR patient* OR population* OR subject*)) OR ("over 50*" OR "over 55*" OR "over 60*" OR "over 65*" OR "over 70*" OR over 75*" OR "over 80*" OR "over 85*" OR "over 90*" OR "over 95*" OR "over 100*") OR "post-menopaus*" OR postmenopaus* OR menopaus* OR (quinquagenarian* OR sexagenarian* OR septuagenarian* OR octogenarian* OR nonagenarian* OR centenarian* OR supercentenarian* OR senium))) OR abstract:(((elder* OR eldest OR "old* age*" OR senior* OR aged OR geriatri*) OR (older AND (person* OR people OR woman OR women OR female* OR man OR men OR male* OR adult* OR patient* OR population* OR subject*)) OR ("over 50*" OR "over 55*" OR "over 60*" OR "over 65*" OR "over 70*" OR over 75*" OR "over 80*" OR "over 85*" OR "over 90*" OR "over 95*" OR "over 100*") OR "post-menopaus*" OR postmenopaus* OR menopaus* OR (quinquagenarian* OR sexagenarian* OR septuagenarian* OR octogenarian* OR nonagenarian* OR centenarian* OR supercentenarian* OR senium)))) AND

(title:(((dance OR dancing) OR ("dance movement" OR "dance exercise" OR "danc* therapy"))) OR abstract:(((dance OR dancing) OR ("dance movement" OR "dance exercise" OR "danc* therapy")))) AND

(title:(((fall OR falls OR falling OR faller) OR ("accident prevention" OR "accidental falls") OR ("fall risk" OR "risk of falling"))) OR abstract:(((fall OR falls OR falling OR faller) OR ("accident prevention" OR "accidental falls") OR ("fall risk" OR "risk of falling")))))

[Filters: protocol=no, classification=systematic-review]

MEDLINE

Database(s): **Ovid MEDLINE(R) and Epub Ahead of Print, In-Process, In-Data-Review & Other Non-Indexed Citations, Daily and Versions** 1946 to December 01, 2022

Search Strategy:

#	Searches	Results
1	exp Aged/	3425630
2	geriatrics/	31212
3	middle aged/	4700938
4	(elder or eldest or "old* age*" or senior* or aged or geriatri*).ti,ab,kw.	880249
5	(older and (person* or people or woman or women or female* or man or men or male* or adult* or patient* or population* or subject*)).ti,ab,kw.	475013
6	("over 50*" or "over 55*" or "over 60*" or "over 65*" or "over 70*" or "over 75*" or "over 80*" or "over 85*" or "over 90*" or "over 95*" or "over 100*").ti,ab,kw.	130167
7	(quinquagenarian* or sexagenarian* or septuagenarian* or octogenarian* or nonagenarian* or centenarian* or supercentenarian* or senium).ti,ab,kw.	7863
8	Menopause/	29638
9	("post-menopaus*" or postmenopaus* or menopaus*).ti,ab,kw.	100082
10	or/1-9	6215371
11	Dancing/	3414
12	Dance Therapy/	439
13	(dance or dancing).ti,ab,kw,kf.	6980
14	((dance adj3 exercise*) or (dance adj3 movement) or (dance adj3 therapy)).ti,ab,kw.	643
15	or/11-14	8224
16	Accident Prevention/	9262
17	Accidental Falls/	27724
18	fall*.ti,ab,kw.	241023
19	((accident* adj3 fall*) or (accident* adj3 prevention)).ti,ab,kw.	5276
20	((fall* adj3 reduc*) or (fall* adj3 risk)).ti,ab,kw.	16264

21	or/16-20	257637
22	10 and 15 and 21	146

CENTRAL

ID	Search	Hits
#1	MeSH descriptor: [Aged] explode all trees	221552
#2	MeSH descriptor: [Geriatrics] this term only	213
#3	MeSH descriptor: [Middle Aged] this term only	334423
#4	((elder or eldest or "old* age*" or senior* or aged or geriatri*)):ti,ab,kw	601325
#5	((older and (person* or people or woman or women or female* or man or men or male* or adult* or patient* or population* or subject*))):ti,ab,kw	65581
#6	(("over 50*" or "over 55*" or "over 60*" or "over 65*" or "over 70*" or "over 75*" or "over 80*" or "over 85*" or "over 90*" or "over 95*" or "over 100*")):ti,ab,kw	10245
#7	((quinquagenarian* or sexagenarian* or septuagenarian* or octogenarian* or nonagenarian* or centenarian* or supercentenarian* or senium)):ti,ab,kw	200
#8	(Menopause):ti,ab,kw	7040
#9	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8	609869
#10	MeSH descriptor: [Dancing] this term only	206
#11	MeSH descriptor: [Dance Therapy] this term only	97
#12	(dance or dancing):ti,ab,kw	1316
#13	((Dance NEAR/3 (exercise* or movement or therapy))):ti,ab,kw	394
#14	#10 or #11 or #12 or #13	1316
#15	MeSH descriptor: [Accident Prevention] this term only	135
#16	MeSH descriptor: [Accidental Falls] this term only	1671
#17	((fall or falls or falling or faller)):ti,ab,kw	23307
#18	((accident* NEAR/3 (fall* or prevention))):ti,ab,kw	3808
#19	(fall* NEAR/3 (reduc* or risk)):ti,ab,kw	4243
#20	#15 or #16 or #17 or #18 or #19	24976
#21	#9 and #14 and #20 in Cochrane Reviews, Trials	112

CINAHL

#	Query	Results
S21	S9 AND S14 AND S20	115
S20	S15 OR S16 OR S17 OR S18 OR S19	74,395
S19	TI ((fall* N3 reduc*) or (fall* N3 risk)) or AB ((fall* N3 reduc*) or (fall* N3 risk))	11,715
S18	TI ((accident* N3 fall*) or (accident* N3 prevention)) or AB ((accident* N3 fall*) or (accident* N3 prevention))	1,716
S17	TI (fall*) or AB (fall*)	66,185
S16	MH accidental falls	25,899
S15	MH accident prevention	1,866
S14	S10 OR S11 OR S12 OR S13	6,793
S13	TI ((dance N3 exercise*) or (dance N3 movement) or (dance N3 therapy)) OR AB ((dance N3 exercise*) or (dance N3 movement) or (dance N3 therapy))	862
S12	TI (dance or dancing) OR AB (dance or dancing)	5,090
S11	MH dance therapy	983

S10	MH dancing	3,572
S9	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8	1,224,850
S8	TI (quinquagenarian* OR sexagenarian* OR septuagenarian* OR octogenarian* OR nonagenarian* OR centenarian* OR supercentenarian* OR senium) OR AB (quinquagenarian* OR sexagenarian* OR septuagenarian* OR octogenarian* OR nonagenarian* OR centenarian* OR supercentenarian* OR senium)	2,556
S7	TI ("post-menopaus*" OR postmenopaus* OR menopaus*) OR AB ("post-menopaus*" OR postmenopaus* OR menopaus*)	31,502
S6	MH menopause	9,823
S5	TI ("over 50*" OR "over 55*" OR "over 60*" OR "over 65*" OR "over 70*" OR over 75*" OR "over 80*" OR "over 85*" OR "over 90*" OR "over 95*" OR "over 100*") OR AB ("over 50*" OR "over 55*" OR "over 60*" OR "over 65*" OR "over 70*" OR over 75*" OR "over 80*" OR "over 85*" OR "over 90*" OR "over 95*" OR "over 100*")	1,432
S4	TI (older AND (person* OR people OR woman OR women OR female* OR man OR men OR male* OR adult* OR patient* OR population* OR subject*)) OR AB (older AND (person* OR people OR woman OR women OR female* OR man OR men OR male* OR adult* OR patient* OR population* OR subject*))	221,800
S3	TI (elder* OR eldest OR “old* age*” OR senior* OR aged OR geriatri*) OR AB (elder* OR eldest OR “old* age*” OR senior* OR aged OR geriatri*)	390,088
S2	(MH middle aged+")	5,609
S1	(MH "Aged+")	931,950

PEDro

Abstract & Title: "older people" danc* fall*

Results = 12 records

Appendix B: Figures and Tables

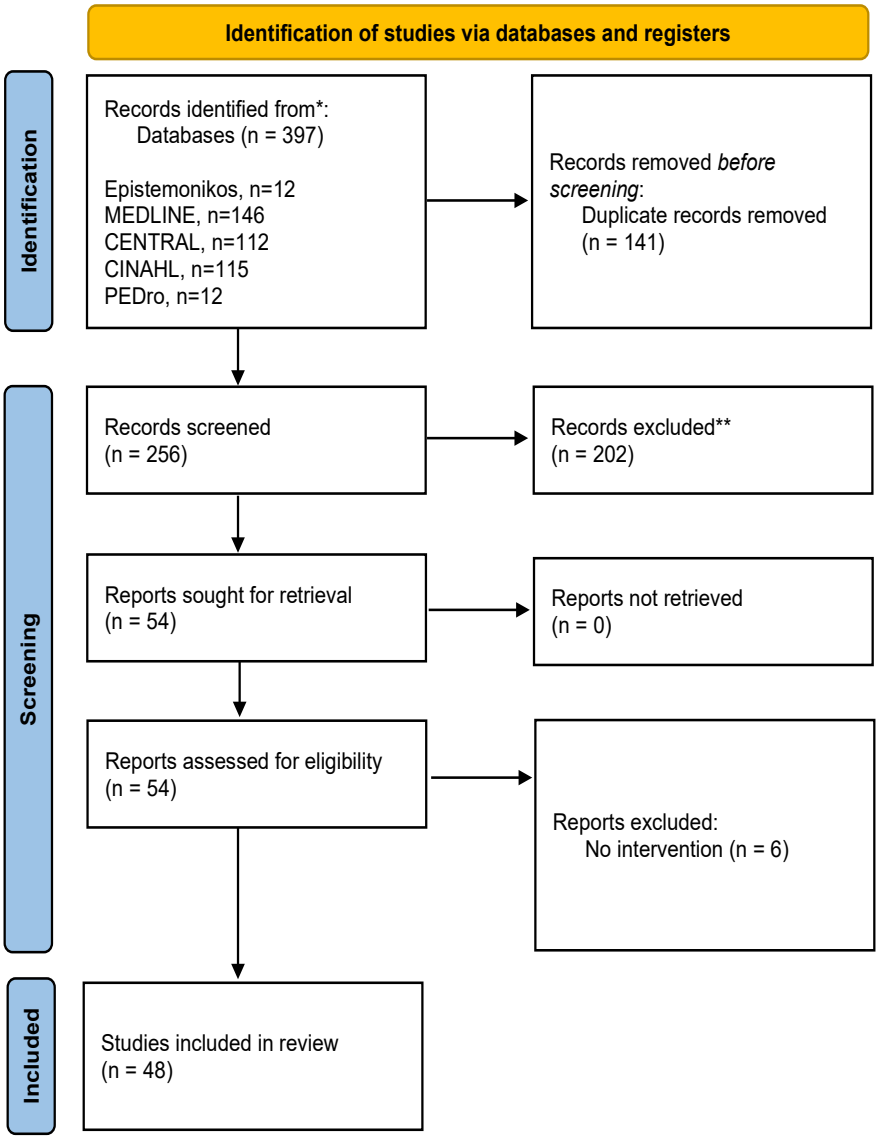

Figure 1 PRISMA diagram[5]

[5] 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 For more information, visit: http://www.prisma-statement.org/

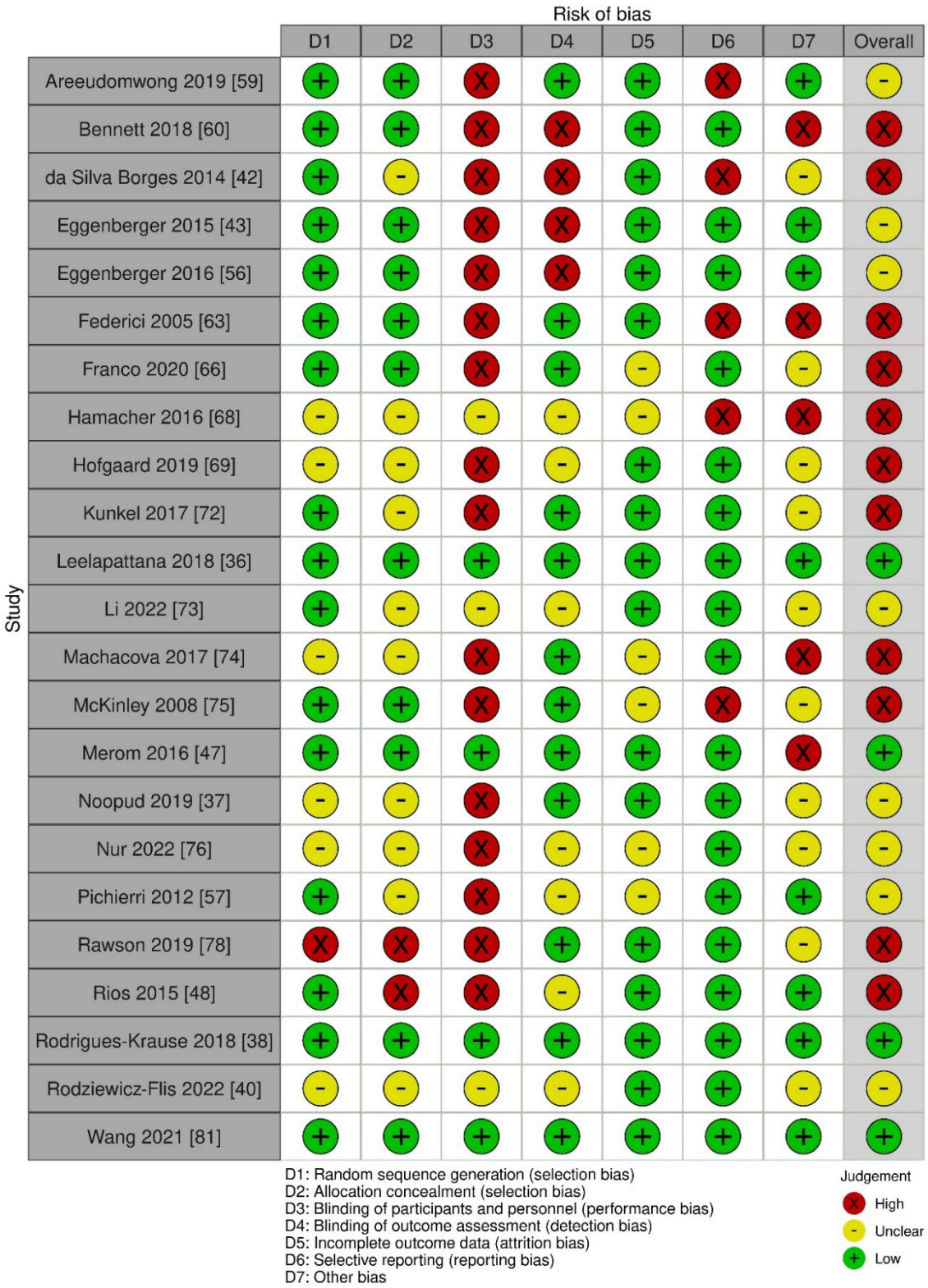

Figure 2: Risk of bias assessment of 23 included randomised controlled trials using RoB-1

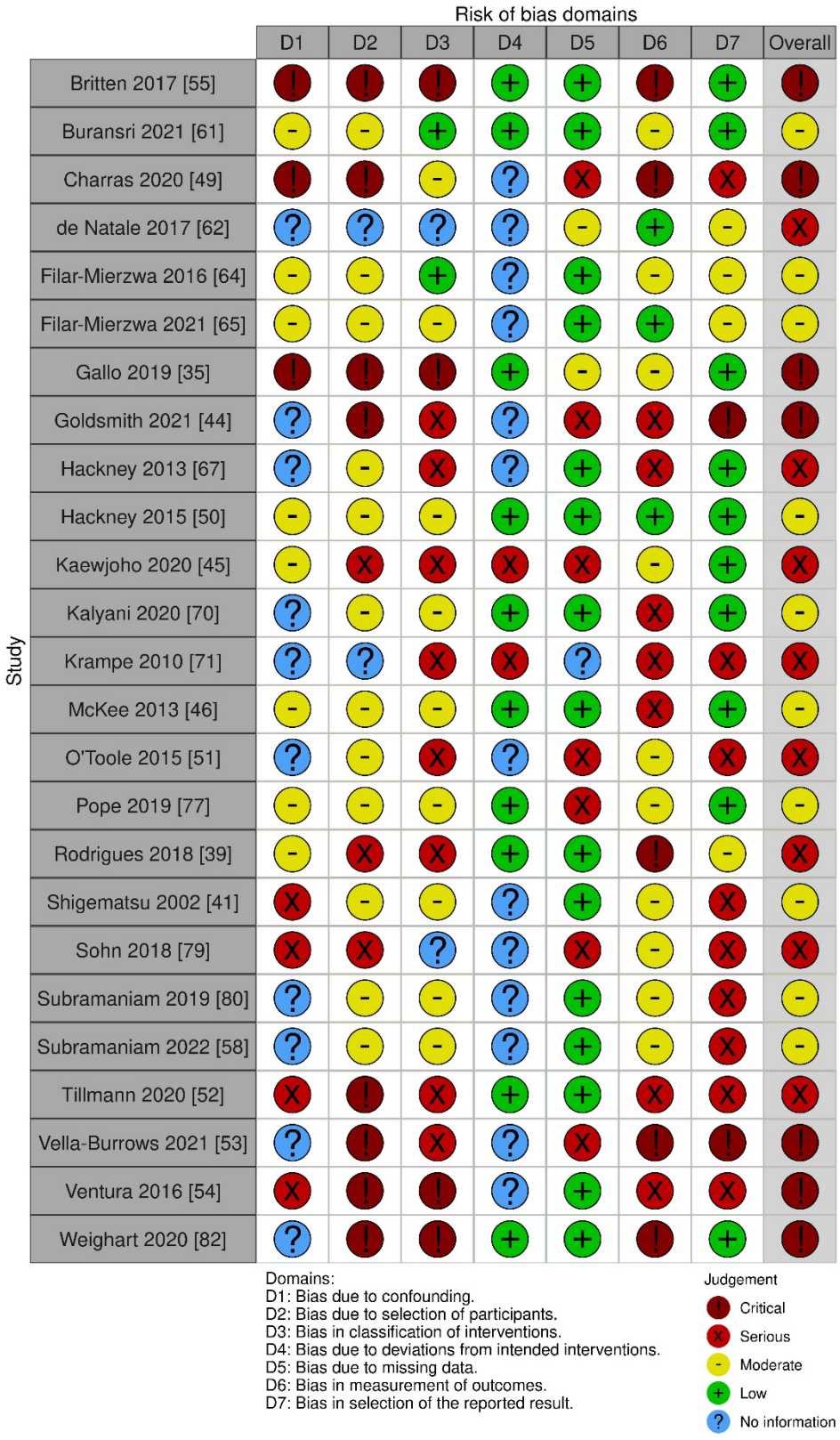

Figure 3: Risk of bias assessment of 25 included non-randomised studies (e.g. quasi-experimental, mixed methods, and cost-effectiveness analysis) using ROBINS-I

Table 1: Summary of study characteristics, N=48 studies

Author, year	Study design	Country	Population (condition)	Mean age	Intervention	Type of dance	Provider of intervention	Setting	Comparison	Duration	Frequency	Total
Areeudomwong 2019 [59]	RCT	Thailand	78 sedentary community dwelling adults.	Cont: 67.33 (4.04), Int: 66.3 (4.33)	Thai boxing dance programme	Dance sport	Trained instructor with four assistants	Primary health	Active control (Falls prevention booklet)	50 minutes	3x a week	4 weeks
Bennett 2018 [60]	RCT	USA	23 sedentary community dwelling adults.	73.4 (8.4)	Line dancing	Low impact	Dance instructor	Community centre	Usual care	1 hour	2x a week	8 weeks
Britten 2017 [55]	Quasi-experimental	UK	38 Healthy, community dwelling adults.	77.3 (8.4)	Contemporary dance	Low impact	Dance instructor	Local community facilities	No control group	90 minutes	1x a week	8 weeks
Buransri 2021 [61]	Quasi-experimental	Thailand	90 Healthy, community dwelling adults.	Cont: 64.20 (4.5), Int: 63.64 (4.6)	Traditional Srichiangmai dance	Folk dance	Sports scientists	School for older people	Active control (Walking)	30 minutes	3x a week	12 weeks
Charras 2020 [49]	Quasi-experimental	France	23 older adults w/ Dementia.	83.47 (5.40)	Dance exercise	Dance exercise	Dance instructor with a nursing background, and 2 facilitators	Day care centre for people with dementia	No intervention	50 minutes	1x a week	24 weeks
da Silva Borges 2014 [42]	RCT	Brazil	59 sedentary adults in long-stay institutions.	Cont: 67 (7.7), Int: 68 (8.3)	Ballroom dancing programme	Ballroom dance		Long-stay institution	Usual care	50 minutes	3x a week	12 weeks
de Natale 2017 [62]	Quasi-experimental	Finland	16 adults w/ Parkinson's disease	Cont: 70 (3.16), Int: 66 (9.15)	Tango	Latin American dance		Dance hall	Usual care	60 minutes	2x a week	10 weeks
Eggenberger 2015 [43]	RCT	Switzerland	71 older adults.	Cont Phys: 80.8 (4.7), Dance: 77.3 (6.3), Memory: 78.5 (5.1)	Aerobic endurance with dance through VR; Aerobic endurance with verbal memory training	Exergaming	Trained postgraduates	Geriatric clinic	Active control (Aerobic endurance only)	1 hour	2x a week	26 weeks
Eggenberger 2016 [56]	RCT	Switzerland	33 older adults..	Cont Balance: 77.8 (7.4), Dance: 72.8 (5.9)	Interactive cognitive-motor video game dancing (DANCE)	Exergaming		Geriatric clinic	Active control (Conventional balance and stretching training)	30 minutes	3x a week	8 weeks

Federici 2005 [63]	RCT	Italy	40 Healthy, community dwelling adults.	Cont: 63.5 (3.7), Int: 62.7 (4.1)	Dance exercise	Dance exercise		Recreation centre	Usual care	1 hour	2x a week	3 months
Filar-Mierzwa 2017 [64]	Quasi-experimental	Poland	24 Healthy, sedentary living adults.	66.4	Dance exercise	Dance exercise			No control group	45 minutes	1x a week	3 months
Filar-Mierzwa 2021 [65]	Quasi-experimental	Poland	39 Healthy, sedentary living adults.	Cont: 67, Int: 67.45	Dance exercise	Dance exercise	Trained instructors	Senior living facility	Usual care	45 minutes	1x a week	3 months
Franco 2020 [66]	RCT	Brazil	71 Healthy, community dwelling adults.	Cont: 70 (6.2), Int: 68.6 (7.2), Dropouts: 66.1 (4.6)	Senior Dance (DanSE)	Folk dance	Dance instructor		Active control (Education)	1 hour	2x a week	12 weeks
Gallo 2019 [35]	Quasi-experimental	Brazil	42 Healthy, physically independent women.	Cont: 68 (65-84), Int: 68 (65-79)	Video game dance training	Exergaming	Trained physiotherapists		Usual care	40 minutes	3x a week	12 weeks
Goldsmith 2021 [44]	Cost effectiveness analysis	UK	1194 older adults	77	Dance to Health	Dance exercise	Dance instructor	Care homes	No control group	2.5 hours	1x a week	56 weeks
Hackney 2013 [67]	Quasi-experimental	USA	13 adults with vision impairment	86.9 (5.9)	Adapted tango	Ballroom dance	Dance instructor, personal trainer	Senior living facility	No control group	1.5 hours	1-2x a week	12 weeks
Hackney 2015 [50]	Quasi-experimental	USA	32 adults with Vision impairment	Tango: 84.9 (9), FallProof: 74.8 (11.2)	Adapted tango	Ballroom dance	Dance instructor, personal trainer	Independent living community	Active control (FallProof classes)	1.5 hours	2x a week	12 weeks
Hamacher 2016 [68]	RCT	Germany	32 Healthy adults.	Cont: 68.33 (3.17), Int: 66.73 (3.33)	Dance programme	Latin American dance			Active control (Strength endurance and flexibility training)	90 minutes	2x a week	6 months
Hofgaard 2019 [69]	RCT	UK	25 Healthy adults.	Cont: 74 (4), Int: 75 (5)	Faroese chain dance programme	Folk dance		Indoor recreation centre	Usual care	30-45 minutes		6 weeks
Kaewjoho 2020 [45]	Quasi-experimental	Thailand	61 community dwelling adults	72.9 (5.7)	Thai dance exercise	Folk dance			No control group	50 minutes	3x a week	6 weeks
Kalyani 2020 [70]	Quasi-experimental	New Zealand	33 adults with Parkinson's disease.	Cont: 66.5 (7.7), Int: 65.24 (11.88)	Dance for Parkinson's Disease® (DfPD®) program	Dance exercise	DfPD-trained instructors	University	Usual care	1 hour	2x a week	12 weeks
Krampe 2010 [71]	Quasi-experimental	USA	11 healthy adults		The Lebed Method Dance therapy	Dance therapy	Trained instructors	Senior living facility	No control group	45 minutes	3x a week	6 weeks

Kunkel 2017 [72]	RCT	UK	51 adults with Parkinson's disease.	Cont: 69.7 (6), Int: 71.3 (7.7)	Mixed dances programme	Ballroom dance	Professional dancer	Local dance centre	Usual care	1 hour	2x a week	10 weeks
Leelapattana 2018 [36]	RCT	Thailand	39 Self-ambulatory women.	Cont: 66.9 (5.6), Int: 66.4 (4.2)	Thai classical dance exercises	Folk dance		Hospital	Active control (Arm-swing exercise)	10 minutes		12 weeks
Li 2022 [73]	RCT	South Korea	40 Healthy adults.	Cont: 61.75 (1.11), Int: 61.8 (1.23)	Cha-cha dance training	Latin American dance		University	No intervention	90 minutes	3x a week	12 weeks
Machacova 2017 [74]	RCT	Czech Republic	189 Nursing home residents.	Cont: 82.88 (8.16), Int: 83.03 (9.10)	EXDASE (EXercise DAnce for Seniors)	Ballroom dance	Dance instructor	Nursing home	Usual care	1 hour	1x a week	3 months
McKee 2013 [46]	Quasi-experimental	USA	31 adults with Idiopathic definite Parkinson's disease.	Cont: 74.4 (6.5), Int: 68.4 (7.5)	Tango	Ballroom dance	Dance instructor	Senior independent living communities	Active control (Education)	90 minutes		
McKinley 2008 [75]	RCT	Canada	25 Healthy, living independently adults.	Cont: 74.6 (8.4), Int: 78.07 (7.6)	Argentine Tango dance programme	Latin American dance	Dance instructor	Senior centre	Active control (Walking)	2 hours	2x a week	10 weeks
Merom 2016 [47]	RCT	Australia	530 Community dwelling adults.	Age >80: 208 (39%)	Social dance	Ballroom dance	Dance instructor	Self-care retirement villages (clusters)	Usual care	1 hour	2x a week	12 months
Noopud 2019 [37]	RCT	Thailand	43 Community dwelling women.	Cont: 68.29 (5.82), Int: 67.5 (5.39)	Thai traditional dance	Folk dance			Usual care	30-60 minutes		12 weeks
Nur 2022 [76]	RCT	Indonesia	41 Community dwelling adults.	Cont: 71.6 (10.11), Int: 67.81 (7.731)	Molong Kopi	Folk dance	Research assistants	Senior long-term care centre	Usual care	15 minutes		8 weeks
O'Toole 2015 [51]	Mixed methods	Ireland	59 Community dwelling adults.		Contemporary dance	Low impact	Dance instructors	Local dance theatre and community centre	No control group		1x a week	6 weeks
Pichierri 2012 [57]	RCT	Switzerland	31 Hostel for the aged residents.	Cont: 85.6 (4.2), Int: 86.9 (5.1)	Dance video game training Cognitive-motor program	Exergaming		Hostels for the aged, Switzerland	Active control (Physical exercise)	40-50 minutes	2x a week	12 weeks
Pope 2019 [77]	Quasi-experimental	USA	163 Community dwelling older adults.	Cont: 71.3 (7), Int: 72.8 (7.6)	The Lebed Method Dance therapy	Dance therapy	Trained instructors		Active control (Stay Active and Independent for Life)	1 hour	2-3x a week	8-10 weeks

Rawson 2019 [78]	RCT	USA	96 adults with Idiopathic Parkinson's disease.	78.97 (20.67)	Argentine tango	Latin American dance	Physical therapist, Trained instructors, laboratory staff	University	Active control (Stretching, Treadmill)	1 hour	2x a week	12 weeks
Rios 2015 [48]	RCT	Canada	33 adults with Idiopathic Parkinson's disease.	Cont: 64.3 (8.1), Int: 63.2 (9.9)	Argentine tango	Latin American dance	Dance instructor	University	Usual care	1 hour	2x a week	12 weeks
Rodrigues 2018 [39]	Quasi-experimental	Brazil	81 Community-dwelling women.	Cont: Fallers 73.6 (5.4) Non-fallers 68.7 (4.8), Int: Fallers 69.8 (4.3) Non-fallers 68.9 (3.3)	Video game dance training	Exergaming	Exercise specialist		Usual care	40 minutes	3x a week	12 weeks
Rodgrigues-Krause 2018 [38]	RCT	Brazil	30 Sedentary women.	Cont (Stretch): 66 (61-70), Dance: 66 (63-70), Walk: 64 (62-65)	Structured dancing	Dance exercise	Specialised instructors		Active control (Walking, Stretching)	1 hour	1-3x a week	8 weeks
Rodziewicz-Flis 2022 [40]	RCT	Poland	30 Community-dwelling women.	Cont: 73.4 (5.0), Dance: 72.1 (4.1), Balance: 74.3 (4.6)	Dance training, Balance training	Dance exercise	Dance instructor, physiotherapist	Community centre	Usual care	50 minutes	3x a week	12 weeks
Shigematsu 2002 [41]	Quasi-experimental	Japan	38 Community dwelling, healthy independent women.	Cont: 79.8 (5.0), Int: 78.6 (4.0)	Dance-based aerobics	Dance exercise	Exercise specialist	Community centre	No intervention	1 hour	3x a week	3 months
Sohn 2018 [79]	Quasi-experimental	South Korea	15 older adults	72 (5.4)	Dansesport	Latin American dance		Senior welfare centre	No control group	50 minutes	3x a week	15 weeks
Subramaniam 2019 [80]	Quasi-experimental	USA	13 Community-dwelling, hemiparetic people with chronic stroke	60.75 (5.12)	Dance-based exergaming	Exergaming		Laboratory	No control group	1hr 50 minutes	2-5x a week	6 weeks

Subramaniam 2022 [58]	Quasi-experimental	USA	13 Community-dwelling, hemiparetic people with chronic stroke	60.75 (5.12)	Dance-based exergaming	Exergaming		Laboratory	No control group	1hr 50 minutes	2-5x a week	6 weeks
Tillmann 2020 [52]	Quasi-experimental	Brazil	20 adults with Parkinson's disease.	66.4 (10.7)	Brazilian samba	Latin American dance	Dance instructor	Rehabilitation centre	Usual care	1 hour	2x a week	12 weeks
Vella-Burrows 2021 [53]	Mixed Methods	UK	67 older adults		Dance to Health	Dance exercise	Dance artists	Care homes	No control group	90 minutes	2-3x a week	6 months
Ventura 2016 [54]	Quasi-experimental	USA	15 adults with Parkinson's disease	Cont: 71.8 (3.6), Int: 70.4 (5.5)	Dance for Parkinson's Disease® (DfPD®) program	Dance exercise	DfPD-trained instructors		Usual care	1.25 hours	1x a week	5 months
Wang 2021 [81]	RCT	China	44 Community dwelling, healthy independent adults.	64.1 (4.02)	Modified tap dance program (MTD)	Low impact	Dance instructor		Active control (Education)	1 hour	3x a week	12 weeks
Weighart 2020 [82]	Quasi-experimental	USA	17 Community dwelling, healthy independent adults.	Cont: 65.9 (11.9), Int: 73.3 (10.6)	Ballet	Low impact	Dance instructor	Dance theatre	No intervention	1 hour	2x a week	10 weeks

Table 2: Summary of study outcomes

Author, year	Outcomes measured and tools used							Key significant results	Authors' Conclusions
	Falls	QoL	Concern of falling	Balance	Strength	Risk of falls	Cost effectiveness		
Areeudomwong 2019 [59]				Timed-up and Go (TUG) (seconds) Romberg test (eyes open and close)	Hip flexors (kg) Hip extensors (kg) Knee flexors (kg) Knee extensors (kg) Ankle dorsiflexors (kg) Ankle plantarflexors (kg)			Participants showed significantly greater improvements in **static balance with eyes open, dynamic balance and all functional fitness** when compared to the control group ($p < 0.05$), and maintained at 4-month follow-up ($p < 0.05$).	Thai boxing is a cheap and safe exercise intervention. It may be implemented as an alternative by health care providers or communities for promoting physical function and well-being of the elderly at risk of falling.
Bennett 2018 [60]				Berg Balance Scale (BBS) Short Physical Performance Battery (SPPB)	Knee extensors (kg) Knee flexors (kg)			The intervention group had significantly greater **SPPB** scores, ($p<0.01$). Results found significant positive differences for the intervention group in **lower extremity function** ($p<0.01$); endurance ($p<0.01$); gait speed ($p<0.001$); and self-reported mobility limitations ($p<0.05$).	Line dancing significantly improved physical function and reduced self reported mobility limitations in these individuals. Line dancing could be recommended by clinicians as a potential adjunct therapy that addresses mobility limitations.
Britten 2017 [55]			Falls Efficacy Scale – International (FES-I)	Timed-up and Go (TUG)				Statistically significant decreases in the mean **fear-of-falling**($p < 0.005$) score were noted, and the time taken to complete the **TUG test** decreased significantly from 10.1 s to 7.7 s over the 8 weeks ($p < 0.005$).	Contemporary dance has the potential to positively affect the physical activity, sitting behaviour, falls related efficacy, mobility and incidence of depression in older females which could reduce their incidence of falls.
Buransri 2021 [61]				Functional reach test (FRT) (cm) Timed-up and Go test (TUG) (seconds) 6-minute walk test (6MWT) (meters) Chair stand test 30 second (reps) Arm curl test 30 second (reps)				**FRT and TUG** ($p<0.001$) was better for those in intervention group compared to the control group. There was significant in the **FRT** ($p \leq 0.001$) for those in the dance group. They had faster movement, took shorter time and performed a better score in the **TUG** after training ($p \leq 0.001$).	Traditional Srichiangmai dance significantly improved balance and mobility among older community-dwelling as potentially prevent age-related mobility and balance decline as well as its related fall risk.

Charras 2020 [49]		QoL in Alzheimer's Disease (QoL-AD)		Timed-up and Go test (TUG) (seconds) One-leg balance		No changes were observed for QoL-AD and Get Up and Go test global scores.	Our study has shown that dance interventions for people with dementia are appreciated and contribute to wellbeing. No results concerning gait, balance, confidence or quality of life enabled us to draw other conclusions.
da Silva Borges 2014 [42]	No. of falls			Corporal balance (kg)		In the intragroup comparison, the EG patients experienced significantly fewer **falls** post-test relative to pre-test ($p < 0.0001$). This improvement was not observed for patients in the CG. In the intergroup analysis, we observed fewer **falls** in the EG post-test compared to the CG post-test ($p < 0.0001$).	Sedentary people living in long-term institutions can improve their balance via a ballroom dancing program. This activity improved balance and reduced the number of falls in this elderly population.
de Natale 2017 [62]				Unified Parkinson's Disease Rating Scale (UPDRS) Unified Parkinson's Disease Rating Scale III (UPDRS III) Berg Balance Scale (BBS) Gait Dynamic Index (GDI) Timed Up-and-Go Test (TUG) 4-Square Step Test (4SST) 6-minutes Walking Test (6MWT)		In the intervention group, motor and cognitive outcomes significantly improved after treatment and retained after follow-up. Significant changes were found for **6MWT** ($p = 0.028$), **TUG** ($p = 0.007$), TMT-A ($p = 0.014$) and TMT-B ($p = 0.036$).	Dance therapy group significantly improved some motor and cognitive tests in PD patients followed-up in an 8-week period. Dance therapy is an entertaining unconventional physical therapy for PD patients and may have relevant impacts on motor and non-motor functions.
Eggenberger 2015 [43]	Fall frequency, falls per year		Falls Efficacy Scale – International (FES-I)	Short Physical Performance Battery (SPPB) 6-minute walk test (6-MWT)		DANCE/MEMORY showed a significant advantage compared to PHYS in DT costs of step time variability at fast walking ($P=0.044$). Global linear time effects showed improved gait ($P<0.05$), functional fitness ($P<0.05$), and reduced **fall frequency** (−77%, $P<0.001$). Only single-task fast walking, gait variability at preferred walking speed, and **Short Physical Performance Battery** were reduced at follow-up (all $P<0.05$ or trend).	The two novel training concepts of simultaneous cognitive–physical training and the exclusive physical exercise program displayed similarly great potential to counteract age-related decline of physical functioning in the elderly persons, while possible advantages of simultaneous cognitive–physical interventions are well worth further investigation.

Eggenberger 2016 [56]		Falls Efficacy Scale – International (FES-I)	SPPB(score) 4-meter walk (s) 5 chair-rises (s) Extended balance (score)		Baseline physical perfromance was not different between groups. Baseline values showed a trend to a significant difference between groups in FES-I (p=0.098).	Exercise training is able to reduce the need of prefrontal resources of executive function and attention involved in challenging treadmill walking. We speculate that the elderly might benefit from these additional cognitive resources to focus their attention on other processes while walking.
Federici 2005 [63]			Tinetti Romberg Improved Romberg Sit-up and Go		Results showed a significant improvement in **balance** in the exercise group at the end of the exercise program, whereas the control group did not show any significant changes. The comparison between exercise and control group variations in **balance** test scores (p<0.001) showed a highly significant difference.	Results suggest that physical activity based on dance may improve balance and hence be a useful tool in reducing the risk of falling in the elderly.
Filar-Mierzwa 2017 [64]			Postural Stability Test Limits of Stability Test Fall Risk Test – Modified Clinical Test of Sensory Integration and Balance (FRT M–CTSIB) open and closed foam surface, open and closed firm surface FRT closed firm surface FRT closed foam surface		A statistically significant difference (p < 0.05) was found between the pre- and postdance therapy results for the **LOS test**. No statistically significant differences were observed between the pre- and postdance therapy values for all the parts of the FRT M–CTSIB.	Our findings partially supported the hypothesis that dance therapy may improve balancing skill in older women. However, it should be remembered that the improvement was confirmed with only one out of the three conducted tests—namely, with the LOS test.
Filar-Mierzwa 2021 [65]			Postural Stability Test Limits of Stability Test Functional Reach Test (FRT) (eyes open and closed) Fall Risk Test – Modified Clinical Test of Sensory Integration and Balance (FRT M–CTSIB) (eyes open unstable surface)		Improvement of the balance was confirmed for only one test (**limits of stability**, p=0.005) after the intervention, both for the dance group and the general exercises group.	Our findings only partially supported the hypothesis that dance and general exercises may improve balancing skills and reduce the risk of falls in older women. It should be remembered that the improvement was confirmed with only one out of the three conducted tests both for the dance group and the general exercises group. These form of physical activity, supervised by qualified professionals, should be recommended for older

					women, especially those who have sedentary lifestyles.
Franco 2020 [66]		Single leg stance (s) Standing balance (s) Sit-to-stand (s) 4-m walk time (s)		**Single-leg stance** with eyes closed improved in the intervention group (mean difference [MD] = 2.3 seconds, 95% confidence interval [CI] = 1.1 to 3.6) compared with the control group at follow-up. Senior Dance group performed better in the **standing balance tests** (MD = 37 seconds, 95% CI = 0.6 to 6.8) and were faster in the **sit-to-stand test** (MD = - 3.1 seconds, 95% CI = -4.8 to -1.4) and **4-m walk test** (MD = -0.6 seconds, 95% CI = -1.0 to -0.1).	Our findings show that Senior Dance can be considered a treatment option when the aim is to impact upon important risk factors for falls, such as balance and mobility, in the older population. Importantly, this intervention can be easily implemented into clinical or health promotion practice by a Senior Dance instructor and may be perceived as an option for older people who may prefer dancing
Gallo 2019 [35]			Handgrip strength (kg)		No study participant was diagnosed with sarcopenia as their handgrip strength, gait speed and calf circumference mean values were higher than 18 kg, 1 m/s, and 31 cm, respectively. (Not significant)	Virtual dance exercise can be recommended to increase muscle mass. The findings presented here suggest that moderate exercise intensity may be a feature of the exercise prescription used for virtual dance programs designed for active community-dwelling older women.
Goldsmith 2021 [44]	No. of falls			Financial ROI for every £1 spent Societal ROI for every £1 spent Net Monetary Benefit (NMB)	Findings from the research suggest that under the suggested health intervention, there was a 58% reduction in the number of falls. Furthermore, the results also claim that Dance to Health offers a potential cost saving of more than £196m over a 2-year period, of which £158m is a potential cost saving for the NHS.	The paper claims that Dance to Health offers the health system a cost-effective means to address the issue of older people's falls and most importantly a method that produces strong results in terms of falls prevention.

Hackney 2013 [67]				30-s Chair Stand (no. of rises)		Participants increased marginally on **chair stand** (1 week pre: M = 10.0, SD = 4.6, 1week post:M= 11.3, SD = 3.2, 1month post: M = 11.3, SD = 4.2; F(2,22) = 2.98,)np2 = 0.213; 1 week pre vs. 1 week post: p = .075).	These older individuals with visual impairment benefitted from 30 hours of tango instruction adapted for their capabilities. Increased lower body strength (17.5% increase from 1 week pre to 1 week post on chair stand) may have clinical relevance and impact ADL performance, pending converging evidence from future studies.
Hackney 2015 [50]		NEI VFQ–25 General health		Berg Balance Scale (BBS) Sensory Organization Test (SOT) Six-minute walk test (meters) Timed-up and Go (TUG) (seconds)		The **balance** reactions of participants in both groups improved ($p < .001$). Endurance, cognitive dual-tasking, and vision-related QOL may have improved more for Tango than FallProof. Group differences and gains were maintained across time.	Participation in both FallProof and Tango may benefit endurance, dual-tasking, balance, and visual QOL in older individuals with visual impairment. Both programs are potential exercise options for older adults with visual impairment and appear equally effective for improving balance and mobility. Similar mechanisms may therefore underlie improvement.
Hamacher 2016 [68]				Local dynamic stability		For **local dynamic stability** of trunk movements, an interaction effect in favour of the dancing group was observed (p=0.026).	Our data indicate that a dancing programme (which combines cognitive and motor efforts) might increase local dynamic stability in older people.
Hofgaard 2019 [69]				Berg Balance Scale (BBS) Fullerton Advanced Balance Scale (FAB) Short Physical Performance Battery (SPPB) Timed Up & Go (TUG) 6-minute walk test 30s sit to stand test		Intervention improved (P<0.05) on **BBS** and **FAB** scores by 3.6 ± 2.1% and 15.8 ± 8.3%, with the change score for FAB being greater (P<0.05) than in CG (0.3 ± 1.6). Moreover, the postintervention **SPPB** score was improved (P<0.05) more in IG (13.9 ± 7.4%) compared to CG, while performance in the **30-s sit-to-stand, 6-min walk, and TUG tests** improved (4–15%; P<0.05) in IG only.	The dance programme lowers blood pressure and improves postural balance and physical function in elderly.

Kaewjoho 2020 [45]	No. of falls		Timed up and go test (s) Five times sit-to-stand test (s) Six minute walk test (m)		Participants improved their **functional mobility** significantly after 3- and 6-week training ($p < 0:01$). The **number of faller** individuals obviously decreased from 35% ($n = 21$) prior to training to only 8% ($n = 5$) after training ($p < 0.01$).	Thai dance exercise program improved functional mobility of the participants after 3- and 6-week of training, as well as reduce the fall rates of older Thai dance exercises benefited functional mobility and fall rates among community-dwelling older individuals. Hence, the present findings further confirm the use of a Thai dance exercise program, which is familiar to Thai individuals, as an alternative strategy to promote independence and safety among community-dwelling older adults.
Kalyani 2020 [70]			Timed Up & Go (TUG) Dual-task TUG (s) Tinetti-Balance Berg Balance Scale (BBS) Mini Best Test ABC scale		Compared to the CG, there was significantly greater improvement in the DG pre-post change scores on measures of symptom severity MDS-UPDRS, dexterity, six measures of functional mobility (**Dual-task TUG, Tinnetti-Balance, Gait, Total, BBS, MiniBest,** $p=0.001$) and the ABC-S, G&F-Q, FOG questionnaires.	DfPD®-based dance classes improved disease-related symptom severity, fine-manual dexterity, and functional mobility. Feasibility of the approach for a large scale RCT was also confirmed. It could be an effective supportive therapy for the management of symptoms and functional abilities in PD .
Krampe 2010 [71]			Functional reach test (FRT) (cm) Timed-up and Go test (TUG) (seconds)		The improvement in the FR from baseline to the end of the intervention was noted in the majority of the participants. The overall functional measure related to balance and gait as depicted by percentage of change (FR score divided by TGUG) that resulted from the intervention showed global improvement of about 50% from baseline in this scoring schema. Not stated if significant	Dance therapy results in positive functional trends, suggesting that further study using dance-based therapy will be useful to decrease fall risks in older persons.
Kunkel 2017 [72]			Berg Balance SS180 (Standing-start 180) (s) TUG 6-minute walk test		No significant results. Significant differences between groups in the study was not found and expected because the sample was not powered for efficacy testing.	We observed some differences between groups in balance and balance confidence, as have other researchers, but the direction of change was inconsistent, leading to an inconclusive picture. We have demonstrated the feasibility of conducting the study through a Dance Centre and recommend a Phase III trial.

Leelapattana 2018 [36]			Timed up and go test (sec), mean (SD) Tandem walk (sec) Chair rise test (sec)		The experimental group had significantly improved over baseline on the **timed up and go test** and on the **tandem walk test** (p = 0.002 and 0.001, respectively), and had also significantly improved on the **timed up and go test** compared to the control group (average 14.2+4.3 to 9.2+2.9 sec, and 13.0+3.8 to 11.2+4.3 sec, respectively; p-value = 0.0125). There was no difference in the chair rise test between the groups.	Dance exercise for one month is an efficacious way to improve physical performance in older women and to help reduce the risk of falls. This study demonstrates that ten minutes of daily Thai classical dance exercise for 4 to 12 weeks is efficacious in improving physical performance in older women and is an alternative means of helping reduce the risk of falls in the elderly.
Li 2022 [73]			Balance Check 636 Score		**Dynamic balance and static balance** in intervention group were significantly improved after the intervention (p<0.05). In addition, the results showed that the improvement was more significant in trials in left foot than right foot, and trials in closed eyes than open eyes, respectively.	The program alone can be an effective intervention to improve balance of the elderly. Especially for the elderly do not often engage in physical exercise, a period of Cha-cha dance training can be used as an appropriate exercise to improve the executive ability of motor functions.
Machacova 2017 [74]			Get-up-and-go test (0-12; 12 = best) Chair stand test (no.) Arm-curl test (no.) 2-min step test (no.) Chair sit-and-reach test (cm) Back scratch test (cm) 8-foot timed test (s)		Participants in the control group experienced a significant decline in **get-up and-go test** (p<0.05), IADL, and in four of the six SFTs (**chair stand, 2-min step test, back scratch test, 8-foot timed test**, p<0.05).	The findings indicate that a relatively simple dance-based exercise can slow down deterioration of functional status in nursing home residents. The intervention proved to be effective in preventing this deterioration and improved chair stand test and chair sit-and-reach test.
McKee 2013 [46]	No. of falls		Baseline-TUG (s) Manual-TUG (s) Four square (s)		Tango participants improved in **balance** (p = .038), and executive function (p = .012). The **number of fallers versus nonfallers** was not significantly different between groups. Tango was 1.42 times (95% CI [0.02, 111.50], φ = .066, p = .724) more likely than education to experience decreased or no change in fall incidence during the follow-up period compared to the year before the program. Among participants who improved balance, 66% of tango and 50% of education experienced decreased or no change in fall incidence.	Within tango, we observed little change in fall incidence outside class. In this study, though two falls occurred during tango, no injuries resulted and participants continued therapy. While other populations may benefit from tango as well, the PD population identified here is appropriate for and may benefit from the adapted tango intervention

McKinley 2008 [75]					Sit to stand				The two-way ANOVAs indicated a significant effect for time for **sit-to-stand (STS)**, F(2, 46) = 15.25, p < .0001. Tukey–Kramer adjusted post hoc tests revealed significant differences between pre- and post- and pre- and follow-up for **STS** (p = .0012 and < .0001, respectively).	Although both interventions are effective activities for increasing strength and walk speed, tango might result in greater improvements than walking in balance skills and in walking speed in the 10-wk intervention.
Merom 2016 [47]	No. of falls	SF-12 survey V2, physical and mental			SPPB Repeated sit-to-stand		Physiological Profile Assessment (PPA)		During the period, 444 falls were recorded; there was no significant difference in fall rates between the control group (0.80 per person-year) and the dance group (1.03 per person-year). In exploratory post hoc subgroup analysis, the rate of falls was higher among dance participants with a history of multiple falls (IRR = 2.02, 95% CI: 1.15, 3.54, p = 0.23 for interaction) and with the folk dance intervention (IRR = 1.68, 95% CI: 1.03, 2.73). There were no significant between-group differences in executive function test (TMT-B = 2.8 s, 95% CI: −6.2, 11.8). Intention to treat (ITT) analysis revealed no between-group differences at 12-mo follow-up in the secondary outcome measures, with the exception of postural sway, favouring the control group.	Participation in social dancing programs did not reduce falls in older adults living independently in retirement villages. Furthermore, the intervention did not lead to significant improvements in cognitive risk factors as measured with the TMT-B, or physiological fall risk as measured by the PPA. The only improvement among intervention participants was a small apparent increase in gait speed, particularly among the ballroom dancing group, but worse performance than control on the postural sway test. Post hoc analysis revealed that multiple fallers, i.e., in the year prior to randomisation, in the social dancing group had a significantly higher rate of falls than multiple fallers in the control group. There were no significant differences between the groups in physical or mental health-related quality of life.
Noopud 2019 [37]					Berg Balance Scale (BBS) Timed Up and Go test (TUG) Sit-to-stand test, weight transfer Step quick turn test Turn and sway time (s) Step up/over test (8-inch curb) Movement time Walk across test				The results revealed that overall **balance** was better for those in TTDG compared to the CG. There was a significantly lower **sway** velocity and faster weight transfer in the **Sit-to-Stand Test** (p ≤ 0.001) for those in the dance group. Intervention group had quicker turn time in the **Step Quick Turn Test** (p ≤ 0.001), improved **Step Up Over Test and Walk Across Test**, faster movement time, walking speed, and a better score in the **TUG** after training (p ≤ 0.001).	Intervention significantly improved balance and mobility among older community-dwelling women as compared to normal daily activities. Thai traditional dance could potentially prevent age-related mobility and balance decline and its related fall risk.

Nur 2022 [76]				Berg Balance Scale (BBS)		Morse Fall scale		There were significant differences in the intervention group after Molong Kopi dance for eight weeks. After treatment, a significant differences between the intervention group and the control group on systole blood pressure, **fall risk** and sleep quality ($p < 0.05$). The number of OA who were not at risk for fall after the intervention were increased from 14 to 38%. Molong Kopi dance intervention did not give a significant difference to the diastolic blood pressure and balance variables (p-value> 0.05)	Molong Kopi dance performed in long-term care turned out to reduce systolic blood pressure in OA in the intervention group. The risk of falling in the elderly is also reduced. Dances performed by OA will increase the ability of the muscles to balance, move quickly or slowly, and this will provide alertness to OA and will reduce the risk of falling on the OA
O'Toole 2015 [51]		EUROQoL	Falls Efficacy Scale – International (FES-I)					No significant differences were found in falls efficacy or quality of life.	Findings suggest that a dance programme may increase activity participation in social and community-based activities. While there was an improvement in participants' FES scores following programme completion, no significant changes were found. This is somewhat in conflict with qualitative data whereby participants described moving in new ways, increased awareness of their body, realisation of abilities and increased confidence as a result of participating in the programme. While it may be that these reported benefits did not translate or relate to increased falls efficacy, it must also be noted that participants' median FES score were low both at programme baseline (Md = 21) and post-programme (Md = 20), indicating that most participants had lowmoderate concerns about falling.

Pichierri 2012 [57]		Falls Efficacy Scale – International (FES-I)					No significant between-group differences were observed in falls efficacy.	There was a significant interaction in favor of the dance video game group for improvements in step time. Significant improved fast walking performance under dual task conditions (velocity, double support time, step length) was observed for the dance video game group only. These findings suggest that in older adults a cognitive-motor intervention may result in more improved gait under dual task conditions in comparison to a traditional strength and balance exercise program.
Pope 2019 [77]			TUG (Timed Up and Go) Hand Reaction Time (HRT) Foot Reaction Time (FRT)	Leg strength	Physiological Profile Assessment (PPA)		There was a statistically significant difference in **falls risk** between interventions (F1, 120=16.121, $p < 0.001$, $\eta 2=.118$). At post-test, participants in SAIL had significantly lower falls risk than those in TLM when adjusted for pre-test values. SAIL participants had a significantly lower **FRT** when compared to TLM counter-parts (F1, 120=43.446, $p < 0.001$, $\eta 2=.266$) when adjusted for pre-test values. For **LLS**, TLM participants were significantly stronger than SAIL (F1, 120=17.662, $p < 0.001$, $\eta 2=.129$). There was a statistically significant difference between interventions (F1, 120=11.982, $p=0.001$, $\eta 2=.091$). **TUG** times were significantly lower for SAIL participants when compared to TLM.	This study was designed to compare the effects of two exercise interventions (i.e., SAIL and TLM) on falls risk and related risk factors for community-dwelling older adults. The results of our study partially supported our hypothesis; SAIL participants had lower risk of falls than TLM after normalizing for training hours and controlling for pre-intervention values. Additionally, SAIL displayed faster reaction and TUG times. Our findings indicate multifactorial exercise interventions can be effective at reducing falls risk and beneficial for older adults.
Rawson 2019 [78]			Mini-Balance Evaluation Systems Test (Mini-BESTest)				Backward velocity and motor functioning improved for the stretching group from baseline to post-test but results did not persist at follow-up. There were no significant changes in the tango group across time points.	Contrary to our hypotheses, only treadmill improved forward walking, while backward walking improved with treadmill and stretching. Future research should examine combinations of exercises with a focus on optimizing dosing and examining whether specific characteristics of people with PD correlate with different types of exercise.

Rios 2015 [48]	Falls questionnaire (Canadian Community Health Survey (CCHS))			Timed Up and Go (TUG) Dual task TUG Dual task, TUG (s) Mini-Balance Evaluation Systems Test (Mini-BESTest)		On the primary intention-to-treat analysis there was no difference in motor severity between groups. **Mini-BESTest** improved in the tango group compared to controls(0.7 ± 2.2 vs. −2.7 ± 5.9, p = 0.032). Among individual items, tango improved in both simple **TUG** time (−1.3 ± 1.6 s vs. 0.1 ± 2.3, p = 0.042) and **TUG Dual Task** score (0.4 ± 0.9 vs. −0.2 ± 0.4,p = 0.012).	Argentine tango can improve balance, and functional mobility, and may have modestbenefits upon cognition and fatigue in Parkinson's disease. These findings must be confirmed inlonger-term trials explicitly powered for cognition and fatigue.
Rodrigues 2018 [39]	No. of falls Causes of falls		Falls Efficacy Scale – International (FES-I)	Timed Up and Go (TUG) Five Times Sit-to-Stand (FTSS)		There were no significant differences between groups for the other variables analyzed. Nevertheless, the occurrence of falls was greater in IG compared to CG during the 12-week experimental period. Other studies have also reported an increase in falls in the intervention exercise group during the experimental period.	Dance exergaming can be indicated to decrease depressive symptoms in fallers and increase the peak torque in nonfallers among community-dwelling older women. Contusions were the most common consequence of the falls reported in our study. Even though contusions are not a severe outcome, the psychological consequences of falls can affect quality of life due to decreased confidence, restriction of ADLs, and increased concern of falling. Thus, investigating falls can help clinicians and public health professionals implement fall prevention strategies, not only for home hazards but also for public places. Training exercise programs should be associated with specific advice about avoidance of falls, such as walking carefully, particularly when footpaths are uneven, and also about which footwear may help reduce falls.
Rodgrigues-Krause 2018 [38]				Gait ability TUG (m·s)		Lower body muscle power and **static balance** improved for dancing (p=0.002) and walking (p=0.001), but not for stretching.	Dancing may be considered as effective as walking in improving CVR associated factors, such as VO2peak, as well as fall-risk factors (static balance and lower body muscle power) in older women with no aging-associated comorbidities. Eventually, these metabolic and functional gains

						will contribute for preserving physical independence with aging.
Rodziewicz-Flis 2022 [40]		Timed Up and Go (TUG) 6-minute walk test (6MWT)			The results showed an improvement in **6MWT** (p = 0.0001 for DG and BD), walking speed (p = 0.0001 for DG and BG) and **TUG**, only for dance group (p = 0.0013). The number of correct responses in dance group increased in both groups (p = 0.014 and p = 0.005, for dance and balance groups, espectively).	Dance training intervention could have more benefits on elders' physical and cognitive functions. However, both trainings may be important factors modifying the concentration of circulating proteins associated with neurodegenerative and cognitive disorders.
Shigematsu 2002 [41]		Single-leg balance with eyes open and closed (s) Functional reach test (FRT) (m)	Keeping a half squat position (s) Hand grip strength (kg)		After intervention, exercise group showed significantly greater **single-leg balance** with eyes-closed (P=0.03), **functional reach** (P=0.01), and walking time (P=0.03). No signficant improvements were made in control group.	Dance-based aerobic exercise specifically designed for older women may improve selected components of balance, therby attenuating falling risk. The positive change in single-leg balance with eyes closed was significant, resulting from the repeition of various stepping movements in the exercise.
Sohn 2018 [79]		Walking balance Standing balance			The results suggested that, after 15 weeks of dancesport participation, older adults' **walking balance** (p=0.04) and **standing balance** (p=0.004) were significantly improved.	Performing dancesport would require moving center of mass rapidly and frequently while maintaining posture. This may result in improving walking balance and standing balance in the present study. The study concluded that dancesport would be an effective exercise method in enhancing postural stability of older adults.
Subramaniam 2019 [80]		Timed Up and Go (TUG)			Similarly, the post-intervention **TUG scores** were significantly correlated with post-intervention changes in peak flexion joint angle (p<.05)	Findings demonstrated the beneficial effect of DBExG for improving UE movement and the training-induced gains were also positively correlated with improvements in fall-risk measures in people with chronic stroke. Thus, DBEx training

							could be used as a meaningful clinical application for this population group.
Subramaniam 2022 [58]			Falls Efficacy Scale – International (FES-I)	Berg Balance Scale (BBS)		Functional clinical measures (**BBS** and **FES**) also improved significantly from pre- to post-intervention ($p < .05$).	The findings support the postulation that DBExG improves postural stability, joint kinematics, gait function, and improving falls-self efficacy among PwCS.
Tillmann 2020 [52]		PDQ-39		Berg Balance Scale (BBS)		During class implementation, there were no falls, as all dance activities adhered to the details of the protocol steps without any changes. On average, patients completed 82.7% of activities. After 12 weeks, the experimental group had improvements in the UPDRS global score, in daily activities, and on motor examination. There was also improvement in balance scores and in the mobility domain of the quality of life in the experimental group.	The samba protocol seems to be feasible and safe for patients with PD. Moreover, it has pleasant characteristics and offers sufficient physical benefits for combination with drug treatment. There were also benefits in social relationships and as a possible rehabilitation tool in individuals with Parkinson's disease.
Vella-Burrows 2021 [53]		EUROQoL				The findings show that the DtH programme can support and enhance physical, mental and social health and levels of interest in dance. The mixed data yielded evidence of positive change, with statistical significance in findings relating to group bonding and improved physical control and coordination. **EuroQOL** overall health scale ($p<.0001$)	The findings support the case for recommending the Dance to Health programme in falls-prevention services in relation to its ability to promote a wide range of health and wellbeing benefits.
Ventura 2016 [54]		Geriatric Depression Scale (GDS)	Falls Efficacy Scale – International (FES-I)	Timed Up and Go (TUG) Standing balance test		Effect sizes were positive (suggesting improvement) for all 12 measures within the intervention group and 7 of 12 measures within the control group. The largest between-group differences were observed for the Test of Everyday Attention (a measure of cognitive switching), gait speed and falls efficacy. Study does not identify whether positive changes were significant or not.	Our findings suggest that dance has potential to improve multiple outcomes in people with PD. Future trials should consider co-primary outcomes given potential benefits in motor, cognitive and emotion/QOL domains.

Wang 2021 [81]				Five times sit-to-stand test (s)				Results revealed significant improvements in **five times sit-to-stand** in the intervention group (mean difference = 1.01, $p<0.05$).	The modified tap dance programme can be an effective exercise programme for ankle function improvement, but it has limited effects on improving postural control among healthy older adults.
Weighart 2020 [82]				Postural stability, center of pressure (CoP) x Displacement				Following the intervention, no significant differences were seen within the dance group from pre- to post-testing or when comparing delta values (post minus pre) between groups in the center of pressure area, displacement, or speed ($p > 0.05$).	While no differences were seen with this intervention, the ballet barre was used for approximately half of each dance class; future ballet interventions for older adults may benefit from training without a barre to enhance potential effects on postural stability.
Total	**8**	**7**	**8**	**43**	**5**	**3**	**1**		

* in green: significant results, in red: non-significant results

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